Combining EEG and Serious Games for Attention Assessment of children with Cerebral Palsy

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Abstract*— *Electroencephalography(EEG) is an electrophysiological monitoring method to record the electrical activity of the brain in a not invasive manner, with low cost hardware, using wireless communication and with high temporal resolution. Serious Games (SG) have demonstrated their effectiveness as a therapeutic resource to deal with motor, sensory and cognitive disabilities. We have considered the combination of both techniques for attention assessment in children with cerebral palsy (CP). In this short paper we present a new approach for the development of a SG based on a Brain Computer Interface (BCI).

I. INTRODUCTION

Human Computer Interaction (HCI) is the discipline concerned with the study of the information exchange between humans and computer systems. Its main objective is to achieve an efficient information interchange, while minimizing the number of errors and improving user satisfaction. Ultimately, its final goal is to improve the productivity of the tasks that people carry out using computers. Usually the interaction between human and computers is performed through common peripheral devices such as the keyboard, the mouse and the display. This type of interaction unavoidably involves the operation of the neuromuscular system as intermediary. However in some cases we don't have the possibility of using the muscles because a disease has broken the channel. In this situation, we can obtain the communication directly from the brain using Brain Computer Interaction (BCI) techniques. One of the main non invasive techniques for brain signal recording is electroencephalography (EEG). EEG refers to the recording of the brain's electrical activity over a short period of time registered from multiple electrodes placed on the scalp. The use of complex, challenging, and ambitious videogames can provide unexpected benefits as hand-eye coordination, decision making, social skills, enhance creativity, improve language, math skills, etc. Serious Games (SG) [4, 5] explore these benefits in order to recover functionality after some stroke or disease, especially in young children who have more neural plasticity. The purpose of our work is firstly to explore which brain waves are involved in the attention process when we are playing a videogame; secondly classify these waves; and finally select visual and acoustics stimulus in order to improve the performance in the proposed serious game.

The rest of the paper is organized as follows. In the next section we present the hardware, software and protocols used. Section III analyzes the obtained results in order to validate the viability of the approach. Finally, the conclusions are presented in the last section.

II. SYSTEM PROPOSAL

A. *User selection and tasks*

In this section we present the whole designed system (hardware, software and the protocol used to acquire the EEG data from end-users). The participants have been selected from an institution for the care of children affected by cerebral palsy (ASPACE[1]). This selection has been performed by the center therapists in order to guaranty that they have a suitable cognitive level to participate actively in two phases of the protocol: (1) *video visualization* and (2) *serious videogame labyrinth (under testing)*. We have 10 cerebral palsy users with ages between 8 and 16 and 8 control users with ages from 8 to 12.

The main task in this first study is to visualize one video on the screen of the computer with visual and acoustic stimuli. The visual stimulus is provided by a video that includes calm images with slowing motion versus images with fast motion displacements. The duration of every stimulus is 20". Stimuli are separated by a 10" black image without any visual or acoustic stimuli. The whole video duration is around 5 minutes. All the capture process is done inside a small room to prevent any external uncontrolled stimuli and to focus user's attention to the main task (see the video). In this first experiment training is not necessary because children have a passive attitude; they don't need to interact directly with the computer.

B. *Experimental setup*

The experimental setup is composed of a portable computer (OS: Windows 7 Pro, CPU: Intel i7, 1.6 GHz, Graphics Card: ATI Radeon HD 5850.) running the EEG software (NIC Online) and the video visualization. In this

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[1] http://www.aspace.org/

BCI set up we select the Enobio EEG system to record the brain data. The spatial distribution of the electrodes is based on the standard 10-20 system configuration with the following electrodes distribution: F3, F4, Fz, C3, C4, Cz, EOG1(Fp1) and EOG2(Fp2). The Enobio system is a wearable wireless EEG sensor with 8 EEG channels and a triaxial accelerometer for the recording and visualization of 24 bit EEG data at 500Hz. The system records the delta, theta, alpha, beta and gamma bands from each electrode without processing as raw data. We calculated the EEG power for every frequency band

EEG data is segmented for each stimulus . The artifacts percentages are evaluated for electrode in order to know the number of eliminated epoch. The band power estimation for the presented stimulus is calculated as the average artifact free power per channel within the stimulus sequence.

The process applied to EEG data includes: (a) Filtering (2 to 45Hz), (b) EOG correction (Optional), (c) Channel Reference (No channel or Cz), (d) Epoching (2") and (e) Artifact rejection (High Amplitude Threshold).

In order to assess the attention of the user we consider the variations of the alpha band [1]. This band is often present in control users with relaxed awareness without any attention or concentration. With active and selective attention in the visual, auditory and tactile domains this band is attenuated. However in some cases this band is also found during continuous attention tasks. Therefore, in order to assess more precisely the attention we have considered both theta and beta bands. Some recently studies [2] consider the EEG theta/beta ratio as a potential biomarker for attention control. A relevant number of these studies are applied in the assessment of attention-deficit/hyperactivity disorder (ADHD) in children and adolescents [3]. A high theta/beta ratio is a signature of ADHD. Based on the previous consideration we would like to evaluate a classification of the CP users versus control users through the alpha values, the theta/beta ratio and/or a weighted function f(alpha, beta, theta) that combine both criteria.

III. ANALYSIS OF THE RESULTS

We consider several options for the analysis of the EEG signal: (a) Non EOG correction and none reference channel; (b) EOG correction and none reference channel; (c) Non EOG correction and Cz reference channel; (d) EOG correction and Cz reference channel. We present the results for the most representative option and subjects . The bands definition is: Delta(1-4Hz), theta(4-8Hz), alpha(8-13Hz), beta(13-30Hz), gamma(30-45Hz). The epoch length is 1000 samples with a frequency of 500 samples/sec. which means 2" width and epoch shift of 50% (overlapping of 1"). Table I shows the results of the mean values of C3 and C4 electrodes for the cerebral palsy users. All tables and extended results can be checked at http://ugivia.uib.es/bcieeg. In order to analyze the table values we use two classification criteria: (a) decrease in alpha and increase in beta means increase in focus attention (FA); and (b) decrease in ϴ/ß ratio means increase in focus attention (FA) [3].

TABLE I
EEG MEAN VALUES FOR CEREBRAL PALSY USERS (μV^2)

Stimulus/Band	alfa	beta	theta	ϴ/ß	Video Info
Initial Base Line	1,57	1,41	6,97	4,95	mesaje
Stimulus 1	1,38	1,44	6,51	4,51	calm, no sound
Black 1-2	1,47	1,38	7,18	5,22	no stimulus
Stimulus 2	1,19	1,30	5,53	4,27	speed, no sound
Black 2-3	1,25	1,50	6,53	4,36	no stimulus
Stimulus 3	1,01	1,39	4,56	3,29	calm, sea sound
Black 3-4	1,15	1,36	4,12	3,03	no stimulus
Stimulus 4	0,82	1,25	4,18	3,33	soft music
Black 4-5	1,09	1,16	3,45	2,97	no stimulus
Stimulus 5	0,90	1,29	5,32	4,13	strident music
Final Base Line	0,88	1,41	4,70	3,33	mesaje

Therefore we can conclude that the best stimulus for FA improvement in PC users is soft music. In control users we have the same values, the main difference is that CU have much more higher values than CP users. Moreover the ratio ϴ/ß in CU are in the range of standard values (1,98-3,23). On the contrary in CP users values are higher (2,97-5,22), similarly to ADHD children. The lower ratio ϴ/ß value in CP users is just after soft music stimulus.

IV. CONCLUSIONS

A system based on the combination of EEG brain wave recording and attention assessment playing with a SG has been proposed. The main information considered is the values of alpha and theta/beta ratio. We have applied this study to CP children and control users in order to assess the differences. The study is divided in two phases. The first one presents a video in order to determine the suitable set of stimulus to be selected. The second phase proposes a SG based in the resolution of a videogame labyrinth. The results of the first phase are currently under evaluation. The main considerations for this preliminary study are: (1) users with CP have lower power band values; (2) the ratio ϴ/ß is abnormally higher, similar to ADHD children; (3) the best stimulus is soft music because the ratio ϴ/ß has the lowest value. Future efforts will be devoted to analyze in detail the acoustic stimulation (different types of frequency values) and apply these specific stimuli to improve the performance in solving the labyrinth videogame.

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