A Pilot Panel Study in User-centered Design and Evaluation of Real-time Adaptable Emotional Virtual Environments

Valeria Carofiglio, Nicola Gallo and Fabio Abbattista
Dipartimento di Informatica, Universita' di Bari, Bari, Italy

Keywords: Brain-computer Interface, Emotional Adaptable Virtual Environments.

Abstract: User-centered evaluation (UCE) is an essential component of developing any interactive application. Usability, perceived usefulness and appropriateness of adaptation are the three most commonly assessed variables of the users' experience. However, in order to validate a design, the new interaction paradigms encourage to explore new variables for accounting the users' need and preferences. This is especially important for applications as complex and innovative as Adaptable Virtual Environments (AVE). In this context, a good design should manage the user's emotional level as a UCE activity, to obtain a more engaging overall user's experience. In this work we overcome the weaknesses of traditional methods by employing a Brain Computer Interface (BCI) to collect additional information on user's needs and preferences. A pilot study is conducted for determining if (i) the BCI is a suitable technique to evaluate the emotional experience of AVE's users and (ii) the contents of a given AVE could be improved in order to result in high subject agreement in terms of elicited emotion.

1 INTRODUCTION

User-based evaluation is an essential component of developing any interactive application and it is especially important for applications as Adaptable Virtual Environments (AVE). Classical usability studies are based on functional task, we focus on fostering a more engaging overall experience by exploiting the user's emotional level as powerful engine in the interaction experience (Emotional Adaptable Virtual Environment – EAVE).

Traditional methods for assessing the user experience, such as self-report or interviews, are not ideal within EAVE because they rely either on sampling approaches or the users' perception of the environment. Also methods for capturing the interaction experience in an unconscious and continuous approach (e.g. log experience) may be troublesome, as they do not collect subjective feedback from (potential) users. The field of Brain Computer Interface (BCI) (van Gerven et al., 2009) has recently witnessed an explosion of systems for studying human *emotion by the acquisition and processing of physiological signals(*Bang and Kim, 2004). A BCI is a direct communication pathway between the brain and an external device. Several researchers (Murugappan et al., 2007), (Bos, 2006) have shown that it is possible to extract emotional cues from electroencephalography (EEG) measurements, which become a way to investigate the emotional activity of a subject beyond his conscious and controllable behaviours. An important distinction is made between two dimensions of emotion: The valence (from negative to positive) and the arousal (from calm to excited) (Russell, 2003). Researchers have investigated how changes along these two dimensions modulate the EEG signals and have determined that the position of an emotion in this two dimensional planes can be derived from EEG data (Chanel et al., 2006), (Heller et al., 1997).

By viewing serious games as one of the most representative examples of EAVE, but also as elicitors of complex user emotion synthesis, we explore on going research on successful realization of *affective loop*, in which "*the system should involve users in an emotional, physical interactional process*" (Leite et al., 2010). To achieve a good design, the phases of *emotion elicitation*, a*ffective detection and modeling* and *affect driven system adaptation are critical.* In this view, we propose a user centered approach to design and support the emotional user experience within EAVE, which will be based on standard BCI. The expected result is a

Carofiglio V., Gallo N. and Abbattista F..
A Pilot Panel Study in User-centered Design and Evaluation of Real-time Adaptable Emotional Virtual Environments.
DOI: 10.5220/0003975500670071
In *Proceedings of the 14th International Conference on Enterprise Information Systems* (ICEIS-2012), pages 67-71
ISBN: 978-989-8565-12-9

dynamic increase of the interaction's customization and therefore an improvement of the user's engagement, focusing on how self-induced emotions could be utilized in a BCI paradigm (real-time data processing).

In this view, the real-time acquisition of information about the emotional state of the user provided by the system should be used to adapt the characteristics of the interaction: That should give the chance of better reaching the intended emotional effects on each individual user. In this paper we conduct a BCI-based pilot study for determining if the contents of a given AVE (see section 4 for more details) could result in high subject agreement in terms of elicited emotion.

2 MEASURING EMOTIONS BY BCI

Emotions are a really complex phenomenon, so there is no universal method to measure them. Methods may be categorized into subjective and objective ones. Questionnaires or picture tools (Self-Assessment Mainkin (SAM) (Bradley and Lang, 1994) or the Affect grid (Russell et al., 1989)) could be used as self-report instruments. Objective methods use physiological cues derived from the theories of emotions which define universal pattern of autonomic and central nervous system responses related to the experience of emotions. Other modalities used for measuring emotions include blood pressure, heart rate, respiration. This paper exploits emotion assessment via EEG.

A BCI records human activity in form of electrical potentials (EPs), through multiple electrodes that are placed on the scalp. Depending on the brain activity, distinctive known patterns in the EEG appear. To account for user emotional state during BCI operation, most of the literature suggests an exhaustive training of the BCI classification algorithm under various emotional states: In the general approach the user is exposed to an opportune affective stimulation. The type of mental activity elicited is then processed to obtain features that could be grouped into features vectors. Such features vectors are then used to train the BCI classification algorithm, which can then recognize the relevant brain activity.

If a passive BCI is employed, as in our case, active user involvement is not required. The interpretation of his/her mental state could be a source of control to the automatic system adaptation (from the application interface to the virtual environment), for example in order to motivate and involve him/her by the application feedback.

3 EMOTIONAL RECOGNITION BY Emotiv^{tm} EPOC

Emotiv^{TM} Epoc (http://www.emotiv.com), is a high-resolution, low-cost, easy to use neuroheadset developed for games. Based on the International 10-20 locations, it captures neural activity using 14 dry electrodes (AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4) plus CMS/DRL references, P3/P4 locations). The headset samples all channels at 128Hz, each sample being a 14 bit value corresponding to the voltage of a single electrode.

Directly based on the user's brain activity, Emotiv^{TM} Epoc reads different emotion-related measures. Among the other, the *Instantaneous Excitement* (IE) *and the Long term Excitement* (LTE). The first is experienced as an awareness or feeling of physiological arousal with a positive value. It is tuned to provide output scores that more accurately reflect short-term changes in excitement over time periods as short as several seconds; LTE is experienced and defined in the same way as IE, but the detection is designed and tuned to be more accurate when measuring changes in excitement over longer time periods, typically measured in minutes. Both these measures are time-independent: At each arousal variation the IE and LTE are detected.

4 THE ADAPTABLE VIRTUAL ENVIRONMENT

Some application require detection of and management of user's emotions to provide an appropriate user experience or even to avoid psychological harm. As main example of this kind of application, we consider a Nazi extermination camp. Moreover, sooner the only way to preserve the remembrance of that terrible historical period will entrusted on indirect documentation in the form of videos, images and texts reporting interviews to last witnesses. A way to maintaining alive the dramatic meaning of that experience could be to reconstruct a 3D virtual environment of one of those camps, such as Auschwitz.

In our VE a digital character representing a prisoner guides users through different parts of the camp. During the navigation, the VE activates links to videos, photos documenting the Jewish and Gipsy's lifestyle in the 1940-1945 period, or plays songs that some prisoners composed during their permanence. By means of the BCI we aim at capturing the user' reaction to presented contents in order to allow the virtual prisoner to dynamically adapt the visit to the user profile, choosing to avoid some media judged too upsetting for the users sensibility or visiting only some zones of the entire virtual world, in order to maintain the current user's emotive state or to induce a desired one. In this way users could be guided along well defined emotional and informative paths.

Our virtual environment has been interfaced with the Emotiv™ Epoc headset (see Figure 1). The headset detect the EEG signal of the user and pre-process them, by means of some C# script:

- A script manages the connection between the headset and the virtual environment.
- Another script receives and saves user’s affective values, i.e. long-term excitement and instantaneous excitement.
- A third script detects user’s head movements to adjust the camera perspective.

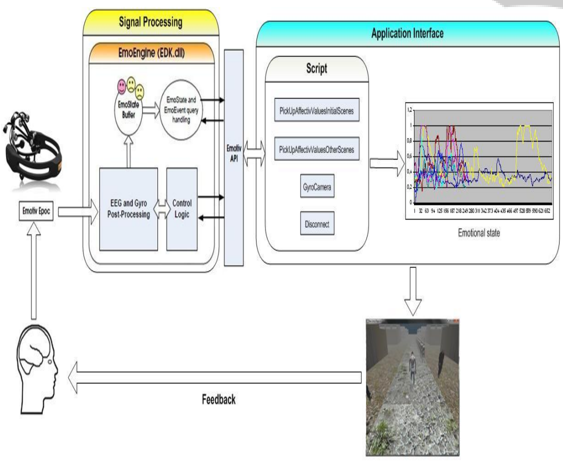

Figure 1: Functional model of the employed BCI.

5 EXPERIMENTAL RESULTS

As stated, in choosing the scenario we avoided scenes that could objectively induce psychological harm. As a consequence, in order to avoid the lack of reaction to the selected scenes, the subject who took part to the experiments were chosen on the base of their knowledge about the domain, avoiding people who reported a strong knowledge of the domain. Moreover, all subjects were preventively informed about the details of the experiment, and only those who have deliberately declared its intention to participate in the experiment were taken into account.

Eight different subjects interacted with the 3D environment (50% males and 50% females). Concerning the age distribution, 25% ranged between 18 and 25 years old; 12,5% ranged between 26 and 35 years old and 62% aged more than 46 years old. Each experimental session lasted about 13 minutes.

The environment includes 8 different scenes; among these, six scenes contain historical multimedia documentation; the remaining two include only the 3D reconstruction of the camp. At the end of the interaction each user answered a self-assessment questionnaire (see Appendix).

The goals of the experiment were to evaluate several different factors concerning the emotional experience of users interacting with our 3D environment:

1. How much the 3D environment is inherently emotive. For each user, we measured the global emotional response due to the whole interaction process, by:
   - A subjective evaluation: Analysis of the user response to the questionnaire;
   - An objective evaluation: Analysis of the recorded user EEG signal;
   - Comparing the two previous analysis to evaluate their consistency;
2. How much each scene contributes to the inherent emotional level of the 3D environment, by analyzing the EEG signals of each user for each scene and by measuring the average IE and LTE;
3. How much the multimedia content of each scene contributes to the emotional response with respect to the scenes not enriched with multimedia contents.

Concerning the first question, experimental data show that 75% of the users claimed they felt different levels of sadness, while 25% felt both anger and fear (see Table 1). The values are moderately low but the coherency between both IE and LTE values indicates that a user emotional response actually occurred.

What about the contribution of each scene?

From Figures 2 and 3, it could be noted that the scene with higher average IE value is the scene 6, a scene lacking multimedia content, but the scene 7 has the higher average LTE value, and this means that users were very involved during all (or most of) the scene.

Table 1: Average IE and LTE values wrt. users' declared emotions.

	Avg IE values	Avg LTE values	User Emotional Response (as declared)
User 1	0.343	0.338	Sadness (4)
User 2	0.543	0.535	Sadness (4)
User 3	0.411	0.402	Sadness (3)
User 4	0.368	0.360	Sadness (6)
User 5	0.467	0.458	Anger (5)
User 6	0.369	0.375	Sadness (4)
User 7	0.463	0.458	Fear (5)
User 8	0.447	0.438	Sadness (5)

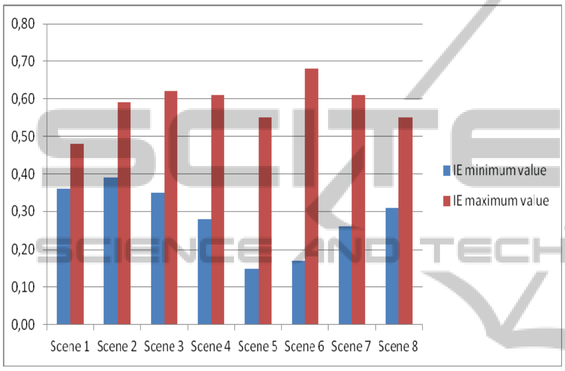

Figure 2: Minimum and maximum average IE values for each scene.

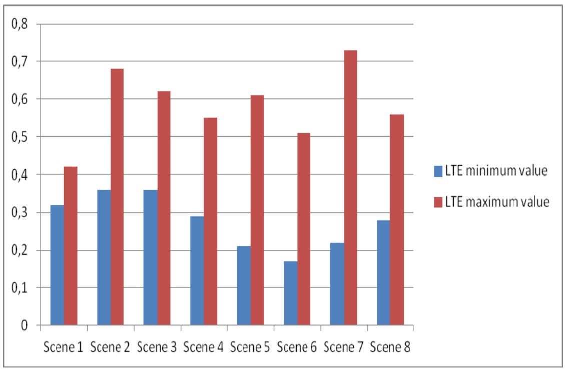

Figure 3: Minimum and maximum average LTE values for each scene.

Finally, we tried to discover if the multimedia contents contribute to the emotional response of the users. Tables 2 shows, for each user, the scene(s) with, respectively, IE and LTE greater than the two scenes with no multimedia contents. The EEG signals detected indicate that 62.5% of the users consider the scenes with multimedia contents more emotionally engaging than the other two scenes (Table 2.a); for 85% of the users the emotional engagement of the scenes with multimedia contents has a longer duration (Table 2.b).

Table 2: Number of scene with multimedia content with greater IE value (a) and greater LTE value (b) wrt the two scene without multimedia content (A zero in the cell indicates that the scene corresponding to the column has an higher IE/LTE value).

(a)	Scene 4	Scene 6
User 1	0	5
User 2	0	0
User 3	3	3
User 4	6	2
User 5	4	2
User 6	0	0
User 7	4	6
User 8	4	0

(b)	Scene 4	Scene 6
User 1	0	6
User 2	4	5
User 3	3	2
User 4	5	3
User 5	1	1
User 6	3	3
User 7	4	5
User 8	2	0

6 CONCLUSIONS

The main idea behind this research was that a good design should manage the user's emotional level as a UCE activity, to obtain a more engaging overall user's experience. To this aim, we employed a BCI to collect additional information on user's needs and preferences without questioning the user itself. This enables a faster collection process avoiding mistakes due to the user misbehaviour. Preliminary results show that our method allows to identify which application's contents do not induce an appropriate emotional response. In this way the designer could delete scenes or multimedia contents if they result in low subject agreement in terms of elicited emotion and replace them with more engaging contents. However, widening the number of experimental subjects or choosing them with given personal characteristics is necessary.

Concurrently, the design and building of the adaptive virtual environment module should be considered. The expected application should be able to choose the proper multimedia content by avoiding some media judged too upsetting for the users sensibility and/or by hiding some zones of the virtual world, in order to induce a desired user's emotional state. In this way users could be implicitly guided along well defined emotional and informative paths.

REFERENCES

van Gerven, M., Farquhar, J., Schaefer, R., Vlek, R., Geuze, J., Nijholt, A., Ramsey, N., Haselager, P., Vuurpijl, L., Gielen, S., Desain, P.: The brain-computer interface cycle. *Journal of Neural Engineering* 6(4), 041001 (2009).

Kim, K. H, Bang, S. W. and S. R. Kim. Emotion recognition system using short term monitoring of physiological signals. *Medical and Biological Engineering and Computing*, (2004) 42:419 427.

Murugappan, M., Rizon, M., Nagarajan R., Yaacob, S., Zunaidi I., and Hazry, D. EEG feature extraction for classifying emotions using FCM and FKM. In *Proc. Of ACACO*. China. 2007

Bos., D. O. *EEG-based Emotion Recognition: the influence of visual and auditory stimuli*, Nederland, 11-16-2006.

Russell, J. A. Core affect and the psychological construction of emotion. *Psychological Review* (2003). 110:145-172.

Chanel, G. Kronegg, J., Grandjean, D. and Pun., T. Emotion assessment: Arousal evaluation using EEG's and peripheral physiological signals. *Technical Report 05.02, Computer Vision Group, Computing Science Center*, University of Geneva, 2005.

Heller, W., Nitschke, J. B. and Lindsay, D. L. Neuropsychological correlates of arousal in self-reported emotion. *Neuroscience letters*, 11(4):383 402, 1997.

Leite, I., Pereira, A., Mascarenhas, S., Castellano, G., Martinho, C., Prada, R., Paiva, A.: Closing the loop: from affect recognition to empathic interaction. In: *Proceedings of the 3rd international workshop on Affective interaction in natural environments*. pp. 43–48. AFFINE '10, ACM, New York, NY, USA (2010)

Bradley, M. M., Lang, P. J., *Behavioral Therapy and Experimental Psychiatry*, Vol. 25, No. 1. (1994). pp. 49-59.

Russell, J. A., Weiss, A., Mendelsohn, G. A.. Affect Grid: A single-item scale of pleasure and arousal. *Journal of Personality and Social Psychology*, Vol. 57, No. 3. (September 1989), pp. 493-502.

APPENDIX

The figure below shows the timeline of each experimental session. The environment includes 8 different scenes; among these, six scenes contain historical multimedia documentation; the remaining two include only the 3D reconstruction of the camp. At the end of the interaction each user answered a self-assessment questionnaire.