Rules of Engagement: Brain-Computer Interfaces for Military Training

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Abstract. Simulation based training systems execute our 'intention to perform' an action in computer space by means of intermediary physical manipulations, such as pressing keys or directing a joystick. Transferring actions through these traditional input devices place an intermediary between the human operator and the simulation that can negatively affect user performance. To eliminate some of these bottlenecks, we explore the use of brain-computer interface techniques to improve the naturalistic interactivity within a military gaming environment using Second Life. We used a P300 speller approach to map action codes of the game to user actions (e.g., walk or run) within the environment. We report on the results of the study as well as discuss implications for future use of hybrid brain-computer interfaces as part of naturalistic interaction schemas for military training.

Keywords: Simulation Based Training, Serious Games, P300, Active BCI, Reactive BCI, brain states.

1 Introduction

Brain Computer Interfaces (BCIs) afford the possibility of removing the computer interface-as-middleman in both gaming and virtual reality contexts [1]. A typical BCI system consists of three processing modules: 1) a brain activity-monitoring device (EEG or fNIRs) that records brain activity, 2) a signal-processing module that identifies specific brain patterns or features related to a person's intention to initiate action, 3) and a translator that converts these brain features into meaningful control commands [2]. Electrophysiological sources of control (ESC) are the mental activities and their associated EEG measures that become the control mechanism that perform actions within a given application. ESC are currently elicited in an active (user conscious control without external stimulation), a reactive (external stimuli elicits user brain response), or a passive (brain activity associate with a cognitive state drives system change) manner. The feature vector represents the ESC and once translated into commands becomes the trigger for action in the application.

For use within military applications, each module of the BCI processing loop needs modification. For example, neurosensing devices should be lightweight, portable,

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ruggedized, and wireless with low battery requirements. Signal processing methods should account for motion artifacts and identify more robust brain signatures that are not solely motor cortex dependent. Additionally, translating neural commands into action within the simulator should be direct and not require traditional interaction schemas (e.g., emulating button presses).

Low cost BCI solutions are making their way to the consumer through the gamming community. Products such as the Emotiv EPOC (http://www.emotiv.com) and NeuroSky Mindset (http://www.neurosky.com) sell for less than 300 US dollars and provide a wireless lightweight BCI solution for gaming platforms. While inexpensive and wireless, these BCI systems limit the user's capability of creating new EEG channel configurations and translation algorithms, which in turn affects the generalizability and extensibility of the interface when moving from pre-defined gaming interaction schemas to non-linear simulations that models real life [3]. As well, researchers estimate that 50% of the end user populations will not be able to use such devices without taking into account individual differences [4].

Pfurtscheller and fellow BCI researchers suggest that a hybrid approach to BCIs using two different brain signals (e.g. EEG and fNIR) or one brain signal in combination with other physiological signals (e.g., heart rate or eyegaze) should address the issues of generalizability and individual differences [5]. This convergent approach of using multiple sensors to detect a user's intention to act is consistent with the adaptive training systems literature where EEG and other psychophysiological measures such as heart rate improve cognitive state detection [6]. In an effort to explore hybrid BCI solutions for military serious training games, we used a P300 speller approach to map the gaming action codes to the ESCs within the 3D virtual world Second Life.

2 Materials and Methods

The 3D virtual world Second Life provided the testing environment for this phase of the research. We implemented a P300 speller paradigm using BCI2000 software to map Second Life interaction codes for moving an avatar forward and backward while walking or running. We acquired brain activity data needed for extracting relevant BCI features using a 10 channel EEG with EKG system made by Advanced Brain Monitoring (ABM, advancedbrainmonitoring.com) for a sample of 15 participants. In addition, we collected eye-tracking data for later data fusion with the BCI P300 data stream.

Participants performed tasks that required movement through the environment and interaction with other avatars and objects as related to a military task scenario. Figure 1 displays one task that required participants to walk to a helicopter, enter the aircraft, and then assume the role of pilot. The main advantage of the BCI approach was that only a single controller was necessary to switch tasks. For example, the same button commands could map from controlling the avatar to controlling the aircraft.

Fig. 1. Second Life user testing tasks for the prototype BCI

3 Results

All participants were able to navigate the 3D environment once they completed training. However, once engaged in an action (e.g., walking), participants had difficulty stopping that action to switch to a new action or task. Despite the frustration, participants reported that the use of BCI augmented their user engagement in the task and felt that the technique would be acceptable to end-users once the technique became more reliable.

4 Discussion

While the goal of this work was to assess the capability of a P300 approach as a means to more naturally interact within a 3D gaming environment. We found that there were several barriers to successful implementation. For example, very few open source BCI software integrate with all EEG manufacturers. While the ABM EEG integrates with BCI2000, there were issues in setup that would preclude a novice who would like to explore the potential use of BCI in their applied work. Once the system reliably performed, tasking issues emerged that highlight the need for improved action code mapping to ESCs for more flexible and fluid interaction within these dynamically changing training environments. Regardless of the current issues, participants reported that they would use this type of system if it became more reliable.

References

1. Lalor, E.C., Kelly, S.P., Finucane, C., Burke, R., Smith, R., Reilly, R.B., McDarby, G.: Steady-state VEP-based brain-computer interface control in an immersive 3D gaming environment. EURASIP J. Appl. Signal Processing 19, 3156–3164 (2005)
2. Wolpaw, J.R., Birbaumer, N., McFarland, D.J., Pfurtschellere, G., Vaughan, T.M.: Brain-computer interfaces for communication and control. Clinl. Neurophy. 113(6), 767–791 (2002)

3. Nijholt, A., Reuderink, B., Bos, D.O.: Turning shortcomings into challenges: Brain-computer interfaces for games. In: Nijholt, A., Reidsma, D., Hondorp, H. (eds.) INTETAIN 2009. LNICST, vol. 9, pp. 153–168. Springer, Heidelberg (2009)
4. Popescu, F., Blankertz, B., Müller, K.: Computational challenges for noninvasive brain computer interfaces. IEEE Intelligent Systems, 78–79 (2008)
5. Pfurtscheller, G., Allison, B.Z., Brunner, C., Bauernfeind, G., Solis-Escalante, T., Scherer, R., Zander, T.O., Mueller-Putz, G., Neuper, C., Birbaumer, N.: The hybrid BCI. Front. Neurosci. 4, 42 (2010)
6. Vartak, A.A., Fidopiastis, C.M., Nicholson, D.M., Mikhael, W.B., Schmorrow, D.: Cognitive state estimation for adaptive learning systems using wearable psychophysiological measures. Biosignals 2, 147–152 (2008)