BCI Gaming

Brain activity as an additional game input modality

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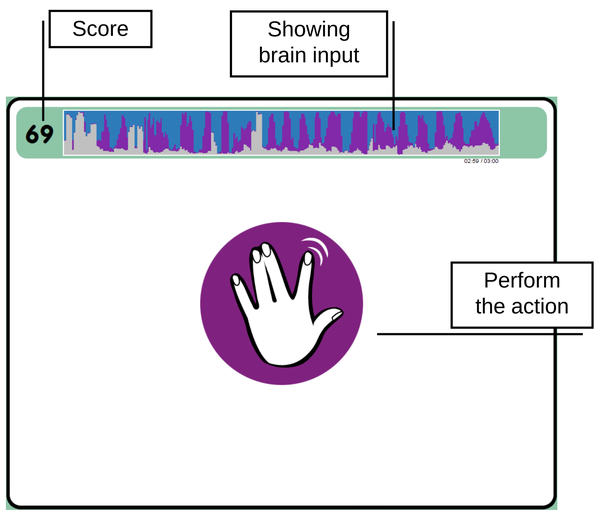
BrainBasher

Brain-Computer Interaction (BCI) is steadily gaining more and more interest in real life applications. The Human Media Interaction (HMI) group at the University of Twente has fairly recently (in 2007) started conducting research in the area of BCI. The focus of our group is applying BCI for use by the general population, in games in particular.

To this extent, *BrainBasher* was developed which you control with your brain. The goal is to perform specific brain actions as quickly as possible. For each correct and detected action you score a point.



game session

Game control can be achieved by different mental tasks: for example imaginary hand movements, but there are more possibilities.

Actual or Imagined Movement?

Most previous research in BCI focused on classifying imagined movement for improving Quality of Life of locked-in patients. At HMI however our research is aimed at healthy users. So why don't we use actual movement?
The possible advantages:

- Stronger activity in the brains leads to better recognition of the actions
- Performing actual movement is more intuitive than imagined movement
- The two previous points lead to a different (possibly better) User eXperience (UX).

Methods

We addressed these issues by conducting an experiment in which we asked users to do two sessions with BrainBasher. One session with imagined movement, one completely using actual movement. The experiments were conducted with 20 participants of which 10 were female.

BrainBasher yields a Cross Validation error which characterizes the ability to recognize a user's actions.
To evaluate the UX a post game questionnaire was developed based on the Game Experience Questionnaire (GEQ) from the Eindhoven Game Experience Lab. The questionnaire consisted of different scales on which both movement modalities could be compared.

Results

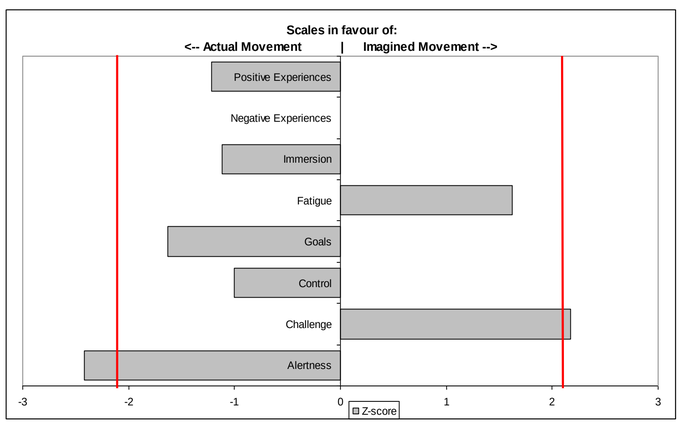
The developed questionnaire proved to be a good instrument with useful scales to compare differences in UX for BCI games.

Comparison of UX in both kinds of movement showed significant results in the Challenge scale (p=0.04) and in the Alertness scale (p=0.03). Users find it more challenging to perform imagined movement. At the same time they are less focused. Actual movement seems to keep alertness at a higher level.

BrainBasher (continued)

"9.3% better"

Comparison of the Cross Validation error yielded a significant difference in favour of actual movement which indicates that this kind of movement is better recognizable. On average actual movement recognition is 9.3% better than imagined movement.



Conclusions

Actual movement can be used as an input modality for games and is more reliable than imagined movement. Users also stay more alert and focussed when actual movement. On the other hand imagined movement is more challenging, probably because it is harder to do.

Publications

[1] B. L. A. van de Laar. D. Oude Bos, B. Reuderink and D. Heylen. "Actual and Imagined Movement in BCI Gaming" Proceedings of AISB'09

[2] D. Oude Bos, B. Reuderink "BrainBasher: a BCI Game"In: *Extended Abstracts of the International Conference on Fun and Games 2008*, 20 October 2008, Demo Paper.

Focus of BCI research @ HMI

To enable use of BCI by the general population, BCI needs to be taken out of the highly-controlled laboratory environments and into the real world. Testing BCI games in more realistic environments will highlight many unresolved issues.

Intuitive Interaction The mapping of a BCI paradigm to a particular task should be intuitive and natural to the user, as this will increase (or maintain) the immersion. This intuitive quality also makes it easier to learn and remember the mental tasks available within the application.

Fusion and Artifacts In a real-world situation, people will talk and move during game-play. This results in artifacts in the recorded brain activity. One can decide to remove the artifacts, or use them as an additional source of information. Apart from combining with other modalities, there is also the question of what BCI paradigms may be used simultaneously.

"Give feedback quickly for more natural interaction"

Transfer Rate The information transfer rate attainable with EEG is not comparable to classical input methods. Our aim is then not to replace those existing methods, but to improve the interaction experience. Still, it is important to use fast processing methods in order to give feedback quickly, for more natural interaction.

Training In most BCI systems, both the user and the system learn to achieve an optimal performance. Usually a training period is required to provide initial detection. This training period should be short, and preferably part of the game itself.

Affective Computing BCI can also be used to create computers that react on the emotion of a user. Recognizing an emotion is still new field within BCI but offers a broad spectrum of possibilities for affective computers.

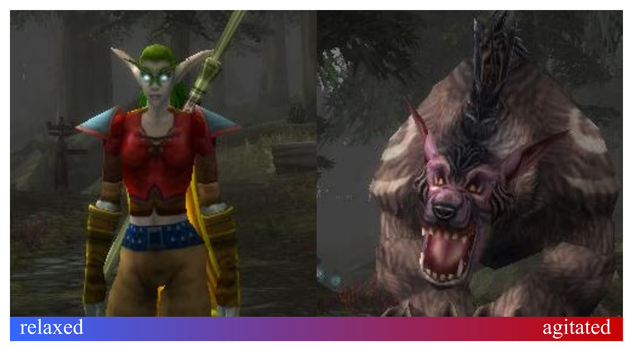
World of Warcraft

This research will focus mainly on *intuitive interaction*, *fusion* with classical input modalities (mouse and keyboard) and using multiple BCI paradigms simultaneously, plus the influence of all of these elements on the *user experience* within the uncontrolled environment of a popular game.

> *"Any sufficiently advanced technology is indistinguishable from magic"*
>
> *Arthur C. Clarke*

Shape shifting

Based on the level of relaxation or agitation, the user can move from one mode of game play (spell-casting) to another (direct combat). While using conventional means would break immersion, this could actually be a more 'realistic' approach (from the point of view of the game world).



Alpha activity

The level of relaxation is based on the amount of alpha wave activity present in the user's brain. This is measured by calculating the band power between 8 and 13 Hz behind the centre of the scalp. (Sensor Pz in the 10-20 system.)

According to various sources the amount of alpha activity is correlated to the level of relaxation or agitation.

Elf or Bear?

When getting more aggressive the user will notice a red indication at the sides of the screen. If the level of aggression is high enough for a defined period of time the avatar in WoW will shape shift into a bear. When the user is relaxing, the user will be notified by a blue indication at the edge of the screen and the avatar will shift back to his normal elfish form.

This is meant as an intuitive mapping of the user's mental state to the in-game action.

Features for the Future

Background Music

The affective state of the user could influence the background music to increase immersion.

Spell Casting

A higher level of concentration could result in more effective (higher level) spells being used. Spell selection requires new BCI paradigms for natural interaction.

Hand-to-hand Combat

Actual or imagined movements could be mapped onto special moves that can be performed in hand-to-hand combat.

Fishing

In the game it is possible to fish. The user looks at the bobber and when it bounces with a splash sound, reels in the catch. As this is a rare and task-relevant event, it could be opportunity of looking into single-trial P300 detection

Further Reading

A. Lécuyer, F. Lotte, R. Reilly, R. Leeb, M. Hirose, M. Slater, "*Brain-Computer Interfaces, Virtual Reality, and Videogames*", IEEE Computer, Vol 41, Num 10, pp. 66-72, 2008

A. Nijholt, D. Tan, G. Pfurtscheller, C. Brunner, J. del R. Millan, et al., *Brain-Computer Interfacing for Intelligent Systems.* IEEE Intelligent Systems, 23 (3). pp. 72-79. 2008. ISSN 1541-1672