(Serious) Gaming and Brain-Computer Interfacing: New Developments

Anton Nijholt
Human Media Interaction
University of Twente, Enschede, The Netherlands
& EU project BNCI Horizon 2020 (2013-2015)

Entertainment vs Serious games?

- Entertainment games
  - Play, challenges, cooperation, competition, communication, decision-making, skills, learning, ...
- Edutainment games
  - Explicit learning goals
- Serious games
  - Game designed for a primary purpose other than pure entertainment
  - Simulations of realistic situations, training, safe failures

Computer-based

- Computer-based simulations
  - Fantasy worlds
  - Real worlds

- From videogames to physical environments equipped with sensors and actuators to immersive virtual reality environments
What can BCI add?

- Entertainment, Edutainment, Serious Games
  - Balancing challenges and skills
    - Measuring attention, engagement, frustration, focus, workload, ...
      - Game design
      - Real-time game adaptation
  - Introducing new challenges in game control
    - New interaction modalities -> new game concepts

- But, seriously ....

Medical EEG-based Serious Games

- Neurofeedback games
  - enhancement of attention and cognitive skills
  - therapies for psychological disorders: ADHD, ASD, GAD, SUD, ....

- BCI games for rehabilitation exercises
  - retain motor control
  - Example: Brain-Kinect interface

Brain Kinect Rehabilitation

**BKI: Brain Kinect Interface, a new hybrid BCI for rehabilitation**

Commercial Brain-Body games

- Brain trainers
  - Left Brain Right Brain
- Body and brain
  - Kinect + Xbox
Serious Games?

- Observation 1: Many authors use the term ‘serious game’ rather than ‘game’, while ….
- Observation 2: BCI does not always add
  Serious game: Rome Reborn
  - Teaching history
  - Navigate avatar through ancient Rome using BCI
  - Control a serious game. Impact on learning? Not investigated.

Developments in BCI Games

And some History

BCI for Games

‘One Trick’
Only Games

Pong
Tetris
Pinball
Brain ball
Mind
Balance
......
MindFlex

BCI for Games

Multimodal Game

- Becoming angry/acting angry
- Becoming relaxed/acting relaxed

Embed BCI in an existing commercial game
Multimodal & Multiplayer

Social interaction between players

Multimodal, Multiplayer, but ....

- Physiologically Modulated Videogame (FPS)
- Controller: Wii Zapper
- Competition/Collaboration

NASA: Interpersonal interactions may be mixes of competition and cooperation for simulation training
BCI for Games

**BrainPong**
- Multiplayer

**BrainBall**
- Competition, Collaboration
- Fusion
- **MultiBrain**

Back in Time
MultiBrain
Early History

**Early History: Rosenboom**
Mike Douglas
Show, 1972

**Early History: Sobell**
Brainwave Drawing Game
Nina Sobell, 1972-1975

Superimpose visualized brain wave synchronicity on the image of the two participants (Lissajous visualization)
Early History: Humbert

- Alpha Garden
- Jacqueline Humbert, April 1973

A synchrony detector triggers the opening of a solenoid valve, thereby controlling the flow of water through a garden hose and lawn sprinkler system.

More Recent Examples

Competition/Collaboration
Integration of brain activities

MultiBrain BCI: Observations

Mind the Sheep!
- No fusion
- MultiBrain?
- Social
- Strategy
- Feedback
- Collaboration
- Competition

BrainPong
- Competition
- No fusion
- MultiBrain?
- No competition about control
MultiBrain BCI: Observations

Brainball
- Competition
- Collaboration
- Fusion
- Feedback
- MultiBrain

BrainArena
- Motor imagery
- MultiBrain
- Fusion
- Competitive/collaborative mode
- Joint visual feedback

MoodMixer
- Sonification
- Visualization
- Relaxation/Focus
- Multibrain

DECONcert1 (2003)
- 48 people's EEG signals
- Collected, averaged
- Alpha synchronization
- Control a soundscape
- Collaborative feedback
MultiBrain BCI: Observations

Multimodal Brain Orchestra
- 4 performers + conductor
- P300 and SSVEP to trigger sound events and modulate the music
- Conductor decides about when, what and how (human fusion)

Two competing teams using BCI: blue team (left) versus red team (right).

MultiBrain BCI: Observations

Serious and Entertainment Games

Team Tasks & Team Performance
- Assess team performance, rearrange tasks
- On-line collaborative decision making in a target decision task
- Team collaboration in movement planning

Research efforts for each of these tasks can be found in the BCI literature

With a Little Help from ...
Stylish Devices ...

Emotiv Epoc, Emotiv Insight, Google Glasses, Oculus Rift, ...

More Stylish Devices ...

This Gaming Headset Shoots Electricity Into Your Brain. Seriously

... and Less Stylish Devices

High resolution tCS with simultaneous EEG monitoring (available from StarLabs)

... for Future Games

University of Washington
Conclusions

• BCI gets more embedded in ‘natural’ situations and applications
  – Multimodal, Multi-party, MultiBrain
  – MultiBrain BCI has become a research area
• Joint development of serious and entertainment games
• Further development of commercial BCI devices and integration with other devices

References


Why Games?

• Why look at BCI in games?
  – Economic importance
  – Games can be designed for health & education & safety & management (serious games)
  – New types of games, new types of users
  – Test ground for BCI for home and professional applications
  – Interesting design challenges: turning shortcomings into game challenges
  – Gamers are early adopters/large market
MultiBrain: Early History

- Ecology of the Skin
  - Rosenboom, 1971, music control, 10 participants

- Brainwave Drawing Game
  - Sobel, 1972-1975, superimpose visualized brain wave synchronicity on the image of the two participants

- Brainwave Etch-a-Sketch
  - Humbert, 1974, two participants control horizontal or vertical movements of a dot on a screen