Hybrid Control and Game Design for BCI-integrated Action FPS Game

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Supachai Tengtrakul

EDUCATION

- Studying master degree, computer engineering, Chulalongkorn University (CU)
- Bachelor degree, computer engineering, CU, 1st class honors

EXPERIENCE

- >1 year of experience as a game developer
BCI games can be used as a rehabilitation tool [1].

improve attention & cognitive skill for healthy players [2].

Most of them are EEG-based...

**PROS**
- Safe and easy to get [3]

**CONS**
- Unreliable [4]
- Restrictive (command)
To make BCI work with games like this...

**We need hybrid BCI.**

**SSVEP**
- Found in EEG when subject focus on flickering graphic.
- Prominent in EEG, more reliable [1].

**EYE TRACKER**
- Work well with SSVEP [5].

**KEYBOARD & MOUSE**
Riemannian-based SSVEP classifier by Kalungu et al. [6]

Modified to use 2.5 seconds of signal instead of 4 as originally proposed.
1st Goal: The game must feature every kind of commands in an FPS game.

- **Movement**
- **Weapon**
- **Item & Ability**
- **Environment Interaction**
- **In-game Menu**

- Mouse & keyboard
- Automatic activation
- Pressing keyboard when looking at a specific HUD
- Closing one eye
- Focusing on a stimulus
- Looking
2\textsuperscript{nd} Goal: The game must feature mechanics to facilitate BCI that cannot be implemented with non-hybrid BCI.

- **SLOW MOTION**
- **AUTO ACTIVATION**

Reward players if they activate a command manually.
Our game...

CORE DEFENDER

Use guns and laser grid to defend the core from waves of enemies. Fire sniper rifle manually to get a bonus score.
CONTROL SCHEME

Movement

Fire assault rifle

Fire sniper rifle

Change AR mode

Aiming down sight

Use slow motion

Switch gun

Use laser grid

Fix core

Skip down time

Mouse & keyboard

Automatic activation

Pressing keyboard when looking at a specific HUD

Closing one eye (short)

Closing one eye (long)

Focusing on a stimulus (slow motion active)

Focusing on a stimulus (slow motion not active)

Looking
Stimulus Design

GAME APPROACH

- Shoot sniper rifle
- Fix core
- Skip down time

Easy to set-up | Fit with the aesthetic | Stand out from BG
Integration

Computer 1

- BCI2000
- Signal Processor (Matlab)

UDP

Computer 2

- Game (Unity)
- Keyboard & Mouse
- Tobii Eye Tracker 4C

Raw EEG Signal (g.Nautilus)

Performed on 10 male subjects. Most subjects were between 21-26, except one who was 46.

EXPERIMENT

- Calibrating & testing eye tracker
- Calibrating & testing BCI
- Play
- Questionnaire
### Calibrating & testing eye tracker

<table>
<thead>
<tr>
<th></th>
<th>Best</th>
<th>Worst</th>
<th>Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closing one eye</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>First attempt</td>
<td>100%</td>
<td>70%</td>
<td>86.5%</td>
</tr>
<tr>
<td>Avg. attempt</td>
<td>1</td>
<td>1.3</td>
<td>1.145</td>
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<tr>
<td>Other methods</td>
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<td></td>
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<tr>
<td>First attempt</td>
<td>100%</td>
<td>86.667%</td>
<td>96.333%</td>
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<tr>
<td>Avg. attempt</td>
<td>1</td>
<td>1.133</td>
<td>1.037</td>
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<tr>
<td>False Triger</td>
<td>1.961%</td>
<td>10.714%</td>
<td>4.128%</td>
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</tbody>
</table>

- Aiming down sight
- Use slow motion
- Switch gun
- Change AR mode
### Calibrating & testing BCI

**Fixed Core**
- **Manual**
  - Best: 9
  - Worst: 1
  - Avg.: 5.4
- **Fail**
  - Best: 0
  - Worst: 4
  - Avg.: 1.7
- **Delay (sec.)**
  - Best: 1.942
  - Worst: 7.85
  - Avg.: 4.064

**Skipping Down Time**
- **Manual**
  - Best: 10
  - Worst: 4
  - Avg.: 6.8
- **Fail**
  - Best: 0
  - Worst: 3
  - Avg.: 1.2
- **Delay (sec.)**
  - Best: 2.223
  - Worst: 5.078
  - Avg.: 3.229

### Shooting Sniper Rifle

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<th>Best</th>
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<td>5</td>
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<td>4.736</td>
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### Activating Laser Grid

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<td>4.9</td>
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<tr>
<td>Delay</td>
<td>1.992</td>
<td>6.7</td>
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RESULT

Calibrating & testing eye tracker

Play

AR: 277
SR: 176

60% of players use SR more than 40%

Base on Game Experience Questionnaire developed by Poels et al. [11]

<table>
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<tr>
<th>Dimension</th>
<th>Value</th>
<th>Dimension</th>
<th>Value</th>
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<tr>
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<td>Challenge</td>
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<tr>
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<td>Positive Affect</td>
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<tr>
<td>Flow</td>
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<td>Negative Affect</td>
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<tr>
<td>Tension</td>
<td>2.3</td>
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CONCLUSION

- BCI is inconsistent.
- Most players cannot close one eye easily and experience facial fatigue.
- Game features can mitigate the issue enough to make players enjoy the game.

Going forward...

Find the right signal window.
Make closing one eye not mandatory.
REFERENCES


