

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

BY Supachai Tengtrakul & Asst.Prof. Dr. Setha Pan-ngum



PRESENTED BY: Supachai Tengtrakul (Computer Engineering, Chulalongkorn University)

E-MAIL: 6170289321@student.chula.ac.th

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].



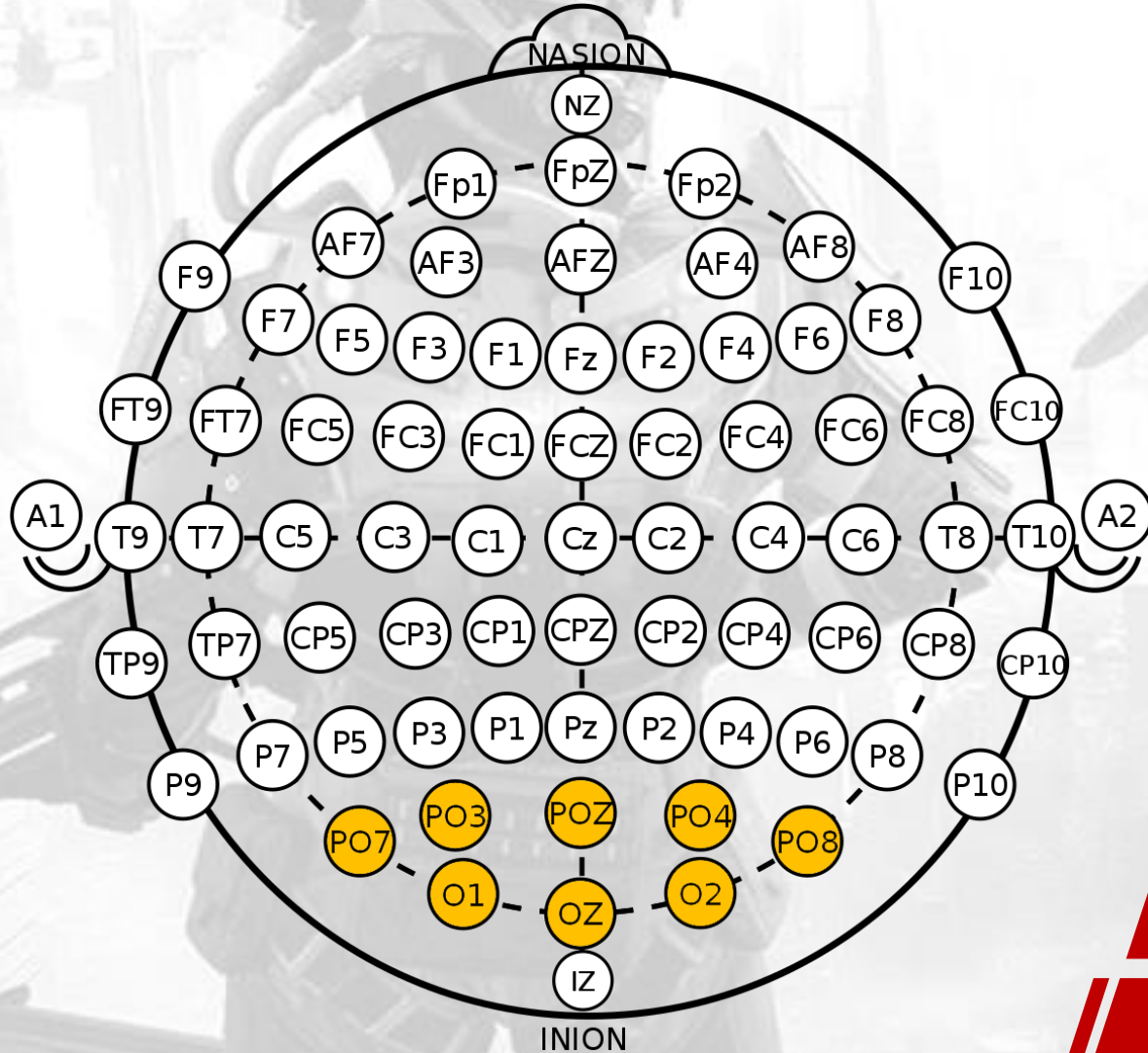
EYE TRACKER

Work well with SSVEP [5].



KEYBOARD & MOUSE





Riemannian-based SSVEP classifier by Kalunga et al. [6]

Modified to use 2.5 seconds of signal instead of 4 as originally proposed.



















G.SAHARA



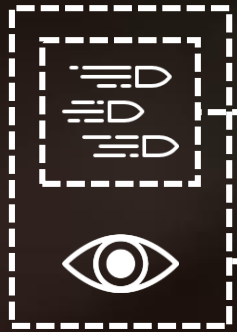
G.MOBILAB+

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

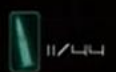
2nd Goal: The game must feature mechanics to facilitate BCI that cannot be implemented with non-hybrid BCI.



SLOW MOTION

AUTO ACTIVATION

Reward players if they activate a command manually.

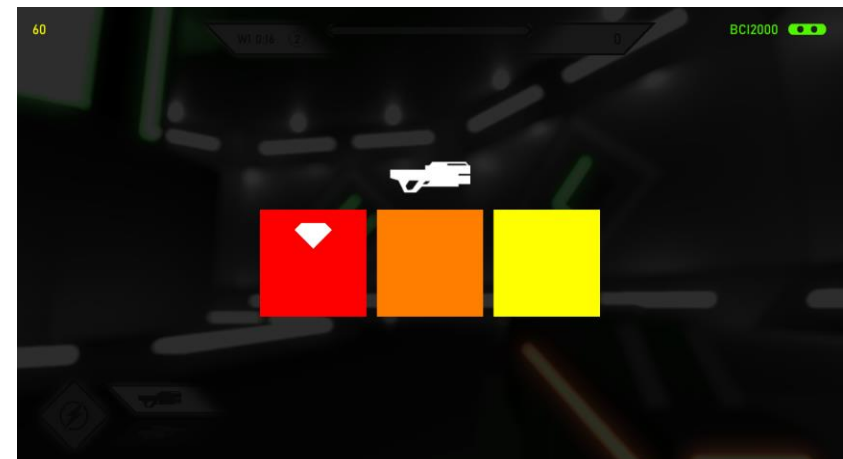
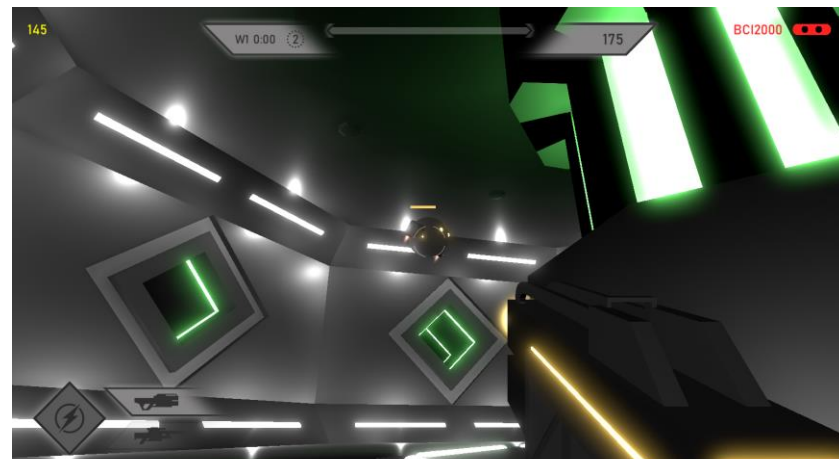
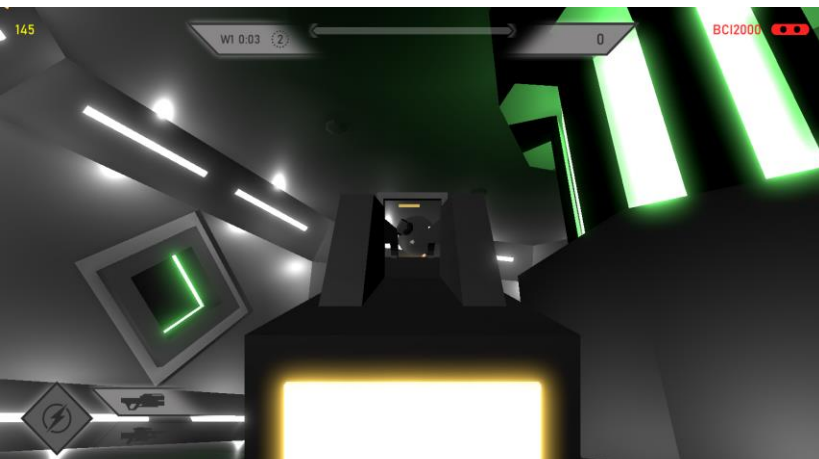




Our game...

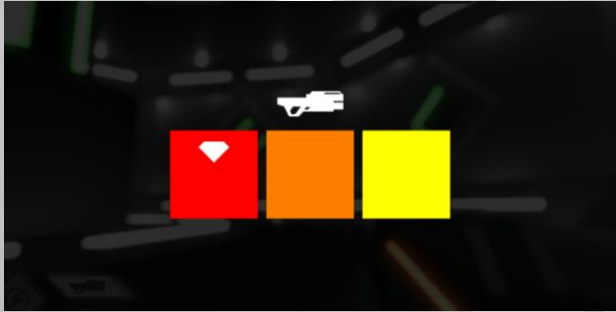
CORE DEFENDER

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



CONTROL SCHEME

W1 0:03



Movement

Fire assault rifle

Fire sniper rifle

Change AR mode

Aiming down sight









Use slow motion

Switch gun

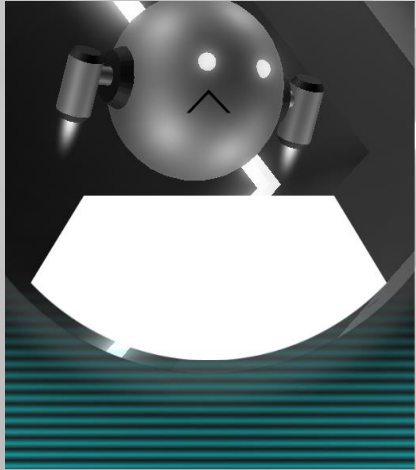
Use laser grid

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





Shoot sniper rifle



Fix core



Skip down time

15 Hz

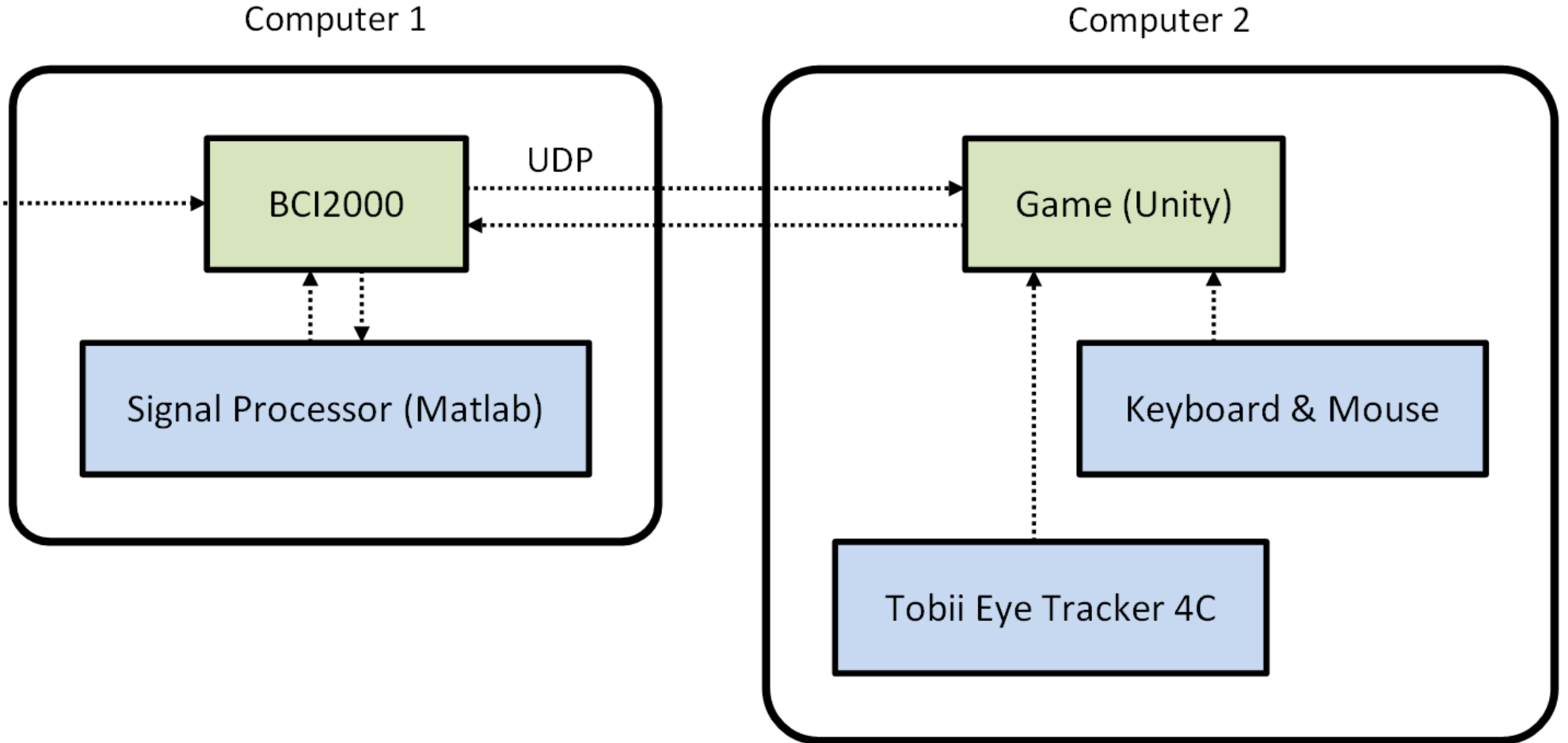


Easy to set-up | Fit with the aesthetic | Stand out from BG

Integration



Raw EEG Signal
(g.Nautilus)



EXPERIMENT

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

Calibrating & testing eye tracker



Calibrating & testing BCI



Play



Questionnaire



RESULT

Calibrating & testing eye tracker

Aiming down sight

Use slow motion

Switch gun

Change AR mode

Closing one eye

First attempt

Avg. attempt

Other methods

First attempt

Avg. attempt

False Triger

Best

Worst

Avg.

100%

1

100%

1

1.961%

70%

1.3

86.667%

1.133

10.714%

86.5%

1.145

96.333%

1.037

4.128%

RESULT

Calibrating & testing BCI

	Best	Worst	Avg.
Shooting sniper rifle			
Manual	9	5	7.1
Delay (sec.)	1.764	4.736	3.569
Activating laser grid			
Manual	9	1	4.9
Delay (sec.)	1.992	6.7	3.413

Fixing core			
< 8 sec.	9	1	5.4
Fail	0	4	1.7
Delay (sec.)	1.942	7.85	4.064
Skipping down time			
< 8 sec.	10	4	6.8
Fail	0	3	1.2
Delay (sec.)	2.223	5.078	3.229

RESULT

Play

Calibrating & testing eye tracker



AR: 277



SR: 176

60% of players use SR more than 40%

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

Competence	2.8	Challenge	3.2
Sensory & Immersion	3	Positive Affect	1.42
Flow	3	Negative Affect	2.9
Tension	2.3		

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

- [1] R. Parafita, G. Pires, U. Nunes, and M. Castelo-Branco, "A spacecraft game controlled with a brain-computer interface using SSVEP with phase tagging," 2013 IEEE 2nd International Conference on Serious Games and Applications for Health (SeGAH), Vilamoura, May 2013, pp. 1-6, doi: 10.1109/SeGAH.2013.6665309.
- [2] K. P. Thomas, A. P. Vinod, and C. Guan, "Enhancement of attention and cognitive skills using EEG based neurofeedback game," 2013 6th International IEEE/EMBS Conference on Neural Engineering (NER), San Diego, CA, Nov. 2013, pp. 21-24, doi: 10.1109/NER.2013.6695861.
- [3] M. Teplan, "Fundamental of EEG Measurement," Measurement Science Review, vol. 2, pp. 1-11, Jan. 2002.
- [4] B. Allison et al., "BCI Demographics: How Many (and What Kinds of) People Can Use an SSVEP BCI?," IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 18, no. 2, pp. 107-116, Apr. 2010, doi: 10.1109/TNSRE.2009.2039495.
- [5] B. Allison et al., "BCI Demographics: How Many (and What Kinds of) People Can Use an SSVEP BCI?," IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 18, no. 2, pp. 107-116, Apr. 2010, doi: 10.1109/TNSRE.2009.2039495.
- [6] E. K. Kalunga et al., "Online SSVEP-based BCI using Riemannian geometry," Neurocomputing, vol. 191, pp. 55-68, Feb. 2016, doi: <https://doi.org/10.1016/j.neucom.2016.01.007>.
- [7] Schalk Lab. BCI2000. Software. available: <http://bci2000.org>.
- [8] Math Works. Matlab R2018b. Software. available: <https://www.mathworks.com>.
- [9] Unity Technologies. Unity 5. Software. available: <https://unity3d.com>.
- [10] Tobii Tech. Stream Engine SDK. Software development kit. available: <https://vr.tobii.com/sdk/develop/native/stream-engine>.
- [11] K. Poels, Y. A. W. de Kort, and W. A. Ijsselstein, D3.3 : Game Experience Questionnaire (development of a self-report measure to assess the psychological impact of digital games). Eindhoven: Technische Universiteit Eindhoven, 2007.