

A Design of BCI based Environment System for Immersion of FPS Game

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Abstract

We present a methodology about BCI (brain computer interface) based environment system for immersion of FPS game play. FPS (First- person shooter) game is a video game genre centered on gun and projectile weapon-based combat through a first-person perspective, immersion is important factor in this game. FPS game designer effort to raise players immersion when make game using interface, graphic effect, sound etc. We implemented real-time game environment changing system using the BCI to raise the degree of immersion in FPS game. EEG¹ is the recording of electrical activity along the scalp. We measure user's EEG using MindSet² for implemented game playing time to get user's concentration rate. This value operates our environment system in virtual space. In virtual space, each player experience different environment situation because each player has various concentration rate. Implemented environment system is formed with alternation of day with night and weather. Human body condition is changed depending on day and night. Player can feel change of character's condition via player's condition by our system. Implemented system can be applied to various game genres to raise player's immersion for game playing time.

1. Introduction

FPS³ game is a video game genre centered on gun and projectile weapon-based combat through a first-person perspective. Immersion is important factor in this game genre. Figure 1 is a one of Korean popular FPS game playing capture image, 'Sudden Attack'⁴. FPS developers try to raise the immersion in game for game playing time using first-person perspective graphic, sound effect etc. In this paper, we tried to implement a high dimensional immersion using connecting virtual world with real world. Player's EEG can connect virtual world with real world to raise immersion for game playing time. EEG is the recording of electrical activity along the scalp and measures voltage fluctuations resulting from ionic current flows within the neurons of the brain [1]. It provides a noninvasive means of reliably monitoring brain activity spatially and temporally.

¹ Electroencephalography

² The MindSet senses EEG brainwave data to power the innovation of laboratory researchers and application developers like no other EEG device in the world. It delivers RAW signal, power frequency bands and NeuroSky eSense meters:attention, meditation. (<http://www.neurosky.com/products/mindset.aspx>)

³ FPS(First-person shooters are a type of three-dimensional shooter game[3], featuring a first-person point of view with which the player sees the action through the eyes of the player character.

⁴ <http://sa.nexon.com/main/index.aspx>

The EEG signal may be one of the most predictable and reliable physiological indicators to measure the level of alertness [2]. EEG was used for medical research. It has developed every



Figure 1. Playing image of FPS game (Sudden Attack)

year and broadened the scope of application. Currently, education, culture and life etc. are focused to EEG's application more than medical purposes. For example, EEG-controlled game, attention training program using EEG and wheelchair using EEG to control. EEG's practical approach has been attempted [4]. We propose a real-time environment changing system using EEG for immersion of game play. Player can control game environment consciously or unconsciously. Each player can know other player's concentration by environment. To implement this system we used MindSet. Figure 2 shows process of implemented EEG environment changing system.



Figure 2. Process of EEG environment changing system.

The following section will describe previous related work. Section 3 will provide the implement of environment changing system using EEG. In section 4, we will present the results of our research followed by our discussion and conclusions.

2. Related Work

Our study uses commercially available dry EEG devices, MindSet. The Neurosky offers reliable low level EEG headsets and stable software tools for researchers and developers. Many researchers have succeeded in testing these single-channel devices in recent projects. In this section we present about EEG, MindSet and Unity environment system. Human body condition is affected by environment. Also time (day or night) can affect human body condition because human has biological clock. Player's EEG control and change game's environment in implemented system. In this section we present about biological clock, EEG, MindSet and Unity.

2.1. Biological clock

Biological clock affects the daily rhythm of many physiological processes. Figure 3 shows the circadian patterns typical of someone who rises early in morning, eats lunch around noon, and sleeps at night (10 p.m.). Although circadian rhythms tend to be synchronized with cycles of light and dark, other factors - such as ambient temperature, meal times, stress and exercise - can influence the timing as well⁵. In humans the average internal temperature is 37.0 °C (98.6 °F), though it varies among individuals. However, no person always has exactly the same temperature at every moment of the day. Temperatures cycle regularly up and down through the day, as controlled by the person's circadian rhythm. The lowest temperature occurs about two hours before the person normally wakes up. Additionally, temperatures change according to activities and external factors.⁶

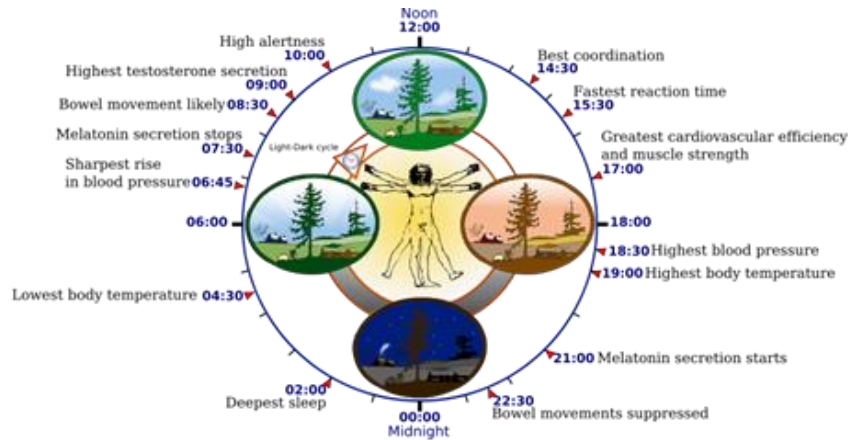


Figure 3. Biological clock

2.2. EEG

EEG means the flow of electricity that is formed when signal is transmitted between cranial nerves. In other words, EEG is called Electroencephalography. Figure 4 shows raw data. We can see the result image like Figure 4 when we measure Brain wave. Figure 5 shows power spectrum. Power spectrum is converted result from raw data. It is divided by the frequency and according to the state of mind and body amplitude is different. The features of each frequency are shown in the Table 1.

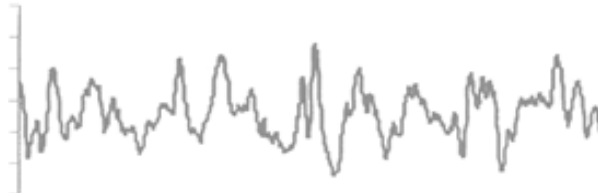


Figure 4. Raw data

⁵ Wikipedia, http://en.wikipedia.org/wiki/File:Biological_clock_human.svg#file

⁶ Kelly GS (March 2007). "Body temperature variability (Part 2): masking influences of body temperature variability and a review of body temperature variability in disease". *Altern Med Rev* 12 (1): 49–62. PMID 17397267.

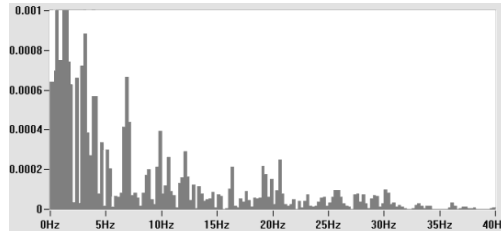


Figure 5. Power spectrum

Tabel 1. Types and Features of EEG

Type	Frequency (Hz)
Delta	0.5 – 4 Hz
Theta	4 – 7 Hz
Alpha	8 -12 Hz
Beta	12 -30 Hz
Gamma	30 Hz and over

As Table 1 there are Delta waves (frequency 0.5-4Hz), Theta waves (frequency 4-7Hz), Alpha waves (frequency 8-13Hz), Beta waves (frequency 14-30 Hz) and gamma waves (frequency 30Hz and over). [5] Alpha waves are associated with meditation and relaxation, all types can also be attributed to attention or concentration at slower frequencies. [6] Beta waves are related to concentration.

2.3. MindSet

Standard medical EEG devices use a conductive gel to facilitate the reading of the signals. Dry active sensor technology does not need such a gel. For this reason, headsets based on Neurosky technology are very low cost, and easy to handle [7]. The MindSet (Figure 6) wireless Bluetooth headset features brainwave-reading and mental-state-translational technology from NeuroSky, Inc., a Silicon Valley company. With earlier NeuroSky partner announcements in the toy (Uncle Milton Force Trainer™, under a Lucas Licensing deal) and video gaming industries (Square Enix Judecca™), the Toshiba-NeuroSky product launch represents the first BCI peripheral directed to mainstream PC users.



Figure 6. Power spectrum

2.4. Unity environment system

To implement EEG environment system we used Unity. It is a cross-platform game engine with a built-in IDE developed by Unity Technologies. It is used to develop video games for web plugins, desktop platforms, consoles and mobile devices. The graphics engine uses Direct3D, OpenGL, OpenGL ES, and proprietary APIs. There is support for bump mapping, reflection mapping, parallax mapping, screen space ambient occlusion (SSAO), dynamic

shadows using shadow maps, render-to-texture and full-screen post-processing effects. We can express day and night, rain etc. using Unity like other 3D game engines. And there are many ways to express various environments in Unity. In this paper, we implement environment simulation system using EEG. Implemented system is as Table 2.

Tabel 2. Types and Features of EEG

Weather Type	Control factor
Day(Sunny)	lighting
Night(dark and cloudy)	lighting
rainy	Texture particle
lightning	Texture particle

3. Implement

The player wear MindSet for environment changing system for playing time. Figure 7 shows process of EEG environment changing system. We separated tester's state from 1 to 8. State 1 indicates meditation and state 8 means attention. According to this separation, state 1-2 simulate day(sunny weather), state 3-4 simulate night(dark and cloudy weather), state 5-6 simulate rainy weather and state 7-8 simulate lightening in 3D virtual world. These weather simulations are shown only in a certain area around each character.

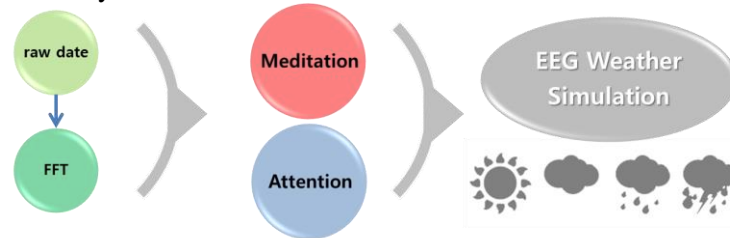


Figure 7. Implement process

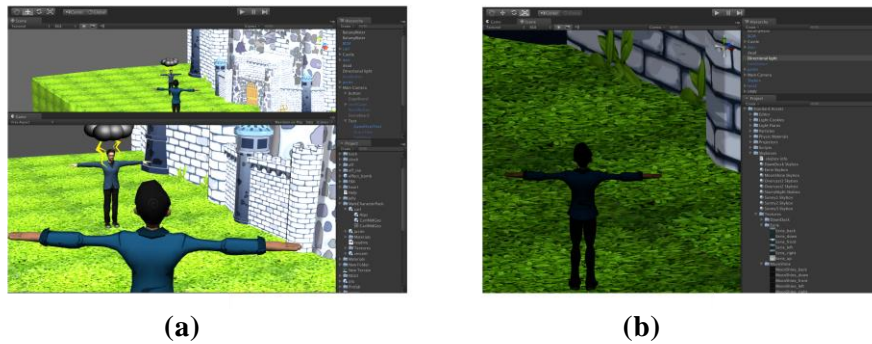


Figure 8. Test image

Figure 8 shows test result, image (a) indicates day and opposite side character is lightning weather situation. Image (b) indicates dark and cloudy day. Each environment's control factor is shown in Table 2.

6. Summary and Conclusion

We propose an environment changing system using EEG for immersion of FPS game play. We measure user's EEG using MindSet for game playing time to get user's concentration rate. This value operates our weather system in 3D virtual space. In 3D virtual space, each player experience different environment situation because each player has various

concentration rate. This system makes game player knows other player's concentration situation and increase player's immersion for game play time. Implemented system can be applied to various 3D game genres, and rise players immersion for game play. Our system takes place in a virtual work, but the actual state of player is shown in contents. This system make player can feel closer to game virtual world and increaser the immersion.

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