

## Implement of weather simulation system using EEG for immersion of game play

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**Abstract.** We propose a real-time weather simulation system using EEG for immersion of game play. Electroencephalography (EEG) is the recording of electrical activity along the scalp. Game designer effort to raise players immersion when make game using interface, graphic effect, level design etc. We measure user's EEG using MindSet<sup>1</sup> for game play 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 weather 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. When player concentrate to game the weather is fine if player doesn't concentrate to game the weather is cloudy and rainy in 3D virtual space. Implemented system can be applied to various 3D games (FPS, MMORPG etc.) and rise players immersion for game play.

**Keywords:** serious game,

### 1 Introduction

Electroencephalography (EEG) is the recording of electrical activity along the scalp. EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain.[1] EEG provides a noninvasive means of reliably monitoring brain activity spatially and temporally. 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 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.[3]

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<sup>1</sup> 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>)

We propose a real-time weather simulation system using EEG for immersion of game play. Player can control weather system consciously or unconsciously. Each player can know other player's concentration by weather system. To implement this system we used MindSet. Figure 1 shows process of implemented weather simulation system.

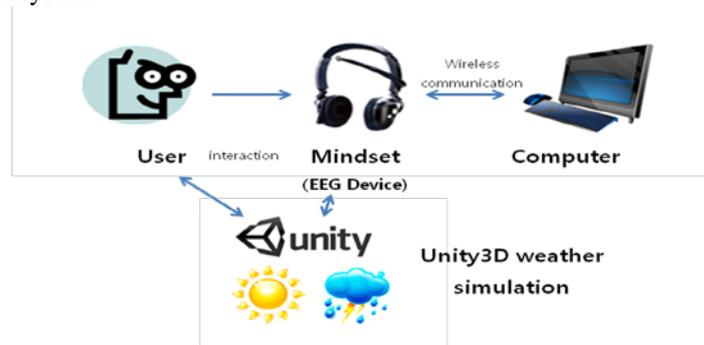


Fig. 1. Process of implemented weather simulation system.

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

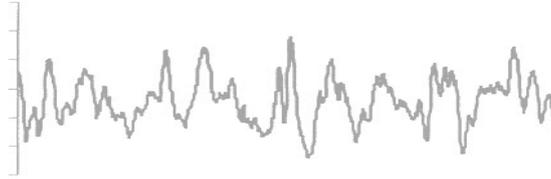
## 2 Related Work

Our study uses commercially available dry EEG devices, MindSet. The Neurosky<sup>2</sup> 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 Unity3D weather system.

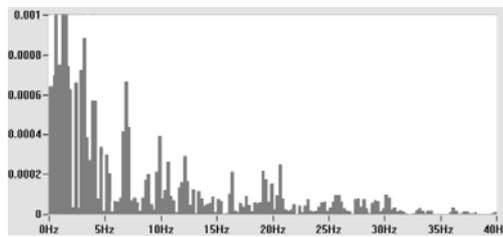
### 2.1 EEG

EEG means the flow of electricity that is formed when signal is transmitted between cranial nerves. In other words, EEG is called Electroencephalography. Figure 2 shows raw data. We can see the result image like Figure 2 when we measure Brain wave. Figure 3 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.

<sup>2</sup> NeuroSky, Inc. is a manufacturer of Brain-Computer Interface (BCI) technologies for consumer product applications, which was founded in 2004 in Silicon Valley, California.



**Fig. 2.** Raw data



**Fig. 3.** Power spectrum

**Table 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). [4] Alpha waves are associated with meditation and relaxation, all types can also be attributed to attention or concentration at slower frequencies. [5] Beta waves are related to concentration.

## 2.2 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. [6] The MindSet (Figure 4) 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.



Fig. 4. MindSet.

### 2.3 Unity3D weather system

To implement 3D virtual place we used Unity3D. 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 snow, rain, lightning and wind etc. using Unity3D like other 3D game engines. And there are many ways to express various weathers in Unity3D. In this paper, we implement weather simulation system using EEG. Lighting, cloud modeling, rain texture are used to express weather in our system as Table 2.

Table 2. Types and Features of EEG

Weather Type	Control factor
Sunny	lighting
cloud	lighting
rainy	Texture particle
lightning	Texture particle

## 3 Implement

The testers wear MindSet for weather simulation system play time. Figure 5 show process of EEG weather simulation 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 sunny weather, state 3-4 simulate 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. Three people can participate in simulation at a time and they can watch each other's character's weather situation.

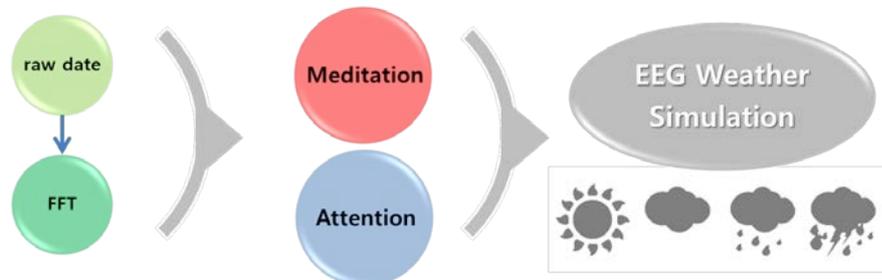


Fig. 5. Implement process

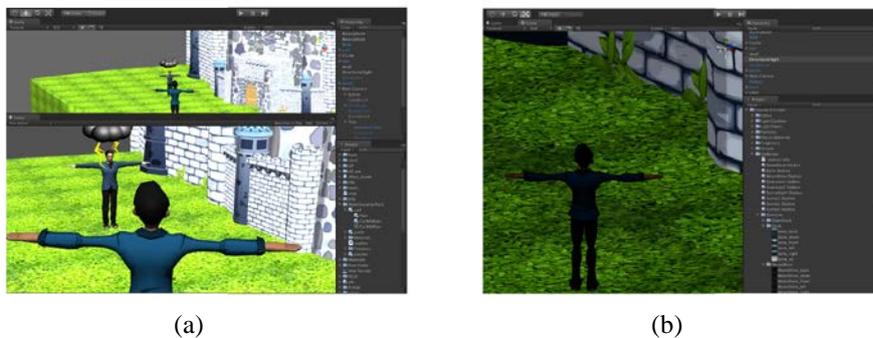


Fig. 6. Test image

Figure 6 shows test result, image (a) indicates sunny day and opposite side character is lightning weather situation. Image (b) indicates cloudy day. Each weather's control factor is shown in table 2.

## 5 Summary and Conclusion

We propose a real-time weather simulation system using EEG for immersion of game play. We measure user's EEG using MindSet for game play time to get user's concentration rate. This value operates our weather system in 3D virtual space. In 3D virtual space, each player experiences different weather situations because each player has various concentration rates. This system makes game players know other players' concentration situations and increases player's immersion for game play time. The implemented system can be applied to various 3D games (FPS, MMORPG etc.) and increase players' immersion for game play. Our system takes place in a virtual world, but the actual state of the player is shown in contents. This system makes players feel closer to the game's virtual world and increases the immersion.

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