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게임 기획 및 디자인

뇌파를 이용한 현실과 가상 오브젝트 제어시스템 설계

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Design of Reality object and Virtual object control System using EEG

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요 약

본 논문은 뇌파를 이용하여 가상현실의 오브젝트와 실제 환경의 오브젝트를 동시 컨트롤하는 시스템에 대해 제안한다. 뇌파를 측정하여 사용자의 집중도를 파악하고 이를 수치화하여 가상과 현실의 오브젝트를 상승 혹은 하강시키는 시스템을 제안한다. 설계에 대한 테스트를 위해 웹 기반의 가상현실 시스템을 구현하였고 라즈베리파이를 이용하여 임베디드 시스템을 구현하였다. 뇌파를 이용하여 가상의 물체와 현실의 물체의 컨트롤이 가능한 것을 확인하였다. 이를 활용한 다양한 콘텐츠의 개발이 가능하다는 결과를 도출하였다.

ABSTRACT

In this paper, we propose the system that simultaneously controls objects in virtual reality and objects in real environments using brain waves. We propose a system that measures brain waves to grasp the user's concentration and quantifies them to raise or lower virtual and real objects. We implemented a web-based virtual reality system and an embedded system based on a raspberry pi for test of design. It was confirmed that the control of virtual and real objects is possible using BCI. The result was that it was possible to develop various contents using this.

Keywords : EEG(뇌파), BCI(브레인 컴퓨터 인터페이스), VR(가상현실), Embedded(임베디드)

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1. Introduction

Various researches have been conducted to understand on human mind and tension, concentration using brain waves. Also applied research has been studied in various aspects. A lot of systems applied to various contents using brain waves have been developed. Sang-Hyub Jung et al. used Kinect and BCI(Brain Computer Interface) to develop a serious game to improve motor skills and concentration[1]. Dong-Min Shin et al. researched emotion recognition interface using EEG(Electroencephalogram) and ECG(Electro cardiogram)[2]. Tae-Hyun Kim et al. proposed a web-based game using BCI on Social Network Game using EEG[3]. Hee-Young Kim analyzed BCI used in the art field and suggested ways to utilize BCI in mixed reality[4]. Eunmin Lee et al. had been a survey using an open source based MindCar using MindWave[5]. MindWave's noise generated by using a single electrode and environment had a problem. MindBall is a physical game that moves a ball placed between two players using brain waves. It moves the ball toward the other side when maintaining a stable brain wave physically and mentally among a person's brain waves[6].

Neurosky proposes various contents using BCI. Paranormal Mynd is a movie that heals people who are possessed by evil spirits, and leads the story using the user's brainwave concentration. The success or failure of exorcism in the movie is decided using Brain waves sent by the user[7]. Mindflex is the first toy to use brain waves. It is a device that passes the ball through a space with various obstacles. Pens are installed on the lower part and when a specific brain wave is sent that moved[8].

[Fig. 1] Mindflex

Past research and products control real or virtual objects. In this paper we proposes a system design that simultaneously controls both virtual and real objects.

In this paper, we propose the system that simultaneously controls objects in virtual reality and objects in real environments using brain waves. We propose a system that measures brain waves to grasp the user's concentration and quantifies them to raise or lower virtual and real objects. In chapter 2, we introduce related research that various systems using EEG measurement. Also we introduce research related to VR. In chapter 3, we introduce the proposed system. Finally, we conclude in chapter 4.

2. Related Works

2.1 BCI

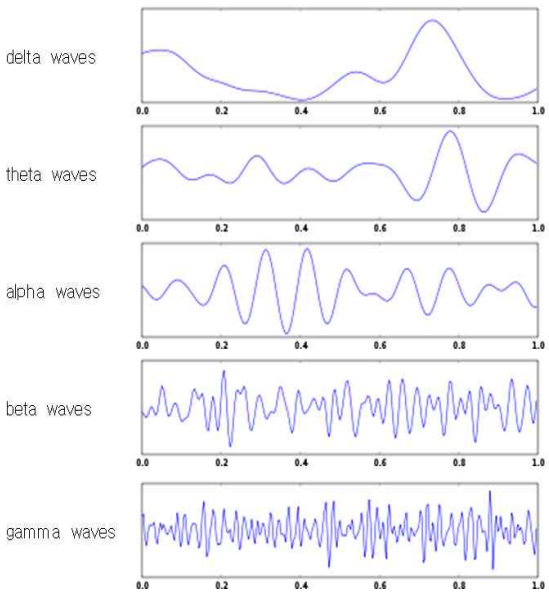
BCI(Brain Computer Interface) is a

technology that directly connects and controls the human brain and a computer. It takes the brain wave through a device that recognizes the brain wave stimulus. It goes through the step of analyzing brain waves and giving commands to input/output devices using signaling process[9]. In the signal measurement step, EEG is measured through an electrode attached to the head, and disturbances are removed in the pre-processing process, and signals necessary for analysis are separated. In the shape extraction process, information of the EEG data received from the EEG measurement device is converted to increase the recognition rate when classifying signals, and the EEG data belongs to which group through a conversion algorithm. The final output through the classifier is converted into a command for terminal control of the computer. The BCI technology method is divided into invasive and non-invasive types depending on the area where EEG is measured. According to the characteristics of the EEG used in BCI, it is divided into EEG-induced and EEG recognition types.

In the invasive type, a microchip is applied to the scalp to measure EEG, and accurate measurement is possible, but the procedure is necessary and there may be side effects surgically. In the non-invasive, a helmet or headset applied to the head to measure EEG, and it is simple, but it is difficult to accurately measure due to severe noise. The EEG induction type is a method of inducing the appearance of a specific EEG and applying it. It needs training to generate a specific EEG because the actual intention of the user and the appearance of EEG do not coincide. The EEG recognition method is a type of recognizing simple intentions or movements by analyzing EEG. it is conveys the user's intention to a computer or machine.

2.2 EEG

EEG(Electroencephalogram) is commonly called brain waves. EEG is a flow of electricity generated when signals are transmitted between the cranial nerves in the nervous system, and appears differently depending on the state of mind and body. It is an important indicator for searching brain activity[10]. Brain waves are artificially divided according to their amplitude and frequency. There are Delta(δ) waves(0.2 ~ 3.99 Hz), Theta(Θ) waves(4 ~ 7.99 Hz), Alpha(α) waves(8 ~ 12.99 Hz), Beta(β) waves(13 ~ 29.99 Hz), Gamma(ɣ) waves(30~50 Hz). Fig. 2 shows each EEG bands waveform pattern[11].



[Fig. 2] Comparison of EEG bands Wave pattern

Delta waves also called sleep waves because it is that occur when you sleep. Theta waves

are called sleepiness waves because it is that pass when you fall asleep. Alpha waves are called stable waves because it is when the mind and body are resting. EEG is a representative component of human brain and it is closely related to the development of the brain. Beta waves are called stress waves. It appears when during anxiety and tension. Gamma waves occur during extreme arousal and excitement. It is reported deeply related to advanced cognitive information. It is common to occur in the frontal and parietal lobes[12].

2.3 Measurement to power of concentration

Concentration is the ability to think or act by being immersed in something. It is referred to the ability to keep one's thoughts consciously gathered. Maintaining this state of concentration is called power of concentration. The most common measurement to power of concentration method using EEG is as Equation (1) devised by Joel F. Luber[13]. It is expressed as the sum of the SMR waves and the M-β waves, divided by the Θ wave. SMR waves and M-β waves are correlated with concentration and immersion. Θ waves are sleepiness waves. it is that pass when you fall asleep.

$$\frac{SMR + M\beta}{\theta} \quad (1)$$

2.4 Virtual Reality(VR)

Virtual reality refers to an environment similar to reality or technology created by artificial technology rather than the real world[14]. It refers to a virtual reality world created with an artificial world view, or provides a system that stimulates the user's senses in a virtual environment or situation and feels a sense similar to the real world. Virtual reality connects humans and computers to give humans a feeling that they are actually existed in the virtual space beyond the feeling of being in a manipulated reality. In order to realize virtual reality that gives a sense of reality, a space made of 3D graphics, a display capable of expressing it, and a sensor that measure body movement are required. Virtual reality is an artificial world that perceives the user's actions, including human senses, and creates a virtual world that occurs based on this by a computer in real time and makes it as if it were reality. Therefore, the virtual world is not a static world, and objects in the world can move, interact with each other, and are affected by external actions.

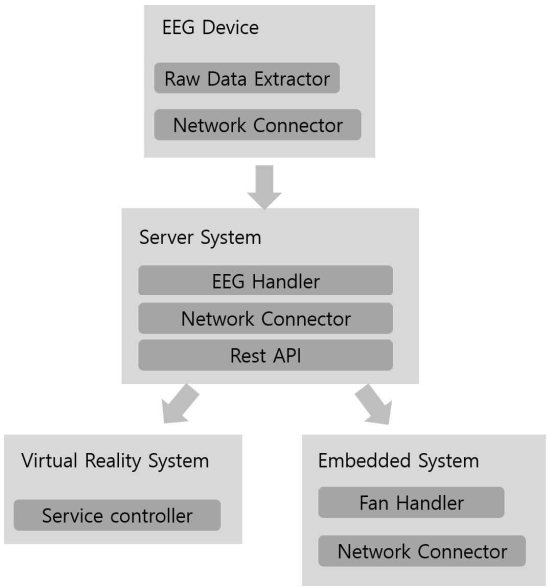
One of the main viewpoints of virtual reality is to make people feel that they are participating in the environment rather than observing the artificially synthesized environment from the outside. By stimulating all the sense organs of the human body to immerse in the artificially created world, the user becomes both a recognizer and a creator in a virtual world where objects perceived based on actions and senses are created by the user's actions. The real-time response of the computer to the user's behavior is one of the important elements of simulation and other virtual reality systems. The most important point of virtual reality is that you become the center of the simulation and interact with the virtual world created by the computer.

2.5 Head Mounted Display(HMD)

The HMD(Head mounted display) is an image output device acting on the head and is a display device that directly displays an image in front of the user's eyes. It is known that the first HMD was developed by Marvin Minsky in 1963[15]. There is one of type that is used as a display for augmented reality by displaying information in a part of the field of view, such as Google Glass[16]. Another type is like Oculus there are products used for virtual reality by displaying images in the entire user's field of view and detecting the movement of the user such as head trekking[17]. The HMD for augmented reality is configured in the form of safety glasses, secures the user's existing field of view, and displays an image or text on it. In the case of an HMD for virtual reality, it is configured in the form of a helmet or equivalent, and blocks the view of the existing user and provides a binocular parallax-based 3D image. In special cases, cameras are installed to secure the user's existing field of view. Since the image must be transmitted based on the user's movement, it is possible to measure the user's direction using head tracking.

3. Proposed system

In this paper, we propose the system that controls the motion of virtual and real objects in virtual reality by using the BCI interface. The composition of the entire system is shown in Fig. 3.



[Fig. 3] Overall system

The EEG device is used to measure the power of brain concentration and the virtual object and the real object move together according to the power of concentration to the EEG. EEG raw data is extracted through the EEG device and the data is transmitted to the server system. The received EEG data is converted into a value representing the degree of concentration using an equation, and transferred to the virtual reality system and the embedded system to control the object.

3.1 EEG Device

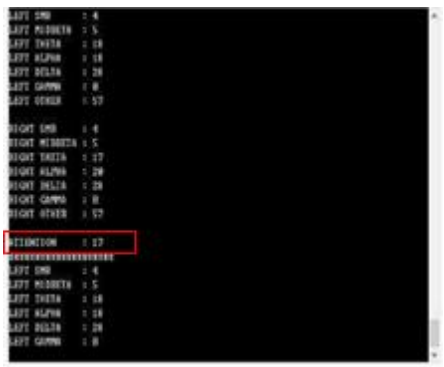
As a device to acquire EEG, a non-invasive headset-type Huboro's BCI acquisition device [18] that contacts the forehead of a human face was used. Fig. 4 shows the appearance of the EEG device. User's brain waves are recognized through the five contact surfaces and converted into data.

[Fig. 4] EEG device

The configuration of the EEG device uses Booststrap to run the program engraved on the ROM at the moment the device is turned on to check and confirm the connection and operation status of the device. Using the program, the user's EEG raw data is extracted and the data is delivered to the server through Bluetooth or serial port. Booststrap OS drives the device, Raw Data Extractor acquires brain waves, and communication with the server is performed through Bluetooth / Serial Connector.

3.2 Server System

The server system converts the received raw data into parameter(the state of concentration) using Equation (1). Figure5 shows each EEG parameters and value calculated by Equation (1).

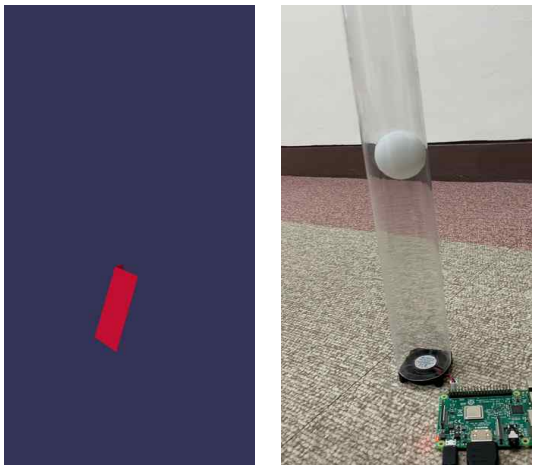


[Fig. 5] Motion of virtual and real objects

The value is transferred to virtual reality games and embedded systems to control virtual and real objects. The virtual reality system was produced based on the web. The embedded system was constructed using Raspberry Pi. The server system sents parameters to the virtual reality system and the embedded system using REST API.

3.3 AR and Embedded System

The virtual reality system applied for the test was implemented using A-Frame[19]. A-Frame is an open-source web framework for building VR. The embedded system was produced based on Raspberry Pi 3B+. Figure 6 shows the motion of virtual objects on the left, and the motion of real objects on the right. The ball move using pen. Virtual and real objects rise and fall according to the value.



[Fig. 6] Motion of virtual and real objects

4. Conclusion

A lot of research has been conducted on how to analyze EEG and activate brain wave. Brain training can improve concentration and

relieve stress, and studies have been published that it can slow dementia. Brain diseases such as dementia are emerging as a long-standing problem in an aging society. In this paper, we proposes a system that controls virtual and real objects using BCI. The power of concentration was quantified by using the brainwave data received through BCI, and this was transmitted to the virtual reality system and the embedded system using brainwaves using REST API, and the operation was performed.

In this paper, we are purpose of establishing and designing a concept, and further research is needed to create related applications. Various contents can be developed applications of the proposed system and integrating with game.

By applying the measurement of brain waves using BCI, more accurate brain activity can be grasped, and games using brain waves can prevent brain diseases such as dementia and improve concentration by training through brain training like exercising the body. Training in which virtual and reality co-exist is given to users through games and can play a role in increasing the user's concentration. This research can be applied to digital twins and is expected to develop into various researches.

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