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Poster

Improving a Sense of Unity via Brain Waves in a Virtual Concert Where Performances in Real Space are Watched in a Virtual Space

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Abstract

In virtual live concerts that can be attended remotely, there is a problem of a weak sense of unity due to a lack of shared reactions among the participants. We have attempted to solve this problem by focusing on the sharing of physiological signals, but there was a limitation in the range of types of virtual live content that could be performed. In this study, we developed a virtual live streaming system that removes this limitation, and confirmed that generating visual effects based on electroencephalography signals at a musical instrument concert improves the sense of unity felt by the audience.

CCS Concepts

• ***Human-centered computing*** $\rightarrow$ ***Virtual reality;***

1. Introduction

In recent years, along with the development of immersive head-mounted displays (HMD), virtual live concerts that can be attended remotely are gaining popularity [Cha17]. However, there are problems associated with participating in a concert from a remote location. Tarumi et al. [TNM*17] explained as follows. A "sense of unity" is an important element in entertainment. It is a buzzword often used to represent a good experience in live music performances, and to evoke it requires sharing reactions between remote locations. It with other audience members is evoked by reacting with other audience members, and it with the performer is evoked when the performer responds to his or her own reactions.

To improve the sense of unity in virtual concerts, we focused on the sharing of physiological signals. Sharing physiological signals has been used to connect people who are physically distant from each other [MWC22] and is a promising method of communicating audience response in online streaming [RRKM22]. Furthermore, it has been shown that detecting involved moments from the electroencephalography (EEG) signals of participants in a event in a virtual reality (VR) space and generating visual effects accordingly could improve the sense of unity among the audience [MGKH22]. We used a similar mechanism and showed that having the performer and the audience share EEG-based visual effects in virtual juggling-shows could improve the sense of unity between them [IH]. However, in the system we used, it was necessary to reflect the performer's movements in the 3D model in order to perform in the VR space. Thus, the performance of motion tracking equipment limited the range of types of virtual live content that could be performed, and live concerts could not be performed.

Therefore, in order to confirm the effectiveness of an EEG-based reaction sharing system for live concerts, which are considered to be in high demand, we developed an EEG-based reaction sharing system while performing a concert in a VR space without intervening 3D models. This paper describes the configuration of the proposed system and experiments in which a small audience was given keyboard concert experiences using this system. It also presents a discussion of whether the generation of visual effects based on EEG improves the sense of unity.

2. Proposed System

2.1. Beta/alpha Ratio

The beta/alpha ratio is calculated from the amplitude spectrum of beta waves, which are stronger during arousal, and alpha waves, which are stronger during relaxation. In this study, as in previous studies [IH], this value is used as an index of involvement.

2.2. System Implementation

A performer plays a keyboard in front of a green background. Audio signals of the performance are sent to a PC assigned to each audience member and played through the HMD speakers. The images of the performance are captured by webcam and sent to each performer's PC. The PCs use chroma key technology to separate only the performer and instruments from the received images, which is then projected onto a screen set up in the live house in the VR space. The screen in the VR space is set away from the wall, and the background-separated images are projected on the screen, making it appear as if the performer is in the VR space. The audience watches these images using HMDs. There is no discrepancy between the audio and the video.

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The performer and audience each wear a simple single-channel EEG recorder. The electrodes are placed on their foreheads where they will not be exposed to the HMD. The signals measured by the EEG recorder are sent to the PC assigned to each participant. Each PC calculates the beta/alpha ratio and sends commands to the server to generate visual effects according to that value. The server generates visual effects in the VR space according to the received commands and synchronizes them with each participants' PC. The audience sees the visual effects through HMD and the performer sees the visual effects through two monitors placed in front of him or her.

In this study, when the value of the beta/alpha ratio is less than 1.35, no visual effect is generated, and when the value is in [1.35, 1.40), [1.40, 1.50), [1.50, 1.60), and 1.60 or higher, visual effects of different shapes are generated corresponding to each of the four states. These thresholds were set empirically in previous studies.

Each participant who watches the concert at the same time emits a different color visual effect. Thus, they can recognize which visual effect was produced by whom. In this study, light blue is assigned to the performer, and yellow, orange, red, and pink to the four audience members watching the concert at the same time, respectively.

3. Experiment Design

The experiment was conducted on nine subjects who gave written consent. One of them participated as a performer, and the remaining eight were audience members. This study was approved by the Ethics Committee of the Shibaura Institute of Technology (20-031) and conducted according to the Declaration of Helsinki. Each audience member viewed two patterns of performance, one with and one without visual effects. To counterbalance, the audience was divided into two groups of four people each, and the order in which they were shown the performances was changed. At all times, the performer played the same music in real time (see Figure 1). The participants were asked to rate of each concert on a 7-point Likert scale, indicating whether they felt enjoyment, a sense of unity with the performer, and a sense of unity with the other audience.

Figure 1: *The performer in concert as seen from the audience in the VR space. It can be seen that visual effects are generated by the performer and the audience.*

4. Results and Discussion

The results of the questionnaire are shown in Figure 2. It was found that sharing visual effects based on EEG significantly increased enjoyment and the sense of unity with the performer and other audience (p<0.01, paired t-test). However, we think it is also possible that the enjoyment rating was improved by the beauty of the visual effect, regardless of whether it was based on EEG or not.

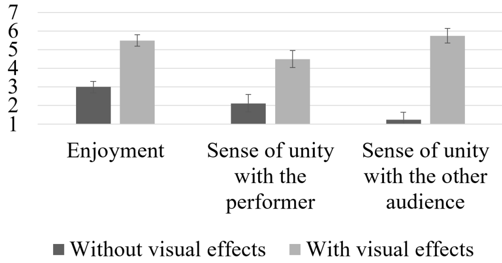

Figure 2: *Average of the concerts ratings by the audience on a 7-point Likert scale. Error bars indicate standard errors.*

4.1. Conclusion

In this study, we proposed a system that uses visual effects based on EEG to share reactions between the performer and audience at virtual concerts, in which performances in real space are watched in a VR space. Experimental results showed that the system significantly improved the sense of unity that the audience felt with the performer and the other audience, and also showed the possibility of improving the enjoyment of the virtual concerts.

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