Towards Enhancing a Recorded Concert Experience in Virtual Reality by Visualizing the Physiological Data of the Audience

Xiaru Meng
mengxiaru@kmd.keio.ac.jp
Keio University Graduate School of Media Design
Yokohama, Japan

Yan He
Keio University Graduate School of Media Design
Yokohama, Japan
yann@kmd.keio.ac.jp

Kai Kunze
Keio University Graduate School of Media Design
Yokohama, Japan
kai@kmd.keio.ac.jp

Figure 1: Three scenes of piano performance in virtual reality.

ABSTRACT

This work is a first attempt to visualize the social atmosphere of a audience in a VR experience using their recorded the physiological state, and then presents them to another group of audience members, aiming at a transformative perception from individual to collective experience. A virtual environment is built to share the audience's aesthetic feelings and emotions, creating a novel way of non-verbal communication in performance scenarios that aim at enhancing audio-visual perception through physiological sensing and emotional experience sharing. This experiment was designed to investigate the effect of physiological data-based reproduction of musical performances in VR on affective states.

AHs '23, March 12–14, 2023, Glasgow, United Kingdom

ACM ISBN 978-1-4503-9984-5/23/03.
https://doi.org/10.1145/3582700.3583709

CCS CONCEPTS

• **Applied computing** → **Performing arts**; • **Human-centered computing** → **Virtual reality**.

KEYWORDS

data visualization, classical music

ACM Reference Format:
Xiaru Meng, Yan He, and Kai Kunze. 2023. Towards Enhancing a Recorded Concert Experience in Virtual Reality by Visualizing the Physiological Data of the Audience. In *Augmented Humans Conference (AHs '23), March 12–14, 2023, Glasgow, United Kingdom.* ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3582700.3583709

1 INTRODUCTION

What makes a live performance different from a recorded experience? It's a fascinating question explored from researchers in different fields. There exist also a lot of related concepts, from presence, to liveness [1, 2, 9]. A crutial part of the live performance are the other attendees, and the social atmosphere they create.

When we are with people, we often see some physical or physiological entrainment (our body signals follow each other) [3], from simple eye blinks and head nods in conversations over heart rate features in music performances to galvanic skin response in theater plays [4, 6, 7, 10, 11].

In our work, we explore if it's possible to use recorded physiological signals from performances and other live events to generate a more immersive feeling for the user if they experience the recorded performance or live event. We want to create a feeling in the user that is similar to that in the live performance using visualizations based on the audience physiology.

This paper presents the first step towards this goal. We present an initial prototype encoding the heartrate and galvanic skin response data from 39 members of the audience who experienced a classical music concert. With the current prototype we want to answer the questions if the virtual environment constructed based on the physiological data of the live audience can enhance the experience of the user. We are particularly interested in if reproducing a performance in a different time and place (VR) with visualizations based on the audience physiology will create similarities or differences in the emotional experience between the user and a live audience member.

2 INITIAL PROTOTYPE

2.1 Background

For our prototype, we recorded a classical music concert with a panoramic camera placed in the middle of the front row of the auditorium. It recorded a panoramic video of the entire concert hall, including the stage and the audiences. At the same time, the Blood Volume Pulse(BVP) and Electrodermal Activity (EDA) data of 50 audience members on site were recorded with wrist-worn data acquisition devices. For recording the audience members, we are using a commonly used physiological sensing platform [8, 13].

All audience members and the performers provided us with their informed consent. The experimental setup was approved by *blinded for review*.

In this study, a 5 minute 11 second solo piano performance was selected and the data from the same time period was transformed into 3D visualization models.

2.2 Data visualization

We transformed the BVP and EDA data of 39 live audience members into 39 units of 3D models, and the morphological changes of each unit reflect the state of one audience member. The model of each unit contains two parts: a dandelion-shaped spherical model floating in the sky and a grass-shaped model. The size range of the spherical model is connected to the BVP data, and the beating of the spherical model simulates the heartbeat (see Figure 2). The height of the spherical model is negatively correlated with the EDA data. When the EDA value increases, the height of the spherical model decreases, and the model is closer to the user. The grass-shaped model consists of a number of slowly rotating florets, and the overall morphology of this model is related to the EDA data. When the EDA value is low, the overall height of the model is negative, and the user cannot see it. When the EDA value becomes high, the grass model will start to rise from the center. When the EDA value is extremely high, the user will see a cluster of lines growing upward(see Figure 3(a)).

2.3 Three Virtual scenes

We import the 360-degree videos, sound and physiological states from the concert into the VR environment. In addition to the 360-degree video recorded at the performance, The 3D-oriented visual output generated by live audience physiological data is introduced into the virtual environment. Over the physiological representations, we hope to recreate a bit more of the emotinal atmosphere of the live concert. We built three different types of scenes to show the same performance in virtual reality. We will explore the impact of visualizing audience data on user experience during piano performance in VR environment though the comparison of the three scenes we have built. The first scene is a recorded 360-degree video of a real-world concert performance(see Figure 3(b)). In the second scene, data presentation is added to the recorded 360-degree performance video(see Figure 3(c)). The third scene is a totally new immersive virtual environment that is constructed based on the physiological data of the audience watching that performance(see Figure 3(d)).

Then, we will explore in an experiment, whether, compared to a usual 360-degree performance video, the reconstructed videos lead to a different amount of presence, emotions, and engagement. In the experiment, participants will experience the original performance video scene and the reconstructed virtual scenes in VR. We collect data through sensing devices (again EDA and BVP, the same devices used in the concert recording) and questionnaires. Physiological data Acquisition Devices include electrodermal activity sensors and heart activity sensors.

3 PLANED EXPERIMENTAL DESIGN

Participants read and sign the consent form and data protection policy. Participants are asked to fill in their basic information (age, gender, concert experience). They were informed about the experimental setup. Before experiencing each virtual scene, participants fill out the SAM (Self-Assessment Manikin) questionnaire on a digital spreadsheet[5]. Then the participants begin the virtual concert experience. The order of the scenes was counterbalanced. Each scene lasted 5 minutes and 11 seconds. The participant is equipped with the physiological data acquisition device and the VR headset. The participant can experience the environment changing their view angle and head position. No other interactions are provided. Every time participants complete an experience with a virtual scene, they will fill out the SAM questionnaire and the Slater-Usoh-Steed (SUS) scale questionnaire to measure a sense of presence in the VR scenes [12] . Physiological data (BVP and EDA data) will be collected as participants go through a total of three different virtual experiences. After all virtual experiences are completed, participants will be asked to share their overall opinions and comments on the entire experience.

4 FUTURE WORK

With this planed experiment we want to compare to analyze the impact of the reconstructed virtual space on an individual's feelings. In a second step we want to make the VR environment reactive to the

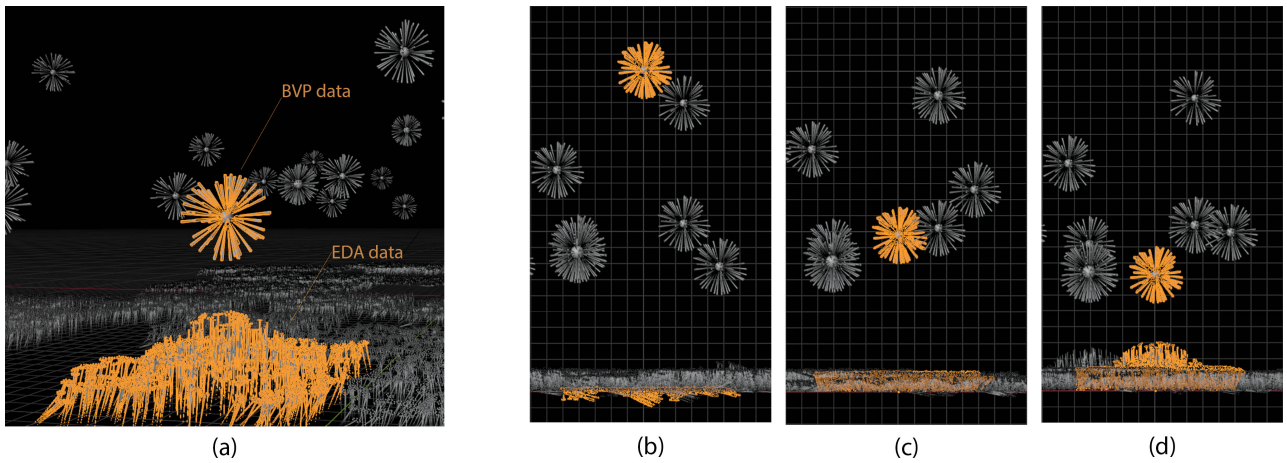

Figure 2: (a) A unit of data visualization (b) Low EDA value (c) Medium EDA value (d)High EDA value

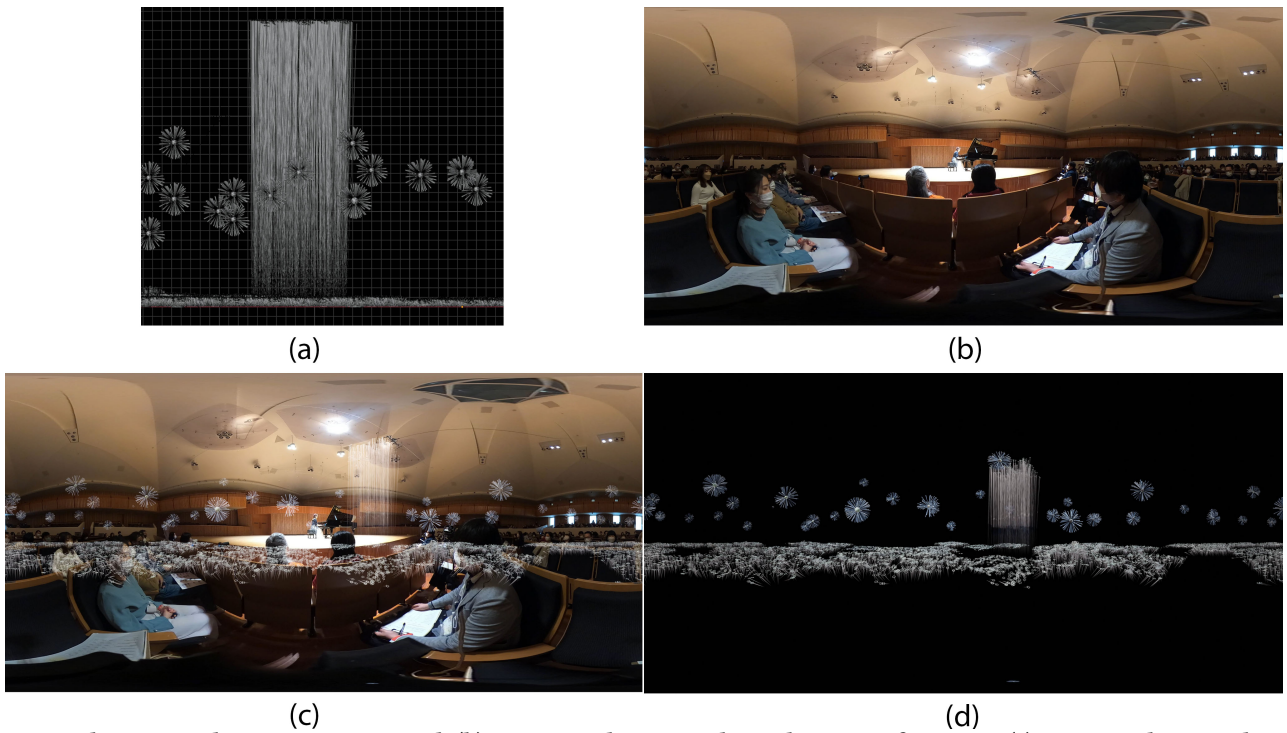

Figure 3: Three virtual scenes were created: (b) Scene A: The original 360-degree performance (c) Scene B:The mixed scene combining data visualization and original performance (d) Scene C: an immersive virtual environment based on the audience data.

physiology of the user and provide a richer interaction experience. This project can explore the effects achieved by the application of virtual reality and data visualization technologies in musical performance at a deeper level. With the increasing popularity of online communication and the introduction of technologies such as virtual reality, the interpersonal communication has entered a new phase. The results and experiences from this project can be applied to change people's lives in their daily communication activities in a variety of places such as concerts, educational institutions, and virtual online platforms. The framework developed in this project can provide a way for people to visualize their abstract ideas so that they may communicate with each other in a faster and more intuitive way.

ACKNOWLEDGMENTS

This work is conducted under the Cybernetic Being project supported by JST Moonshot R&D Program Grant Number JPMJMS2013. This work is partially supported by Karuizawa International Youth Concert 2022 Committee.

REFERENCES

[1] Bowen Alpern and Fred B Schneider. 1985. Defining liveness. *Information processing letters* 21, 4 (1985), 181–185.

[2] Philip Auslander. 2008. *Liveness: Performance in a mediatized culture*. Routledge.

[3] Asaf Bachrach, Yann Fontbonne, Coline Joufflineau, and José Luis Ulloa. 2015. Audience entrainment during live contemporary dance performance: Physiological and cognitive measures. *Frontiers in human neuroscience* 9 (2015), 179.

[4] Patrícia J Bota, Chen Wang, Ana LN Fred, and Hugo Silva. 2020. A Wearable System for Electrodermal Activity Data Acquisition in Collective Experience Assessment.. In *ICEIS (2)*. 606–613.

[5] Margaret M Bradley and Peter J Lang. 1994. Measuring emotion: the self-assessment manikin and the semantic differential. *Journal of behavior therapy and experimental psychiatry* 25, 1 (1994), 49–59.

[6] Aman Gupta, Finn L Strivens, Benjamin Tag, Kai Kunze, and Jamie A Ward. 2019. Blink as you sync: Uncovering eye and nod synchrony in conversation using wearable sensing. In *Proceedings of the 23rd International Symposium on Wearable Computers*. 66–71.

[7] Yan He, George Chernyshov, Jiawen Han, Dingding Zheng, Ragnar Thomsen, Danny Hynds, Muyu Liu, Yuehui Yang, Yulan Ju, Yun Suen Pai, et al. 2022. Frisson Waves: Exploring Automatic Detection, Triggering and Sharing of Aesthetic Chills in Music Performances. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 6, 3 (2022), 1–23.

[8] Yan He, George Chernyshov, Dingding Zheng, Jiawen Han, Ragnar Thomsen, Danny Hynds, Yuehui Yang, Yun Suen Pai, Kai Kunze, and Kouta Minamizawa. 2021. Frisson Waves: Sharing Frisson to Create Collective Empathetic Experiences for Music Performances. In *SIGGRAPH Asia 2021 Emerging Technologies*. 1–2.

[9] Kwan Min Lee. 2004. Presence, explicated. *Communication theory* 14, 1 (2004), 27–50.

[10] Haruka Shoda, Mayumi Adachi, and Tomohiro Umeda. 2016. How live performance moves the human heart. *PLoS One* 11, 4 (2016), e0154322.

[11] Fernando Silveira, Brian Eriksson, Anmol Sheth, and Adam Sheppard. 2013. Predicting audience responses to movie content from electro-dermal activity signals. In *Proceedings of the 2013 ACM international joint conference on Pervasive and ubiquitous computing*. 707–716.

[12] Mel Slater, Martin Usoh, Ernest Catena, and Sima Arman. 2000. Using presence questionnaires in reality. *Presence: teleoperators and virtual environments* 9 (2000), 497–503.

[13] Moe Sugawa, Taichi Furukawa, George Chernyshov, Danny Hynds, Jiawen Han, Marcelo Padovani, Dingding Zheng, Karola Marky, Kai Kunze, and Kouta Minamizawa. 2021. Boiling Mind: Amplifying the Audience-Performer Connection through Sonification and Visualization of Heart and Electrodermal Activities. In *Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction*. 1–10.