Multimedia Performance Installation with Virtual Reality

Cheng Lee
The Education University of Hong Kong
lcheng@eduhk.hk

ABSTRACT

This paper presents an interdisciplinary approach for incorporating computer music and virtual reality (VR) practices into a multimedia performance installation. The approach makes use of the complete surrounding virtual environment made available by VR technology and the stage acoustic setting of spatial audio to achieve a fully immersive experience for the audience. A bring-your-own-device (BYOD) strategy is adopted that requires the audience members to use their own smartphones as a 360-degree viewing device. A number of issues in relation to the implementation of multimedia performances that incorporate VR are discussed, including a technique for synchronizing the visual content of the audience and the interactivity among sound, music, and vision.

1. INTRODUCTION

Advancements in computer and mobile technology have made access to virtual reality (VR) technology an affordable possibility for the general public. People can now engage in the immersive experience of VR using mobile devices such as tablets and smartphones, allowing the viewer to navigate freely within a three-dimensional environment. To date, the application of VR technology has largely focused on the entertainment industry for gaming and film screening purposes, yet few efforts have been made to apply the technology to multimedia performances. This paper presents an interdisciplinary approach for incorporating computer music and VR into multimedia performance installation.

Three factors were considered during the development of the approach: low cost, adaptability to various stage settings, and few technical barriers for the audience. These advantages allow this approach to be implemented with few restrictions and little extra equipment.

2. RELATED WORK

The concept of VR emphasizes audience interaction, immersion, and participation compared with watching from a single vantage point. The earliest implementation of this idea can be dated back to the 1952 music performance by John Cage at Black Mountain College, which incorporated various art forms including sound, music, dance, poetry, and text reading, although there was no immersive technology available at that time.

As VR technology is becoming available and affordable for non-professionals, many musical applications have been developed to synergize the immersive effect of VR. These include musical instruments that allow users to interact with musical objects within a virtual environment [1, 2, 3, 4], embedded systems for cognitive and motor rehabilitation [5], interactive theatre performances [6], and immersive music video [7], musical gaming [8], VR live music performance [9], and other forms of entertainment. These applications provide isolated treatment, enjoyment, or entertainment on an individualized basis; however, to date, no approach has been developed for implementing VR technology in large-group, synchronized live events. The rest of this paper illustrates the technical details of an interdisciplinary approach that can be used to incorporate sound, music, and VR in a multimedia performance installation, and provides an example of the implementation of the approach.

3. SOUND AND MUSIC PERFORMANCE WITH VIRTUAL REALITY

3.1 Performance Practice

The performance approach presented in this paper allows interactions between the visual and audio content performed live by musicians and artists, creating for the audience an immersive experience of both types of content using VR technology and spatial audio. Performative elements such as prerecorded samples, visual effects, synthesized sounds, and prepared music can be structurally performed in a timely manner with scores or any other forms of instructions, or they can be improvised interactively depending on the themes and the performance practices adopted. The following subsections detail the required hardware and software, technical settings, and considerations needed to implement this performance approach.

3.2 Synchronization of the Visual Content

One of the key issues with the current performance approach is how to synchronize the visual content of each head-mounted display. Ideally this would be done by uploading the immersive video onto a 360-degree video platform, providing the audience members with access, and instructing them to play the video at the same time. However, this solution is unsatisfactory when there is unstable bandwidth, which may pause and further delay some of the visual content. To ensure synchronization among the head-mounted displays and the sonic and music performance, 360-degree live video streaming is used instead of pre-uploading to the video platform. Video files that contain the visual content of the performance are prepared, including all of the workflows to record, edit, and render the videos. These videos can be transmitted from one to another in real time using live streaming software.

Some live streaming software, such as the Open Broadcaster Software[1] shown in Figure 1, allows the live streaming of 360-degree video to an appropriate online platform with all of the necessary networking and streaming settings available for tailor-made performances. Wi-Fi hotspots must be available to the audience at the performance venue to minimize the risk of disrupting their video streaming. Stress tests should also be implemented to determine the video bitrate of the video streaming and to determine whether the server computer is capable of live streaming a high-resolution 360-degree video without any dropped frames. Taking into consideration the balance between the fluency and clarity of video and the bandwidth limits of the server and mobile devices, a video bitrate between 2500 kbps and 3500 kbps is appropriate for mobile data consumption over a 2-hour performance. The resolution of video files should be set to 4 K with a frame-rate between 24 fps and 30 fps.

Figure 1. Live streaming Open Broadcaster Software and bandwidth stress testing.

[1] https://obsproject.com/

3.3 Bring Your Own Device (BYOD) – Smartphones for VR Display

Unlike Bluetooth headphones, which are cheap to purchase for the purpose of a silent disco [8], the high cost of integrated head-mounted displays is one of the main barriers against the use of VR technology in live performances for large audiences. The current approach adopts a bring-your-own-device strategy, allowing the audience members to use their own smartphones as a display unit with the smartphone mount provided. Audience members are provided with a QR code and a URL that direct them to the live streaming webpage, which triggers the app to view the 360-degree video. YouTube is used as the online video sharing platform in this performance approach due to its popularity and the availability of 360-degree live video streaming.

3.4 Spatial Sound and Music

Spatial audio is available for some online video-sharing and social media platforms such as YouTube and Facebook, allowing users to upload 360-degree video in an appropriate format with spatial audio embedded. However, to achieve a live interactive performance, the immersive sound and music effects are performed rather than embedded in the video. This can be achieved by the positioning of multi-channel surround-sound speakers or by having performers walk around the venue with portable speakers and sound-generating units.

Various computer and electronic music performance practices can be adopted, depending on the thematic content of the performance and the availability of computer equipment. Live coding, electronic improvisation, sample-based synthesis, and ambient noise performance are viable options for the performance approach presented in this paper.

Although the visual content of each head-mounted display is synchronized via live streaming, there may be time differences of several seconds among the audience members due to the latency of live streaming. Therefore, sound and music performative content that requires exact timing with the visual content is not feasible.

4. PERFORMANCE EXAMPLE – TRAM (DING DING) TOUR

The example performance presented here is a solo work by the author of this paper, which adopts a tram tour as its theme. A tram is popularly known as a “Ding Ding” in Hong Kong because of the iconic double bell that is rung to warn pedestrians of its approach. Trams are also a significant cultural icon of Hong Kong because they have been running through the urban areas of Hong Kong Island for more than a century. This theme was chosen because of its capacity to showcase the immersive characteristics of VR technology and spatial audio. The following subsections detail the preparation and implementation of the tram tour performance, which adopts the approach presented in this paper.

4.1 Visual Content

All trams in Hong Kong are double-deckers with enclosed balconies, with two open-balcony tourist trams available for private hire. One of the open-balcony trams was hired because of the need to film 360-degree video to capture the full cityscape during the 2-hour trip. Figure 2 shows a screen capture of the 360-degree video presented as a panorama before any rendering and editing.

Figure 2. Screen capture of the 360-degree video presented as a panorama.

The performance aimed to virtually reproduce the tram trip with ambient sound and music spatially performed to create a fully immersive experience; therefore, the visual content consists only of the 2-hour tram trip video without any transition or visual effects involved. The video was rendered in 4-K resolution with a 24-fps frame-rate.

4.2 Audio Content

Ambient sounds, including the famous double bell ring, noise from pedestrians and passengers, and environmental sounds, were captured with a portable recorder during the tram trip to constitute the ambient audio components of the performance. Significant and symbolic cues such as the double bell ring were sampled, to be triggered during the performance as part of the musical content. The musical content comprised an electronic improvisation during a live set by the performer. Figure 3 shows the live set, which included a gird controller that triggered the samples through Ableton Live.

Figure 3. Live set of the performance.

4.3 Performance Preparation

Four-channel speakers connected to the live set were positioned in each corner of the performance venue: a computer classroom with Wi-Fi hotspots to provide stable bandwidth. All audience members were provided with a smartphone mount and were instructed to scan the QR code projected on the screen to view the live video stream. Once the display units were ready, the performer triggered the live stream on the server and performed the electronic improvisation while interacting with the visual content.

Audience members may encounter virtual reality sickness after exploring to the virtual environment for a period of time [11]. They were informed to take off the headset and recess for a while whenever they feel uncomfortable. The 360-degree video was also rendered as a little planet video and was projected onto the screen during the performance, in case any of the audience members felt dizzy while experiencing the virtual trip and needed to take off the headset for a while. Figure 4 shows how the performance was conducted in a computer classroom.

Figure 2. The Tram Tour live performance with VR technology in a computer classroom.

5. FUTURE WORKS

The performance approach presented in this paper was driven by recently available and affordable VR technology, including a 360-degree live streaming software platform, low-cost action cameras, VR headsets, and a mobile app for viewing 360-degree live video content. Future studies to incorporate VR in live multimedia performances using this approach would facilitate the further development of VR technology in the performing arts. These studies could include live performances with augmented reality on the head-mounted displays and live VR performances over the Internet.

6. CONCLUSIONS

This paper presents an interdisciplinary approach for incorporating computer music and VR practices into multimedia performance installation, allowing visual and audio content to interact in a live context. While previous performance approaches that combined music and other art forms have rarely focused on the interactivity between the musical content and other artefacts, the approach presented here attempts to fill this gap in performance

practice by incorporating VR, spatial audio, and other up-to-date digital technologies. These technologies allow access to innovative multimedia performance practices that were previously unavailable.

7. REFERENCES

[1] T. Mäki-Patola, J. Laitinen, A. Kanerva, and T. Takala, "Experiments with virtual reality instruments", *Proceedings of the 2005 International Conference on New Interfaces for Musical Expression* (NIME05), Vancouver, BC, Canada, 2005, pp. 11-16.

[2] M. Karjalainen, and T. Mäki-Patola, "Phyics-based modeling of musical instruments for interactive virtual reality", *Proceedings of the International Workshop on Multimedia Signal Processing* (MMSP04), Siena, Italy, 2004, pp. 223-226.

[3] I. Poupyrev, R. Berry, and J. Kurumisawa, "Augmented groove: Collaborative jamming in augmented reality", *Proceedings of the SIGGRAPH2000 Conference Abstracts and Applications*, New Orleans, LA, p.77.

[4] A. G. D. Correa, G. A. de Assis, M. do Nascimentom I. Ficheman, and R. de D. Lopes, "GenVirtual: An augmented reality musical game for cognitive and motor rehabilitation", *Proceedings of the Virtual Rehabilitation Conference*, Venice, Italy, 2007, pp. 1-6.

[5] F. Berthaut, M. Desainte-Catherine, and M. Hachet, "Drile: An immersive environment for hierarchical", *Proceedings of the 2010 Conference on New Interface for Musical Expression* (NIME10), Sydney, Australia, pp. 192-197.

[6] M. McGinity, J. Shaw, V. Kuchelmeister, A. Hardjono, and D. Del Favero, "AVIE: a versatile multi-user stereo 360° interactive VR theatre", *Proceedings of the 2007 workshop on Emerging displays technologies: Images and beyond: The future of displays and interaction* (EDT07), San Diego, CA.

[7] M. B. Korsgaard, "Music Video Transformed", *The Oxford Handbook of New Audiovisual Aesthetics*, pp. 501-524.

[8] Z. Lv, A. Halawani, S. Feng, S. ur Réhman, and H. Li, "Touch-less interactive augmented reality game on vision-based wearable device", *Personal and Ubiquitous Computing*, Vol. 19, no. 3, pp. 551-567, 2015.

[9] S. deLahunta, "Virtual reality and performance", *PAJ: A Journal of Performance and Art,* vol. 24, no. 1, pp. 105-114, 2002.

[10] R. E. Dobda, "Applied and proposed installations with silent disco headphones for multi-elemental creative expression", *Proceedings of the 2013 Conference on New Interface for Musical Expression* (NIME13), Daejeon and Seoul, Korea, pp. 69-72.

[11] B. K. Wiederhold, and S. Bouchard, "Sickness in virtual reality", *Advances in Virtual Reality and Anxiety Disorders*, pp. 35-62.