AoEs: Enhancing Teleportation Experience in Immersive Environment with Mid-Air Haptics

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Figure1: We introduce Area of Elements (AoEs), a new haptics technology that augments multiple tactile sensations in the immersive environments for enhancing the teleportation experience. The scenario of teleporting to another environment:(a) staying in the desert, (b) opening the portal, (c) walking through the portal and (d) closing the portal. More specifically, (e) a user can receive visual, auditory and tactile feedback from both scene (desert and snow) by utilizing our steerable mid-air haptics device and wearing the HMD with earphones.

ABSTRACT

To alleviate cybersickness in the immersive virtual reality (VR), teleportation is a common method of moving around in virtual spaces. Although users can receive the visual and auditory feedbacks from their first-person perspective with the advances of immersive head-mounted displays (HMD), they do not have the haptic experience when they teleport to another environment. Based on the immersive HMD, many research groups have shown that haptic feedback is one of the important key to enhance the immersive experience in the virtual reality. However, to simulate the haptic feedback from different environments e.g. desert and snow, it require many devices in the real environment to simulate the sun, airflow, humidity and temperature. In this work, our main concept is to provide a haptic tower in the room-scale VR, which allow the game designers to enhance the player experience in the immersive environments. We present Area of Elements (AoEs), an integration device for simulating immersive environments with haptics, which can provide two kinds of virtual environments simultaneously for teleportation experience.

CCS CONCETS

• **Human-centered computing** → **Interaction paradigms**; *Virtual Reality*

KEYWORDS

haptics; immersive virtual environment; teleportation experience

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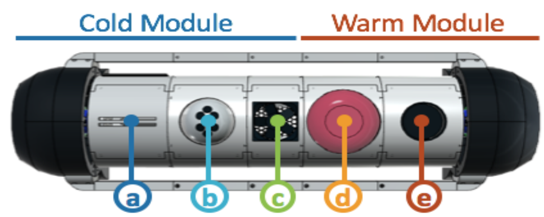

Figure2: Hardware Design of AoEs: (a) mist (b) rain drop (c) wind blow (d) heat and (e) hot air channel.

1 INTRODUCTION

To enhance the immersive experience in the virtual reality (VR) game, adding multiple tactile sensations is one of the quick and useful methods for providing strong feedback to the player, which includes kinesthesia and cutaneous feedback. TurkDeck [Cheng et al. 2015] have referred the differences between the walking experience and touching object experience. Manipulating object and moving around in the virtual space is the key to explore virtual world. Our previous work, OoEs [Han et al. 2016] has created an orb-form controller with the multiple tactile sensation, which let the user receive related haptic when they bending elements in the immersive game such as heat, air-blow, vibration and reaction force. SoEs [Chen et al. 2016] has shown an attachable case for enhancing VR controller, which simulates the haptic feedback when the player manipulates the virtual tool in the immersive environment e.g. playing as blacksmith. The player can receive heat and reaction force when they strike while the iron is hot. However, those are the haptic feedback only for enhancing the haptic feedback only for enhancing the manipulation experience.

Additionally, haptic technology also enhances the immersive experience when user moving around in the virtual space. Birdly [Rheiner 2014] utilized a motion-platform and an electric fan to provide a bird flying experience. Han et al. [2015] utilized three electric fans to simulate the experience of flying with rope. Jain et al. [2016] also utilized the motion-platform and peltiers to simulate the scuba diving experience. AmbioTherm [Ranasinghe

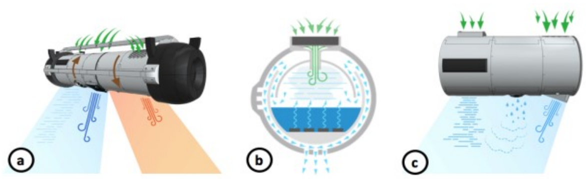

Figure3: Hardware Design of (a) the airflow in our steerable device, (b) mist channel and (c) cold module.

et al. 2016] utilized wearable devices to simulate the ambient temperature and wind condition in the virtual environments. Those simulators can provide haptic feedback when users are moving, especially to a far distance. With the development of tracking technology, walking around by feet in VR can be easily done, and the haptic feedback in the virtual environments can be enhance by setting devices in the physical space. Hülsmann et al. [2014] utilized fans and infrared lamps on the top of the CAVE to enhance users' state of presence in VR application. Turkdeck [Cheng et al. 2015] has shown a large-scale prop-based haptics for simulating the structure of environments based on labors. Although those works have been very successful at giving users the experience of moving or walking in VR with haptics, they are not well suited for recreating the experience of teleportation.

To create the teleportation experience with haptics, we need to simulate two virtual environments in the portal simultaneously with each of multiple tactile sensation. In this work, we design a steerable device (as Figure 2) which provides cold module and warm module for simulate two different scenes. In addition, we also consider that the different combination of channels brings about varying results, especially, the humidity and coldness in the air.

2 IMPLEMENTATION

The hardware design of AoEs is shown in Figure 2. The device is divided into two parts, the cold module and the warm module, each module has their own axis of rotation which can simulate two virtual environments with haptic simultaneously as Figure 3a. The cold module consists of three channels: (1) mist, (2) rain drop and (3) wind. The mist channel, shown in Figure 3b, utilize four ultrasonic mist makers and an electric fan (3300 rpm) to create and store the mist. The four mist makers are placed in a water tank, and the fan is on the top of this channel which can flow out the mist through the drain. The rain drop channel is similar to the mist channel, but utilizes seven micro-aperture atomizers which directly spray the water. The wind channel is equipped with a 8600 rpm electric fan which provides the highest wind speed 11.5m/s. With different combinations of the channels, our device can simulate varying degrees of cold environment. For example, we activate the mist channel to simulate a cool feeling (from 22°C to 19.66°C). While activating the three channels at the same time, our device can simulate even cooler and wetter environment (from 22°C to 18°C), shown in Figure 3c. The warm module consists of two channels: (1) heat and (2) hot air. The heat channel is equipped with infrared light which can make the temperature of the object increase from 22°C to 25°C. The hot air channel utilizes 110V, 1300w heat blower which not only provides the wind but also increases temperature from 22°C to 38°C. To control all the aspects described above, Arduino and Bluetooth module were used for system integration and wireless connection.

3 APPLICATION: VIRTUAL TOUR

Teleport are used to seeing in many movies, animations and video games. The players can teleport to another space or environment through a portal. This teleportation approach has usually seen in VR games to alleviate cybersickness when player moving around in the virtual space. To demonstrate our design of enhancing teleportation experience in the immersive environments with mid-air haptics, we have built a virtual tour containing with five different scenes. In this tour, we have designed each of the tactile sensation. The user can experience the first-person perspective when walking through or staying in the portal, and feeling the different haptic feedback from both virtual scenes. For example, player can walk from the snow scene to the desert scene. Then, the user will receive the visual and auditory feedback from both scene, and feeling the cold wind and hot wind simultaneously. For other teleportation experience can be seen in the video.

4 DISCUSSION AND FUTURE WORK

In this work, we present a teleportation experience with mid-air haptics, which uses a steerable mid-air haptics device. Through hanging AoEs on the top of the physical space, player can receive the combination of wind, cold wind, hot wind, wet air and heat feedback. Furthermore, applying the concept presented in this work also could be used in other interactive 360 video. Our future work will gather the user feedback to inform researchers, game makers and practitioners the playful uses of this technology.

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