Embodied Weather: Promoting Public Understanding of Extreme Weather Through Immersive Multi-Sensory Virtual Reality

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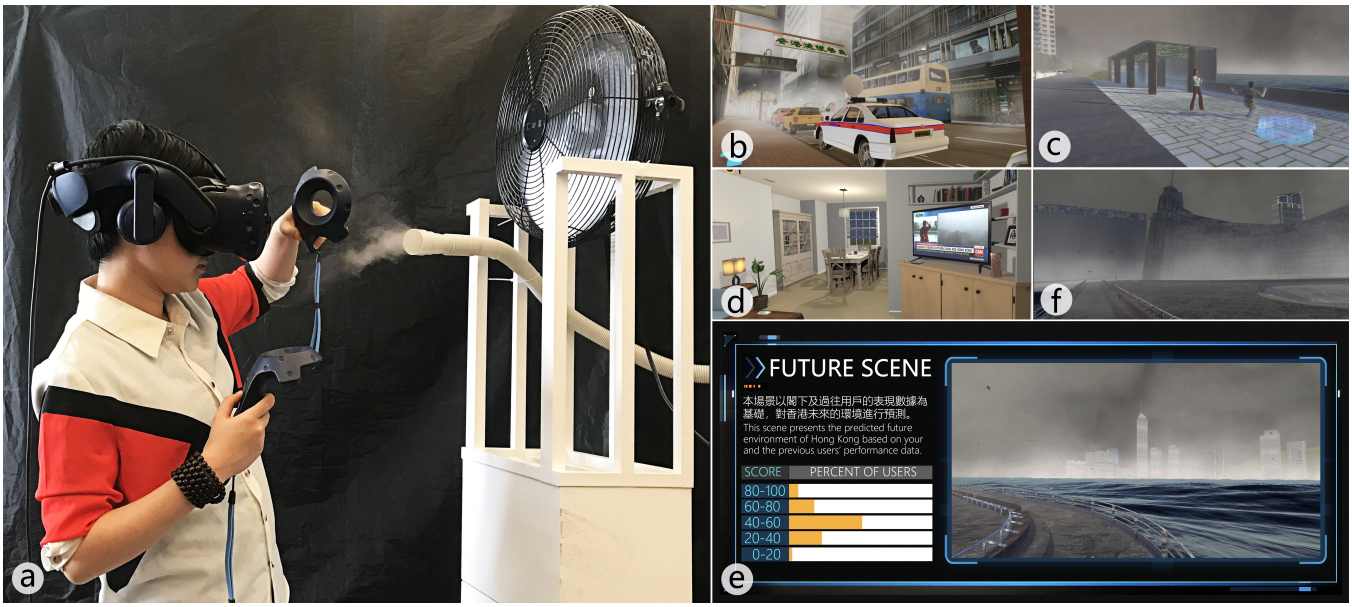

Figure 1: *Embodied Weather* system: (a) system setup with the fan and the humidifier,(b) virtual scene of Hong Kong street under typhoon,(c) virtual scene of Hong Kong harbour, (d) Interactive home environment for probing user's daily energy usage, (e) the predicted result based on all users' performance, (f) the predicted future scene.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**.

KEYWORDS

virtual reality, multisensory, extreme weather, education

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1 INTRODUCTION

Increased anthropogenic activities have been changing the earth's environment, leading to a higher frequency of extreme weather, such as typhoons, flooding, heat waves, and cold surges [Coumou and Rahmstorf 2012]. The potential for extreme weather has become severe across the globe, affecting the social, economic, and

environmental aspects of our daily life. Raising the public's understanding of these issues could reduce the impact of extreme weather. Although there are various educational materials (e.g., books, talks, documentary videos, etc.) on extreme weather, the general public still has limited understanding of the immediate and long-term impacts of extreme weather. This could be due to the lack of active user engagement in the existing educational media, as users can read books, listen to lectures, or watch videos without any further interaction. While haptic feedback in VR has shown positive effects on the user experience [Chen et al. 2018; Zhu et al. 2019], immersive multi-sensory virtual reality (VR) could be proven to be an effective medium for active learning [Dede et al. 1996]. Therefore, this technology has great potential to promote the public's understanding of extreme weather and its impact on our daily life.

In this demonstration, we present *Embodied Weather*, a multisensory Virtual-Reality (VR) installation, for promoting the Hong Kong public's understanding of typhoon, a common type of extreme weather in Hong Kong. The experience depicted in *Embodied Weather* is inspired by the actual stories and news of Hong Kong citizens and tourists who are keen to "chase" strong typhoon and often get hurt by the extreme weather. The aim is to educate the general public about the cause and the danger of typhoon, and promote everyday low-carbon behavior. *Embodied Weather* used visual feedback, audio feedback, and tactile feedback (wind and rain) to simulate the experience of typhoon in Hong Kong. In addition, we also developed an interactive home environment to prob users' usage of energy in their daily life. According to the different usage of energy, the system predicts and simulates future weather through visual, audio and tactile sensation.

2 SYSTEM DESCRIPTION

Embodied Weather was developed using Unity 2019.1, and deployed through HTC Vive VR system, including a head-mounted display (HMD), two Vive handheld controllers, and two base stations. To simulate the real-life experience of typhoon, *Embodied Weather* offered different sensory feedback controlled by the reference data (i.e., wind speed, rain volume, etc.) on different levels of the typhoon, offered by Hong Kong Observatory. As shown in Fig. 1a, the wind feedback will be generated by an external fan, and the rain/humidity feedback will be provided by a humidifier with the tune next to the fan. The fan was powered by 220V AC power with a relay module, and the humidifier was driven by a 24V5A power supply with an external motor shield (L298N). These two peripheral devices were controlled by Arduino Mega by receiving the serial signal from the VR system.

In the virtual world, the user could perform the movement of swinging hands with the VR controllers as a controlling approach for walking in VR. In addition, we built an interactive home environment which prompts the user to control the energy usage of the electrical home appliances, such as TV, air conditioner, water heater, etc., based on their everyday practices. The user could turn on and off each appliance by touching it with the VR controller and pressing the button on the controller. More importantly, we implemented an prediction algorithm based the historical climate data from Hong Kong Observatory, to simulate the future environment of Hong Kong according to the user's energy usage in VR.

3 NARRATIVES

In the VR environment of *Embodied Weather*, the user acts as an office worker in Hong Kong. When working in the office, he/she receives a notification of Storm Signal No. 8 from Hong Kong Observatory. The user's character is encouraged to leave the company and go home as early as possible. The scenario switches to the street area where the user's character is on his/her way to the subway station. The user swing the VR controllers to walk in the street, and he/she can see the street environment of Hong Kong (Fig. 1b). As the user approaching the station, the wind and the rain become stronger. The user can experience different effects of four types of weather (cloudy, drizzle, heavy rain, and storm) over time, and see the VR animation of the street being affected by the typhoon. For example, the signboards are swaying and garbages are blown by the strong wind.

In the next scenario, passing by the harbour area on the way home (Fig. 1c), the user can feel the wind and the rain becomes even stronger. In addition, he/she can see two non-player characters watching strong waves near the harbour, which is strongly discouraged by the Hong Kong government yet commonly conducted by the citizens and the tourists. The user can see the animation that these two characters are hit by the strong wave, and go to help them. When the user reaches home (Fig. 1d), he system will prompt the user to perform his/her energy-use behaviors, such as turning on/off the electrical home appliances, etc. In this gamified scenario, the user has to perform his/her energy-usage practices within 100 seconds. He/she needs to find and turn off the home appliances which are operating in the house.

In the end, *Embodied Weather* presents the user's performance of energy usage, and presents the predicted future environment of Hong Kong (Fig. 1e & f) based on his/her and the previous users' performance data. The purpose is to educate the user about the relationship between the usage of energy in daily life and future climate in our interactive game.

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