Sophroneo: Fear not. A VR Horror Game with Thermal Feedback and Physiological Signal Loop.

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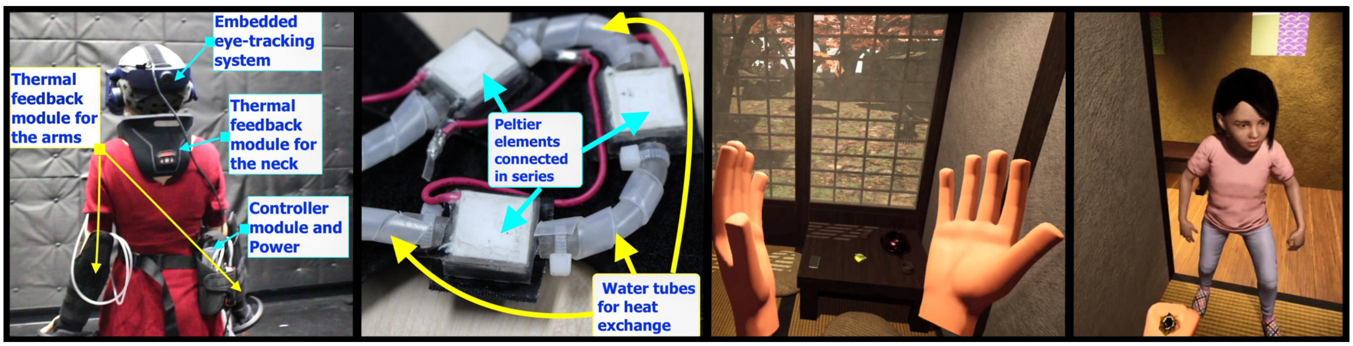

Figure 1: Overview of the Thermal Feedback setup and the VR environment.

ABSTRACT

We present "Sophroneo: Fear not", a VR horror experience with thermal feedback interface. To emphasize the supernatural side of the experience we introduce several innovative approaches, such as long intense cold feedback, liminal audio and physiological feedback loops. We built a wearable thermal feedback setup with water-cooled Peltier TEC elements for long cold sensations to improve the immersion and to increase the sense of fear and unease. At several points of the experience the player will have to close their eyes and interact with the VR environment depending on their other senses alone.

KEYWORDS

Thermal Feedback, Eye-Tracking, Virtual Reality, Liminal Audio, Sensory Supplementation

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1 INTRODUCTION

In modern games, player's physiological signals and thermal feedback are rarely used. For this project we have developed a wearable thermal feedback system covering player's forearms, palms and the neck. To explore the possibilities of thermal feedback we have designed a game in a way that requires the players to rely only on the physical sensations and perform certain interactions with their eyes closed during several points it the game. To increase the sense of immersion we connect user's physiological signals to the game environment. The game experience affects the player's emotional state and physiological readings (e.g. heart or respiration rate), which in return changes the experience itself, forming an implicit feedback loop. Quantification of cross-modal effects is very difficult due to their liminal or subliminal nature, which makes projects utilizing such approaches even more interesting from both the research and entertainment perspectives.

The major contributions of this project include three aspects: (1) Virtual Reality experience encouraging the player to utilize the cutaneous senses rather than visual. (2) Wearable thermal feedback system with water cooling for the Peltier TEC elements, providing cold and hot sensations for extremely long periods. (3) Feedback loop mechanism connecting player's physiological signals to the game environment.

2 RELATED WORK

Usage of thermal feedback using Peltier TEC elements for virtual environments is hardly novel [Benali-Khoudjal et al. 2003; Jones and Berris 2002]. The main challenge for such applications is the TEC's reaction time and it's limited heat capacity. We solve the limited heat capacity problem by using a water-based heat exchange mechanism allowing the element to stay cold for long periods. The TEC's heating or cooling time can be compensated using machine learning for motion prediction techniques [Chernyshov et al. 2018].

Presenting subjects with a false representation of their internal physiological events (such as heart beats) has been shown to have a significant effect on the subject's self assessment and judgement [Ehlers et al. 1988; Valins 1966]. We are using similar feedback loops to induce a sense of fear by playing back the sounds of the player's heart beat at a slightly increased rate.

3 DESIGN

This presented work is a VR horror game with the main focus on the thermal feedback. According to psychologist John B. Watson's fear theory, humans are not afraid of anything until something causes them to fear [Watson 1924]. In order to connect with the player's individual fear experiences, we set the game in a traditional Japanese horror style and use Japanese the folklore spirit Zashiki-Warashi ("guest room spirit") for inspiration. Zashiki-Warashi are spirit-like beings living in "zashiki" (storage or guest rooms) from Japanese folklore [Sasaki 1924]. In the game, a new resident Lee (player's character) recently moved into a big old Japanese house while occasionally a little-girl-like being visits him (Fig.1).

Cold shivers are often associated with the supernatural [Tandy and Lawrence 1998]. To simulate this, we use thermal feedback on both arms and the neck. In the presented game the player will have to interact with invisible game entities that can be perceived as cold when the player's hand is pointed towards them. To make a more convincing demonstration of the capabilities of our setup, we require the player to close the eyes when performing certain interactions with the in-game supernatural entities (e.g. finding a spirit in the room, fighting with a spirit, etc).

In order to provide a more immersive experience we are connecting certain in-game parameters to player's physiological signals. For example, the lighting and acoustic landscape of the game are connected to the heart or breathing rate of the player. During the intense moments we are replaying the sounds of a beating heart and breathing at a rate slightly higher than the players' to lead them to believe that they are more scared than they actually are. This would in turn increase the breathing and heart rate, resulting in a feedback loop enhancing the immersion.

4 IMPLEMENTATION

The experience is created using the Unreal Engine 4. Hardware control is implemented in a separate program.

The thermal feedback system consists of 4 modules: power and control module, left and right hand, and a neck modules. In order to provide long-lasting cold sensations we designed a miniature water cooling system for the Peltier TEC modules. See Fig.(1. The thermal sensations are provided by 7 15×15 mm TEC Peltier elements; 3 on the palm and 4 on the inner side of the forearm. TEC elements on each hand are split into 3 individually controlled groups: palmar (3), lower forearm (2) and upper forearm (2). TECs are connected to the water cooling system in series. Vibro-Haptic feedback is given via handheld controllers or the LRA actuators built into the gear.

The power and control module uses 433/915 MHz ISM band radio for communication. Each TEC group is powered through it's own low ripple step-down converter capable of reversing the current polarity to provide both hot and cold sensations on the same element. Low ripple current is necessary to keep the TECs efficient, especially in cooling mode. The system is powered from a 7.4V 4000mAh LiPo battery.

The soundtracks are using traditional Japanese taiko drums and shakuhachi flutes. Much of the sound design within the game is comprised of low-level room noise, amplified to create an uneasy feeling. This approach is used frequently in horror films and the works of experimental filmmakers such as David Lynch [Van Elferen 2012]. Studies have shown that exposure to 10-19 Hz low frequencies can cause cold shivers, feelings of depression, and experiences of seeing apparitions in your peripheral vision [Tandy 2000; Tandy and Lawrence 1998]. These sonic approaches place the user in a horror-esque environment.

5 CONCLUSIONS

We introduce several novel approaches to immersive experience design. We demonstrate that thermal feedback can be used for interaction and navigation in VR with or without visuals.

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