2025 IEEE World Haptics Conference (WHC)
Suwon Convention Center, Suwon, Korea
July 8 ~ 11, 2025

Demonstration of Thermal Flow Illusions with Tactile and Thermal Interaction

Yatharth Singhal   Daniel Honrales   Haokun Wang   Jin Ryong Kim

***Abstract*—We present thermal motion, a novel interaction technique that creates the illusion of flowing thermal sensations by combining thermal and tactile actuators. Using dynamic thermal referral across multiple tactile points, users perceive moving thermal cues delivered through a sleeve worn on the forearm. Our demonstration supports multiplayer experiences, allowing participants to collaborate or compete while receiving synchronized thermal feedback. This highlights thermal motion's potential to enhance immersion and engagement in shared virtual environments.**

***Index Terms*—Thermal Motion, Thermal Feedback, Haptics, VR, Thermal Referral, Thermal Masking**

I. Introduction

Our demo introduces thermal motion, a novel technique that creates the illusion of moving thermal sensations by combining thermal and tactile actuators. Utilizing dynamic thermal referral illusions across multiple tactile points, this method enables users to perceive shifting thermal cues [1]. By precisely coordinating thermal and tactile activation near the skin, the system generates strong and localized thermal illusions, significantly enhancing the realism of VR experiences.

This approach offers several advantages. Unlike traditional systems that require dense actuator arrays, thermal motion achieves dynamic thermal effects with fewer actuators, reducing hardware complexity and cost. Its thermal referral technique provides precise control over temperature movement, enhancing realism while maintaining efficiency. These features make thermal motion a scalable and cost-effective solution for integrating dynamic thermal feedback into VR. For detailed methodology and experimental validation, refer to [2].

Figure 1 showcases our prototype, a sleeve-shaped device that provides dynamic thermal and tactile feedback on both sides of the forearm. Each side features four vibrotactile and one thermal actuator, allowing for customizable sensations. The forearm's sparse thermal receptors are ideal for strong thermal illusions, with direct skin contact ensuring consistent feedback. The thermal actuators (S043A030040, TEGWAY) are flexible Peltier-based devices paired with heatsinks for efficient heat dissipation. For vibrotactile sensations, we used ERM actuators (Tatoko, B07PXZSP7J) that deliver 1.5 N of force and 125 Hz vibrations at 3V, with precise intensity control via MOSFET modules and power supply. This setup enhances user engagement in VR by enabling precise tactile and thermal control.

All authors are with the Department of Computer Science at the University of Texas at Dallas. email jin.kim@utdallas.edu

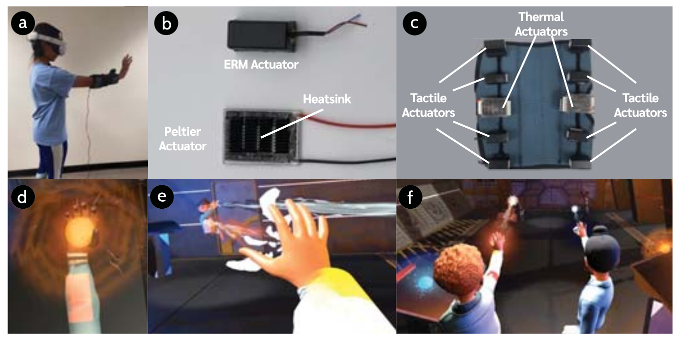

Fig. 1. a) A user wearing the sleeve interface, b) Thermal and Tactile actuators, c) close up of thermal sleeve, d) VR view of user interacting with the orb, e) competitive play, and f) collaborative play.

II. Demo Experience

At WHC 2025, we demonstrate the potential of thermal motion through two multiplayer VR experiences: Collaborative Play and Competitive Play. Participants will wear thermal sleeves capable of delivering dynamic hot and cold motion patterns synchronized with their virtual actions. In Collaborative Play, users work together to defeat robotic enemies by absorbing red (hot) or blue (cold) orbs through a fist gesture, feeling a thermal motion from wrist to elbow during charging and from elbow to wrist when discharging power as a laser beam. Synchronizing attacks amplifies thermal and vibrational intensity, encouraging teamwork. In Competitive Play, users face each other, using fire and ice powers to deplete the opponent's health. Upon being hit, users feel outward thermal motion from the center of the arm, while defensive moves create an inward sensation. Temperatures and intensities vary dynamically as players clash. The demo setup includes instructions, fitting the sleeves and headsets, and a brief calibration to align physical and virtual spaces. Attendees will experience both VR scenarios, with the full demonstration, including setup and interaction, taking approximately 5 minutes per participant.

References

[1] B. G. Green, "Localization of thermal sensation: An illusion and synthetic heat," *Perception & Psychophysics*, vol. 22, no. 4, pp. 331–337, 1977.

[2] Y. Singhal, D. Honrales, H. Wang, and J. R. Kim, "Thermal in motion: Designing thermal flow illusions with tactile and thermal interaction," in *Proceedings of the 33rd Annual ACM Symposium on User Interface Software and Technology*, ser. UIST '24, 2024.