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Demonstration of Thermal Masking: When the Illusion Takes Over the Real

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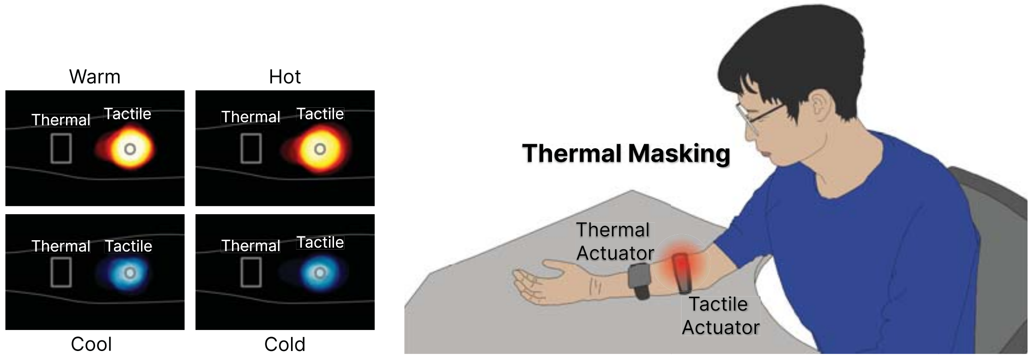

Fig. 1. We demonstrate a novel interface that can deliver thermal sensation to the location of tactile cues. The concept diagram shows a user wearing the setup system where the thermal actuator is placed at the center of the forearm and the tactile actuator is placed at the upper arm. The perceived thermal sensation is shown as a red area with an arrow pointing.

***Abstract*—We present a novel wearable thermal interface that delivers localized temperature sensations on the forearm without requiring a thermal actuator at the perceived location. This effect is achieved through thermal masking, a perceptual phenomenon that synthesizes thermal referral and tactile masking—causing users to perceive heat or cold at the site of a vibrotactile cue, rather than at the location of thermal actuation. Implemented in a sleeve-style form factor, our system demonstrates how this illusion enables spatially flexible, perception-driven thermal feedback across a large skin area.**

I. Introduction

Thermal feedback plays a crucial role in enhancing immersion in virtual and augmented reality (VR/AR), while current technologies face challenges in delivering spatially resolved sensations. Existing methods—such as Peltier-based arrays, water flow, or mid-air infrared heating—are often power-intensive, bulky, or difficult to scale across larger body regions. In contrast, vibrotactile actuators are inexpensive, compact, and energy-efficient. Our system integrates both modalities by combining a single thermal actuator with one or more vibrotactile actuators to induce thermal illusions at arbitrary, actuator-free locations.

This effect builds on earlier findings where users perceived warmth on a finger receiving only vibration, when adjacent fingers were thermally stimulated [1]. We extend this principle beyond the fingers to larger body areas, demonstrating thermal masking effects up to 24 cm away from the actual heat source—including across the medial axis of the forearm. By selectively activating vibrotactile cues, our system allows users to experience heat or cold precisely where they feel touch—even though thermal energy is applied elsewhere.

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The prototype consists of Velcro-mounted actuators placed along the forearm. The thermal actuator is a curved-surface Peltier element (30 mm × 40 mm × 2.3 mm) capable of raising or lowering the local temperature by +3°C or -5°C relative to skin temperature. Vibrotactile cues are generated using a coin-style eccentric rotating mass (ERM) motor (10 mm × 3 mm), operating at 175 Hz (10 mN) for warmth and 225 Hz (14 mN) for coolness. A digital power supply (Korad KD6005P) ensures stable and precise actuation control.

At IEEE WHC 2025, we will demonstrate three spatial configurations of thermal masking: (a) Short-range illusions within 8 cm of the heat source, (b) Extended illusions reaching up to 24 cm along the forearm, and (c) Cross-arm illusions that project thermal sensations to the opposite side of the arm.

II. Demo Experience

During the demo, participants will wear the actuated straps at user-defined positions. Upon activation, they will experience thermal sensations in areas where no thermal actuator is physically present. Each session is designed to be brief and intuitive, lasting under two minutes per participant. This demonstration showcases thermal masking as a powerful interaction technique—offering a scalable, lightweight, and perceptually rich solution for next-generation thermal interfaces in immersive environments.

References

[1] H. Wang, Y. Singhal, H. Gil, and J. R. Kim, "Thermal masking: When the illusion takes over the real," in *Proceedings of the CHI Conference on Human Factors in Computing Systems*, ser. CHI '24. New York, NY, USA: Association for Computing Machinery, 2024. [Online]. Available: https://doi.org/10.1145/3613904.3641941