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

A Wearable Haptic Module Delivering Co-Located Suction and Thermal Feedback for Head-Mounted Displays

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***Abstract*—We developed a wearable haptic module that provides co-located tactile and thermal feedback by combining a transparent suction port and a high-power LED. The transparent suction interface, fabricated via resin-based 3D printing, transmits light while applying suction pressure to the skin. Its thin design enables easy integration into head-mounted displays (HMDs), supporting immersive, hands-free VR experiences. A prototype demonstration highlights the potential of this system to enrich VR interactions.**

***Index Terms*—Thermal, Suction, Wearable Devices, HMD**

1. Introduction

In VR experiences, enhancing immersion can be effectively achieved through multisensory presentation. While individual modalities such as tactile and thermal stimulation have been studied, simultaneous and co-located presentation of multiple sensations is still a challenge. We propose a wearable haptic module that presents co-located tactile and thermal feedback—specifically, the sensation of contact (pressure) and warmth—at the same skin location.

Wolf et al. [1] developed a system combining vibrotactile and thermal feedback via embedded vibrator and Peltier devices. However, vibration tends to propagate across regions, making spatially precise pressure feedback difficult. Our approach enables more localized stimulation by combining suction and thermal input.

2. System Overview

The haptic module consists of a high-power LED (Chanzon High Power LED Chip 10W Cool White, Shenzhen Chanzon Technology Co., Ltd.) and a transparent suction port fabricated using resin-based 3D printing (BioMed ElasticResin50A, Formlabs). Micro suction holes densely arranged on the surface provide localized suction pressure for tactile feedback. The LED is positioned behind the transparent interface, allowing visible light to reach the skin surface and deliver radiant thermal feedback.

The thin design of the module allows embedding into the cushion area of HMDs, supporting wearable and hands-free interaction. As shown in Fig. 2, the device can present multiple haptic modalities—including suction, thermal, and their combination—synchronously with virtual events.

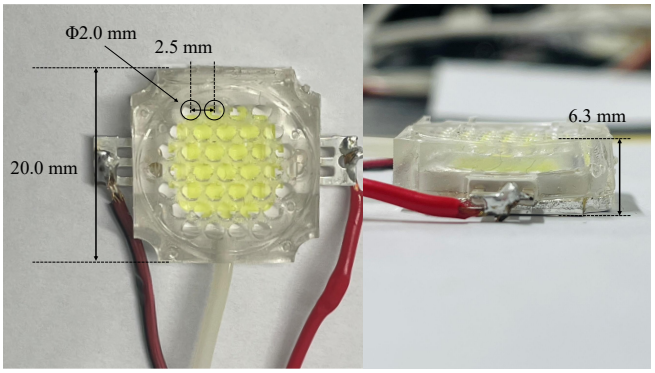

Figure 1. Suction and thermal haptic module.

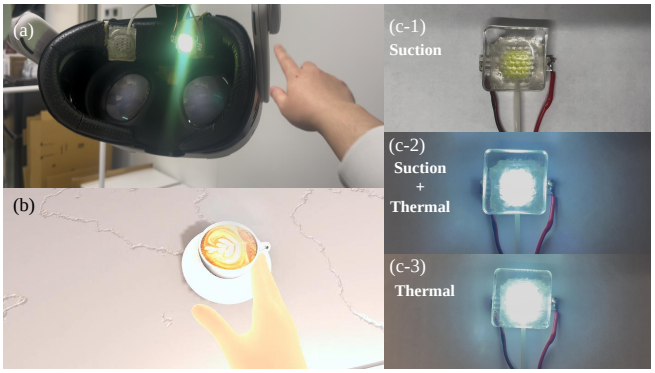

Figure 2. Prototype of the suction and thermal haptic module integrated on an HMD. (a) Haptic module mounted on Meta Quest 3. (b) VR scene interacting with a coffee cup. (c) Three haptic states: suction only, suction + thermal, thermal only.

Acknowledgments

This work was supported by JSPS KAKENHI Grant Number JP23K19992.

References

[1] D. Wolf, M. Rietzler, L. Hnatek, and E. Rukzio, "Face/On: Multi-Modal Haptic Feedback for Head-Mounted Displays in Virtual Reality," in *IEEE Trans. Vis. Comput. Graph.*, vol. 25, no. 11, pp. 3169–3178, Nov. 2019.