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AirHook: An Ear-based Display for Simulating the Surrounding Airflow in Virtual Reality

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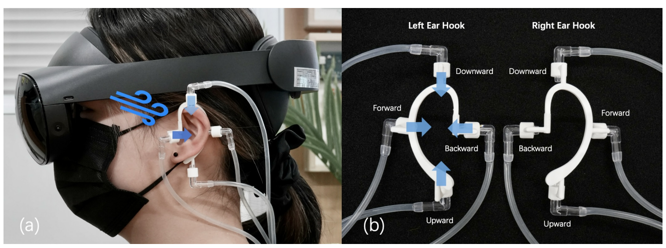

Fig. 1: (a) Left side view of a VR user wearing AirHook; (b) Top view of AirHook showing the nozzle arrangement.

***Abstract*—We propose AirHook, an ear-worn device designed to create airflow sensations around the ear region in Virtual Reality, providing a multi-directional airflow experience while improving the wearability of wind display.**

***Index Terms*—Virtual Reality, Haptics, Wind display**

I. Introduction

Wind is a natural form of haptic perception that humans commonly experience as part of their environment. To replicate this sensation in Virtual Reality (VR), airflow-based devices have been developed to enhance users' sense of presence and immersion—an approach shown to be effective across various VR scenarios [1].

To further enhance the wearability of haptic devices and reduce user burden, we propose shifting the stimulation area from the entire head to the ears. This approach takes advantage of prior findings [1], [2] that indicate the significance and high sensitivity of the ear to airflow stimuli, allowing a highly localized presentation of wind direction. VWind [3] also successfully proved the replication of virtual wind around the ear through a cross-modal effect. However, existing methods remain inadequate in delivering directional information specifically around the ear-side region, which is potentially exposed to airflow originating from any direction within the 3D VR environment. Hence, we present AirHook (Fig. 1), an ear-worn haptic display that supports multi-directional wind perception in 3D VR space through airflow.

II. Implementation

AirHook is designed as a pair of symmetrical 3D printed ear hooks worn separately on each ear (Fig. 1b). Each hook integrates four nozzles, individually connected to a 12V air pump (AP520B-120). Airflow intensity is controlled via pulse-width modulation (PWM), using a MOSFET driver module to regulate each pump.

When wind originates along one of the principal axes (forward, backward, upward, or downward), airflow is emitted through the corresponding nozzle (Fig. 1b). For intermediate directions, airflow is simultaneously output from adjacent nozzles and blended to approximate the desired vector. For example, as the wind shifts from front to top, the PWM value for the forward nozzle decreases while the upward nozzle increases equally. When the wind direction is perpendicular to the interaural axis, both ear hooks emit airflow equally. If it shifts to the user's left, the left ear hook increases airflow while the right decreases, and vice versa. During a 2-minute demonstration, users remain stationary above a terrain in VR, while the wind gradually shifts in direction, producing a range of directional airflow sensations around the ears.

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