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Helmo: Real-Time Vibrotactile Rear Warning System for Scooter Helmets

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I. Introduction

Taiwan has one of the highest scooter ownership rates globally, with 99.8 scooters per 100 people as of 2024 [1]. Among various traffic incidents, improper turning accounted for 11.18% of all accidents [2], underscoring the vulnerability of scooter riders—particularly due to blind spots. Unlike cars equipped with rear sensors, most scooters rely solely on rearview mirrors [3], limiting riders' situational awareness. Furthermore, motorcycle environments—characterized by engine and wind noise, as well as exposure to sunlight and weather—pose significant challenges to systems that rely on visual and auditory feedback [4][5]. We present *Helmo*, a wearable vibrotactile warning system embedded in scooter helmets. By delivering directional haptic feedback, *Helmo* alerts riders to approaching vehicles in their blind spots, enhancing safety without introducing additional visual or auditory distractions.

II. Prototype

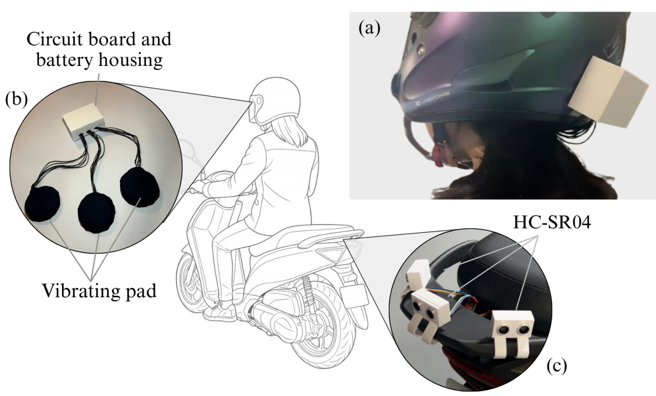

Fig. 1. Overview of the Helmo system and its components: (a) haptic helmet overview, (b) vibrator pads, and (c) distance sensor.

The *Helmo* prototype consists of two main components: a haptic helmet and a distance-sensing module. For the haptic helmet, an array of eccentric rotating mass (ERM) motors (see Fig. 1b) is arranged in three directional zones—left, center, and right—each affixed to any commercially available helmet using Velcro. Each zone contains three spatially distributed motors with intensity varying proportionally to the proximity of nearby obstacles. The motor vibration intensity was calibrated to a range between $1.9\,\text{V}$ and $5.0\,\text{V}$ to ensure perceptibility without discomfort.

The distance-sensing module transmits real-time proximity data via Bluetooth from an external unit powered by an ESP32 microcontroller. This module integrates three HC-SR04 ultrasonic sensors, each positioned at $60°$ to monitor rear blind spots (see Fig. 1c).

Furthermore, to optimize object detection in *Helmo*, we implemented a dynamic duration mechanism that adapts haptic duration based on object distance.

III. Demonstration

We employed a virtual reality (VR) setup via Meta Quest 3 for participants to experience two scenarios: one without Helmo and one with Helmo enabled. In both scenarios, the user is immersed in a busy traffic scenario with ambient traffic sound. The simulation began when users activated the turn signal via the Quest's hand-tracking feature. The user then attempts to make a turn after checking the rearview mirror and perceiving no nearby vehicles. However, during the turn, an unseen vehicle approaches from the side—outside the mirror's field of view—resulting in a simulated collision.

In the next scenario, where we use Helmo, users receive tactile cues that indicate the presence and direction of the approaching vehicle, preventing them from having traffic accidents caused by blind spots.

Fig. 2. VR view of the demonstration with instructions.

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