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A Method for Non-visual Navigation of Motorcycle Riders Using In-Helmet Haptic Feedback

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Motorcycle riders must monitor both distant traffic conditions and nearby road surface hazards, which places a high demand on visual attention. Although auditory navigation systems are available, wind and engine noise often degrade speech perception. To address this issue, this study proposes a non-visual navigation method using haptic feedback inside a motorcycle helmet.

The proposed system presents vibration stimuli directly to the rider’ s head using eight vibration actuators arranged at 45° intervals (Fig. 1). Each actuator corresponds to a specific direction, enabling intuitive spatial perception without requiring interpretation of complex patterns. This one-to-one mapping allows riders to recognize navigation cues without shifting their visual attention. Distance is encoded using three levels of intermittent vibration cycles (200, 400, and 800 ms), which are designed to be distinguishable under noisy conditions. This design was adopted because head-mounted implementations are limited in actuator number, making moving-pattern-based distance presentation unsuitable.

A perceptual experiment was conducted under three engine conditions (0, 1500, and 4000 rpm) with five participants. Each participant performed 24 stimulus conditions combining eight directions and three distance levels. Accuracy, miss rate, and reaction time were measured to evaluate perceptual performance under engine-induced vibration and noise.

As shown in Fig. 2 and Fig. 3, the system achieved a complete correct response rate of 83.3% under the high-rpm condition, compared with 85.8% with the engine off. Miss rates remained below 7.5% across all conditions. Reaction times remained within 2.5–3.0 s across all conditions, indicating no significant delay in decision making. Furthermore, most errors occurred in adjacent directions rather than opposite ones, suggesting that large directional errors are unlikely.

These results suggest that directional and distance information can be perceived under engine-induced vibration and noise. In addition, subjective questionnaire responses indicated that both tactile and vibration-related auditory cues were utilized, suggesting the potential for multimodal perception through the combination of haptic and auditory cues. These findings provide a basis for further development of non-visual navigation systems for motorcycle riders.

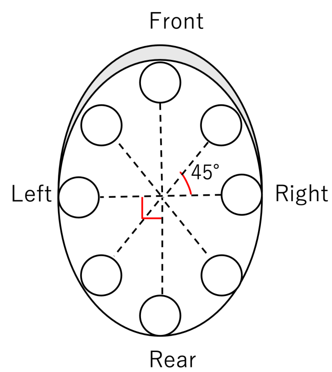

Fig.1 Arrangement of vibration actuators

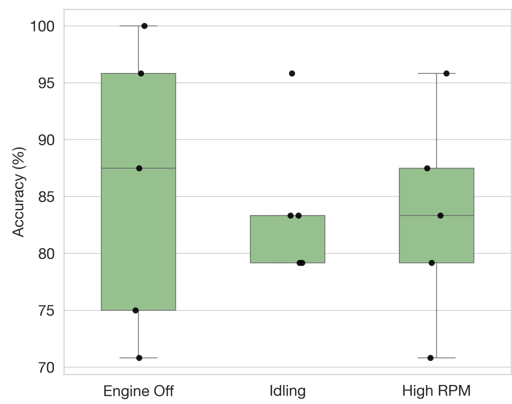

Fig.2 Complete accuracy distributions across conditions

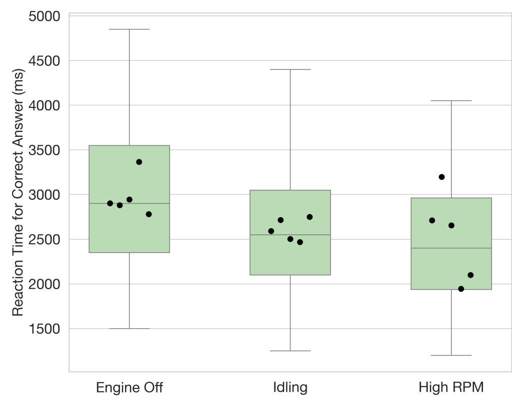

Fig.3 Reaction time distributions across conditions