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Study on Automotive Seat Vibration for Improving Driver Situational Awareness

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1. Introduction

In recent years, tactile information via seat vibration has gained attention as an alternative or supplement to visual and auditory stimuli. Tactile stimuli allow drivers to keep their eyes on the road and minimize interference with environmental sounds. This study focuses on chirp waves (frequency-modulated waves) to improve driver situational awareness and acceptance of driving assistance systems.

2. Determination of Appropriate Frequency and Acceleration

Experiments were conducted using an experimental seat equipped with 17 haptic reactors (Fig. 1). The results indicated that for notification vibrations, a frequency range of 30Hz to 120Hz and an acceleration level of 2.5G or less are appropriate to avoid driver discomfort, such as numbness or itch.

3. Design of Chirp Waves

The study found that a frequency difference of approximately 35Hz (or an acceleration difference of 1.0G) is required for drivers to perceive a smooth transition in vibration intensity (Fig. 2). Compared to sine waves, chirp waves significantly reduce perceived annoyance while maintaining high detectability (Fig. 3). Furthermore, the study clarified that "Seriousness" is primarily controlled by vibration intensity, while "Urgency" is influenced by both intensity and the Duty ratio.

4. Application to Driving Scenarios

The effectiveness was evaluated in a "Leading Vehicle Start Notification" scenario. Drivers rated chirp waves, particularly those with increasing intensity, higher than traditional sine waves because they were less annoying and more intuitive (Fig. 4). Personalizing vibration parameters to match a driver's subjective feeling of a situation further enhanced the appropriateness of the notification.

5. Conclusion

The use of chirp waves in seat vibrations is effective for enhancing driver situational awareness with high acceptance. Future work will involve investigating characteristics across different age groups and applying these findings to various driving scenarios.

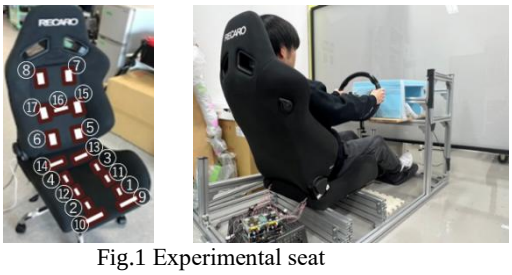

Fig.1 Experimental seat

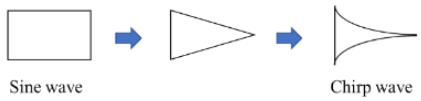

Fig.2 Illustrative Diagram of the Transition from a Sine Wave to a Chirp Wave

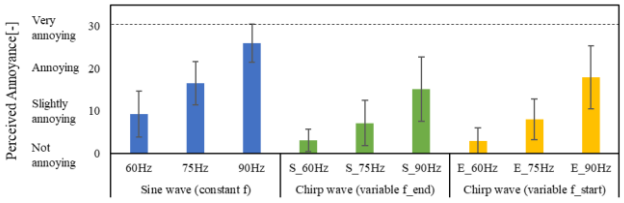

Fig.3 VAS Results for Perceived Annoyance

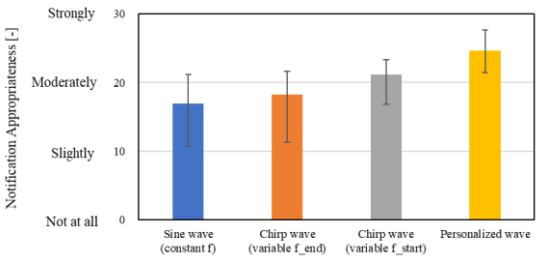

Fig.4 Video-Based Relationship between Perceived Seriousness and Urgency