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Verification of Driver Delay Time (τ_L) Caused by Human Stimuli Using a Vibrator

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In vehicle motion control, the driver performs cognition of various traffic situations and vehicle behaviors mainly through visual information. However, as vehicles gain more functions and the amount of visual information increases, there is a concern that the driver's cognitive load will increase and their decision accuracy will decrease. Therefore, in this study, we checked whether driving operation can be improved by a seat that triggers vibration-based haptic information, which can send information independently from the visual channel and uses the wide contact area of the seat.

These effects are evaluated using a method that quantitatively evaluates steering characteristics by using steering parameters such as the first-order lag time constant parameter τ_L of the driver model. This model was identified from steering angle data and lateral displacement data during lane changes, and was proposed in prior research by Abe et al. of Kanagawa Institute of Technology. The evaluation was conducted with a driving simulator that reproduces lateral acceleration equivalent to actual vehicle motion. The evaluation method starts with driving in the center lane of a three-lane course, and the driver receives directional triggers—such as LED (Light Emitting Diode) signals or vibration—at arbitrary timing. The driver then performs a lane change in the instructed direction. From the data recorded at that time, we identify the steering parameters and check differences in driving operation to determine whether cognition, decision, and operation are improved.

In this evaluation, LEDs and vibrators were used as information-trigger devices, and a comparison test was conducted. As a result, an improvement in driving operation was confirmed in 5 out of 6 drivers (Fig.1,2). From the driver's comments, when information was triggered by LEDs, the moment the light turned on, their attention and gaze were drawn to the LED. They felt a disturbance in their look-ahead point, and the timing of looking at the target point for starting the steering operation became delayed. Based on these results, information triggering through seat vibration is considered effective for improving driving operation. These results were verified by using a t-test, with the LED-based information condition used as the baseline to check superiority in each test condition.

Next, to check how visual information triggers and the resulting gaze shifts affect driving operation, gaze measurement during the test was conducted using an eye tracker. When the lane-change direction was triggered by an LED, it was found that the driver's gaze often moved toward the LED or its surrounding area, and the gaze shifted much more compared with the vibration condition (Fig.3,4). The gaze shift took about 1 second before the driver's gaze returned to the look-ahead point, and compared with vibration, the look-ahead point moved downward and the look-ahead distance became shorter.

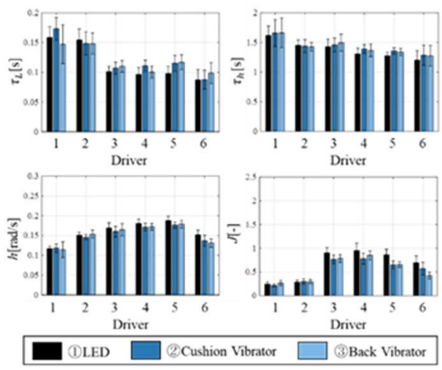

Fig 1. Steering Parameters by Direction-Indication Medium

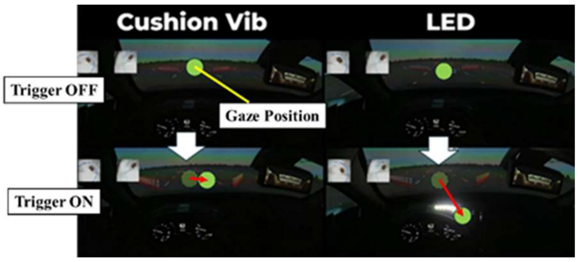

Fig 2. Gaze Measurement Using an Eye Tracker

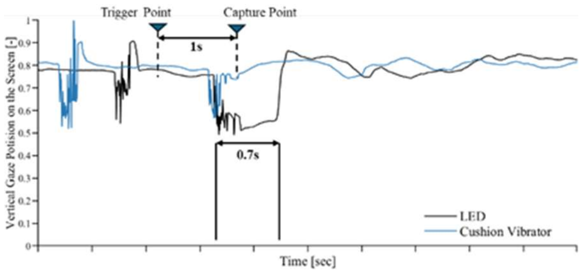

Fig 3. Vertical Gaze Position on the Screen

Through this study, it was found that haptic information triggered by seat vibration is effective for improving driving operation. In addition, by comparing test results using steering parameters such as τ_L, it was shown that the degree of influence can be captured quantitatively.