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Transmitting the Movement of Surrounding Objects through the Upper Limb Using Vibrotactile Apparent Motion

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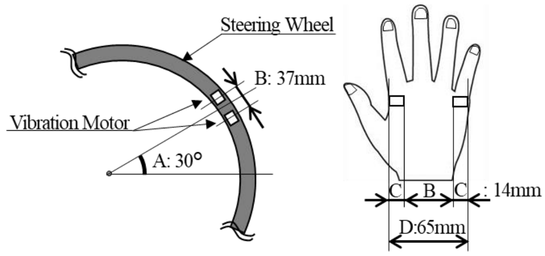
When driving a car, a driver must pay attention to the driving environment, which includes surrounding vehicles, pedestrians, traffic signs, road conditions, etc., which has a high visual workload. Furthermore, the amount of information presented to the driver has increased in recent years due to the increasing functionality of advanced driver assistance systems. If information can be transmitted through other senses rather than relying on visual information, the driver's workload can be significantly reduced. Therefore, we focused on tactile stimuli as an alternative to visual information.

In this study, we consider transmitting the movement of surrounding objects through the upper limbs using vibrotactile apparent motion. First, we identified the characteristics of the clearest apparent motion for hands and elbows by experiments (Fig.1, 7subjects, 18 to 20 years of age). Then, we identified a correspondence between visually perceived distance and the vibrotactile stimuli to the upper limbs by subjective evaluation using 5 question items (Fig. 2, 10subjects, 18 to 21 years of age).

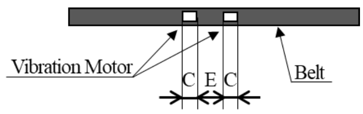
The result shows that the clearest apparent motion of "from the right hand to the left hand" and "from the right elbow to the left elbow" had the following characteristics: a duration of stimulus (DOS) of 300–400 ms and a stimulus onset asynchrony (SOA) of 300 ms. Fig. 3 shows the results of the correspondence between the visually perceived distance and vibrotactile stimuli to the upper limb. The figure shows the ratio of responses to the relative distance to other vehicles. Regarding the distance of 10 m on the driving simulator, 80% responded that the stimuli to elbows matched their visual perception. Regarding the distances 20–40 m on the driving simulator, 47.7% to 67.7% responded that the stimuli to hands matched their visual perception .

For 30 m distance that produced no responses involving the elbow, the other vehicle was at a viewing angle of 10.8°, whereas for 10 m, the viewing angle was 28.4°. From this result, it is thought that within the effective visual field (approximately 15 °) correspond to stimuli to hands, and out of the effective visual field corresponded to stimuli to elbows.

The results of this study showed the possibility of transmitting information of surrounding objects through upper limbs using vibrotactile apparent motion. As an issue for application to actual vehicles, it is necessary to clarify the difference between the field of view of the driving simulator and that of a real car, and re-examine the correspondence between the field of view and the upper limbs.



(a) Device for hands (Steering wheel)



(b) Device for elbows

Fig.1 Device for experiment

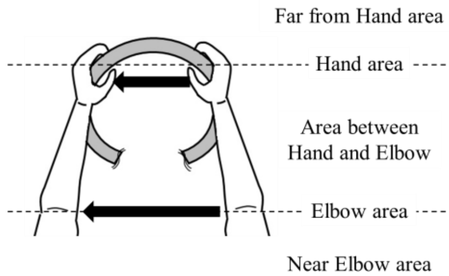


Fig.2 Question items of experiment for correspondence

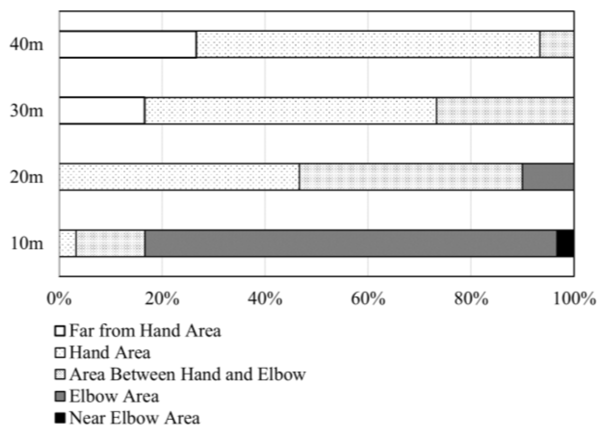


Fig.3 Experimental results of correspondence between distance of surrounding objects and vibrotactile apparent motion