Evaluation of Performance of Shared Control

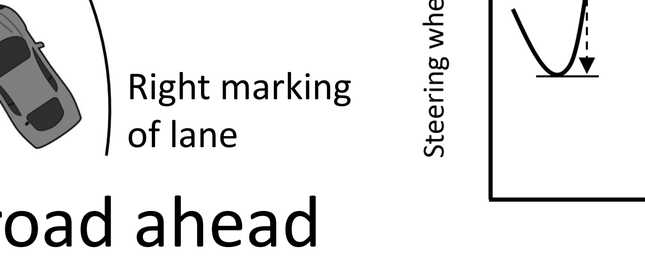
Partner: JTEKT Corporation
Fund: Grant-in-Aid for Scientific Research

Introduction

Shared control is a system controlling something cooperating with a human. A part of advanced driver assist systems of automobiles are corresponding to it. Our laboratory is conducting researches on a haptic steering guidance system as an example of the shared control.

The haptic guidance torque T_h is obtained as

$$T_h = K_1(a'_1 e'_y + a'_2 \dot{e}'_y + a'_3 e'_\theta + a'_4 \dot{e}'_\theta)$$



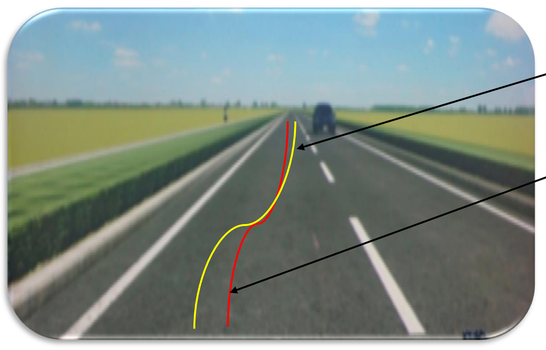
Movie of the haptic guidance

Performance Evaluation Methods

Standard deviation of lane position (SDLP)

$$\mathrm{SDLP} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \mu)^2}$$

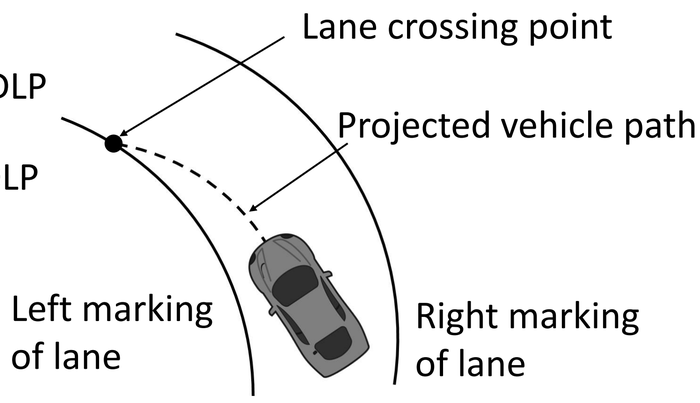
- x_i: Lateral position of vehicle,
- N: Number of samples,
- μ: Mean lateral position of vehicle.



Time-to-lane crossing (TLC)

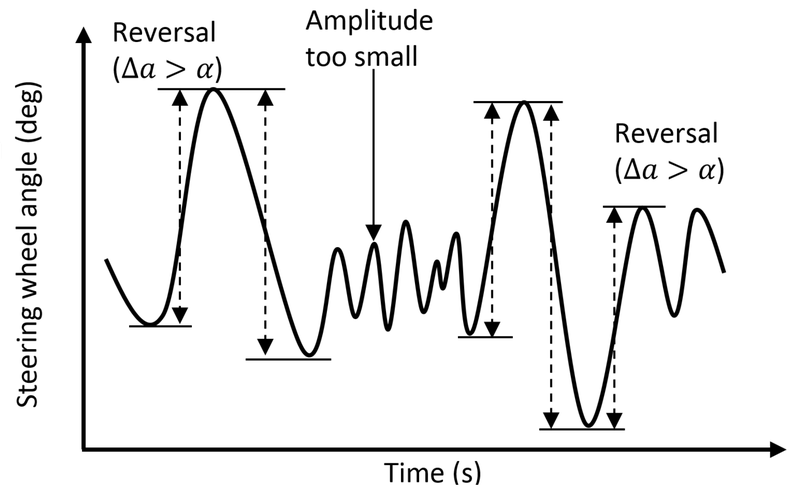
$$\mathrm{TLC} = \frac{\mathrm{DLC}}{v}$$

- v: Driving speed
- DLC: Distance to lane crossing along the projected vehicle path



Steering wheel reversal rate (SWRR)

SWRR is defined as the number of changes in steering wheel direction per minute. Reversals with the steering wheel angle signal Δa that are greater than a given gap size α (3°) were counted.



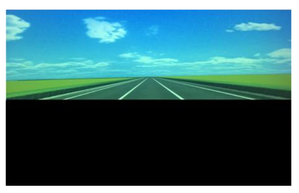
Case study of visual occlusions from road ahead

The experimental conditions combined three degrees of haptic guidance (HG): none, normal, and strong toques, with four scenarios of visual feedback (VF): whole, near, medium, and far segments.

VF whole

VF mid

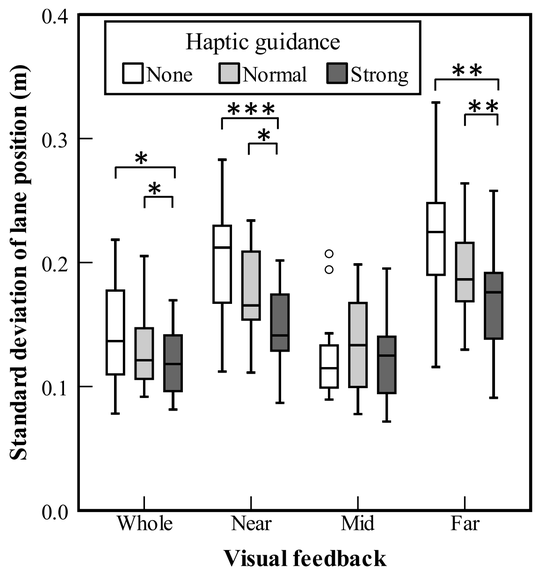
VF near

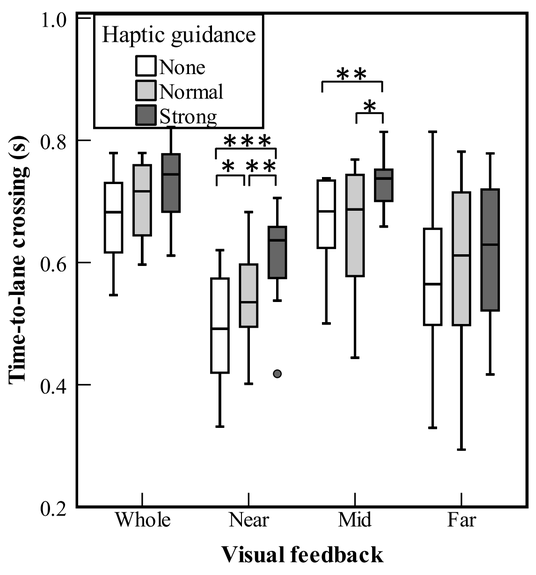


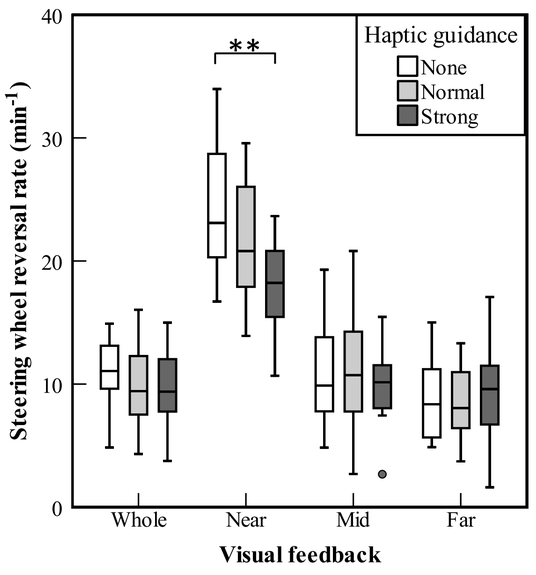
VF far

Number of participants: 12

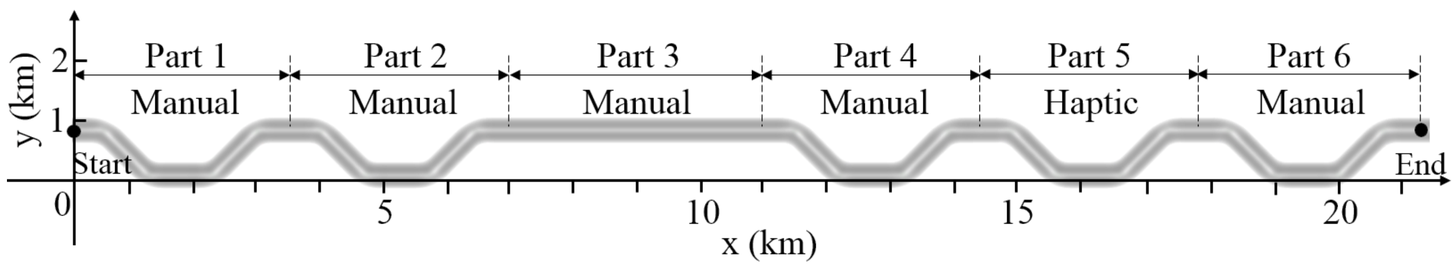
*: p<0.05, **: p<0.01, ***: p<0.001



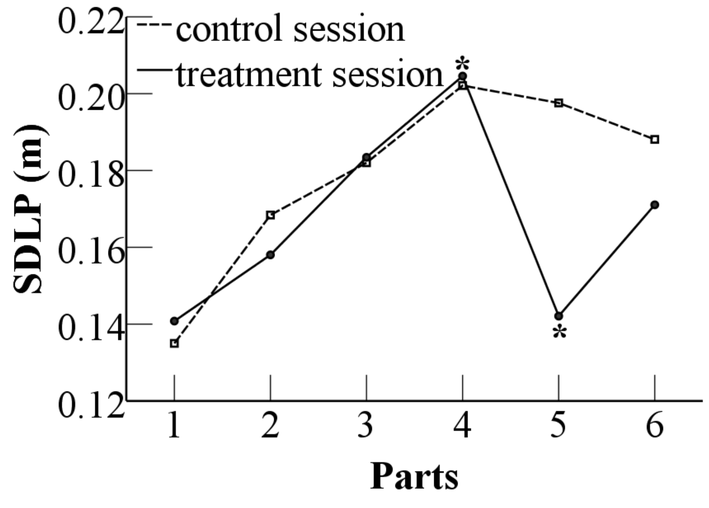




Case study of declined visual attention driving under fatigue



An experiment with 12 participants was conducted in a high-fidelity driving simulator. A treatment session was arranged with the haptic guidance system, and a control session was conducted as a comparison.



SDLP throughout the driving course

Publications

Zheng Wang, Rencheng Zheng, Tsutomu Kaizuka, and Kimihiko Nakano, “Influence of haptic guidance on driving behaviour under degraded visual feedback conditions,” IET Intelligent Transport Systems, vol. 12, no. 6, pp. 454-462, Aug. 2018.
Zheng Wang, Rencheng Zheng, Tsutomu Kaizuka, Keisuke Shimono, and Kimihiko Nakano, “The effect of a haptic guidance steering system on fatigue-related driver behavior,” IEEE Transactions on Human-Machine Systems, vol. 47, no. 5, pp. 741-748, Oct. 2017.