Evaluation of factors to reduce visual cognitive load for drivers in VR-CAR

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1. Introduction

For traffic safety, visual perception is important because drivers need to make correct judgments and operations while driving. In addition, there are several visual tasks that may cause drivers mental fatigue. Mental fatigue is a condition caused by prolonged mental activities that require work efficiency, such as driving, and is the cause of 20% ∼ 30% of traffic accidents.

On the other hand, a virtual driving environment called VR-CAR [1], which realizes an "ordered" driving environment, has been proposed for reducing visual cognitive load. Kato et al.[1] demonstrated the effectiveness of the ordering method by improving the ease of driving in the ordered environment of VR-CAR in a subjective evaluation and increasing electroencephalogram (EEG) in a relaxed state. However, since several factors such as the color, shape, and presence/absence of objects were changed in the ordered environment of Kato et al., it was unclear which factors reduced the visual cognitive load.

Therefore, in this study, we evaluated the factors that reduce the visual cognitive load in VR-CAR by changing the factors such as presence and colors of buildings.

2. VR-CAR

In this study, a virtual driving environment called VR-CAR is used to replace visual information in real-time in a real-world driving space.

In VR-CAR, the driver drives the vehicle by simply viewing a replayed VR environment in real time via a head-mounted display (HMD). Information on the actual physical space is collected using sensing technologies such as light detection and ranging (LiDAR) as necessary information for driving and is provided to the driver after being ordered.

It is expected that ordering can reduce the driver's mental fatigue by controlling the driver's cognitive visual tasks.

3. Evaluation Conditions

On the basis of the ordered environment (Order) shown in Fig.1, we created three conditions (Nothing, White, Black) in which the presence and color of buildings were changed while keeping the same conditions for appearing objects (other cars and pedestrians) and events (such as signal transitions), except for buildings (Fig.1).

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(a) Order (b) Noting (c) White (d) Black

Fig. 1 Driving Environments.

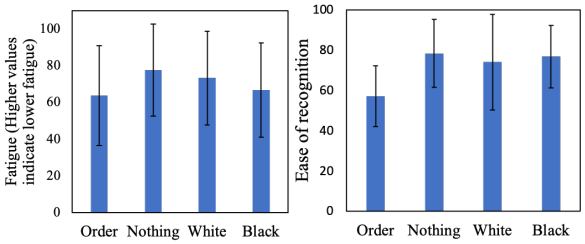
4. Results and Discussion

In the evaluation, the effects of an orderly driving environment on driving conditions and ease of driving were assessed through qualitative measurements. Participants were asked to answer two questions using a visual analog scale (VAS) with the rating axes of (1) the degree of fatigue from "strongly fatigued" to "not fatigued at all" and (2) the ease of recognizing signals and signs from "very difficult to recognize" to "very easy to recognize". The participants in the evaluation experiment were six engineering students from Tokyo Metropolitan University (average age: 22.8 years old) who had obtained a Class I regular driver's license.

As shown in Fig.2, fatigue was lower and ease of recognizing signals and signs was higher in driving environments where there were no buildings or where all colors were white or black. These results indicate that the presence or absence of buildings and the uniformity of colors are factors that reduce visual cognitive load.

References

[1] Ryoto Kato, Takashi Nishitsuji, and Takuya Asaka, "VR-CAR: Real-time Virtual Substitute for Real-world Driving Space", International Photonics 2022 (IP2022), IP5-02, April 2022.



(a) Fatigue level when driving (b) Ease of recognizing signals/signs

Fig. 2 Results of subjective evaluation using VAS.