Advantage of Head-Up Display for Automobiles

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In this paper, we evaluate a harmful influence on normal driving behavior of Head-Up Display (HUD). It is one of major concerns in the latest HUD development. We confirmed whether inter-vehicle distance varies depending on HUD display by monitoring a distance between driving vehicle and one in front when the vehicle is stopped. The result shows that HUD indication does not influence the inter-vehicle distance when stopping on the general road. Therefore, it can be concluded that the concern in the latest HUD does not hamper its advantage.

1. Introduction

In recent years, HUD has attracted attention as an in-vehicle display device. HUD makes the virtual image display visible to the driver. By projecting the image displayed on the display or the screen onto the wind shield through the magnifying optical system. We think that advantages of HUD are to reduce the followings:

-Eye movement,

-Focus adjustment, convergence angle adjustment.

HUD does not need to move the line of sight for obtaining information, because a display area is provided in an area close to the driver's view of driving in comparison with other on-vehicle display devices such as a meter in instrument panel. The study shows the difference in viewing time on each display unit, indicating that it is possible to acquire information in a shorter time than Center Information Display(CID) and meters. This suggests a reduction in the look-ahead behavior, and contributes to safe driving.

Since HUD has a virtual image display surface farther than wind shield. The difference in focus and convergence angle between the background view and information image is small. This indicates that the mental work load is small when information visualization behavior is repeated.

Recent trend is to increase the image distance as changing from conventional vehicle status information to Augmented Reality (AR) image adding information to the real landscape. Although the above-mentioned advantages present, the problem which has not occurred in the conventional HUD has emerged, because the image distance becomes far.

If image distance of HUD gets longer, in situation such as when the vehicle waits for a traffic signal to change, it is considered that the virtual image visible from the driver is stuck into a forward vehicle. We made a hypothesis that the above situation gives the driver a sense of incongruity and affects normal driving behavior, especially when a vehicle is stopped. We think that the situation disturbs the advantage of HUD and we have conducted some experiments.

2. Experiment

Hypothesis

Driving with HUD indication, inter-vehicle distance becomes longer when a vehicle is stopped than driving without HUD indication.

Input

Following contents conveyed to participants before experiment:

-Driving course

-The aim is to obtain the gaze data

We tried not to give attention to the distance between vehicles that we want to acquire by stating that it is aimed to collect gaze data.

Output

The inter-vehicle distance when the vehicle is stopped

Participants

We selected participants (10 males and 2 females) who have driver’s license. The age range of participants is from 20's to 60's and each decade is constructed with 2 participants. This experiment was conducted with ethical consideration such as acquisition of informed consent.

Experiment procedure

The procedure of the experiment is as follows.

1. Explanation of this experiment
2. Practice time for driving.
3. Public road driving. From location A to B without HUD image.
4. Public road driving. From location B to A without HUD image.
5. Public road driving. From location A to B with HUD image.
6. Public road driving. From location B to A with HUD image.

In this experiment, we took breaks appropriately between tasks. We recorded front view continually with a camera during the experiment. Inter-vehicle distances are calculated from movies that include forward vehicles.

HUD specification

We used the HUD with the following specifications to embed the virtual image indication into the forward vehicle when driving vehicle is stopped:

Field of view	10x5 degree
Image distance	10 m
Brightness	3000 cd/m2

3. Results and Discussion

The acquired data of 12 participants are shown below:

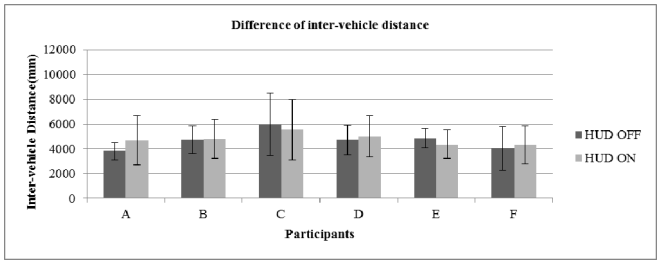

Figure 1

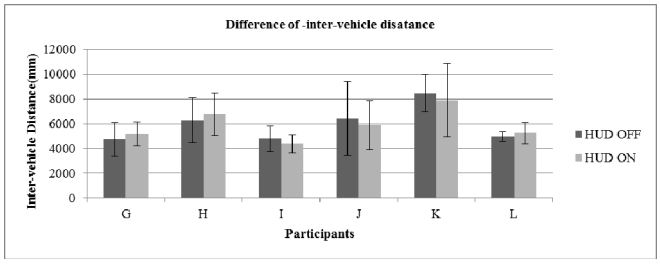

Figure 2

The bar graphs in the figures show the average value of distances, and they compare the cases with HUD display and without HUD display. We conducted dominance difference test (T test) at the 5% level against the comparison result, which resulted in no dominant difference among all the participants. These show that the HUD indication does not have a certain directional effect on the driving behavior when the vehicle is stopped.

That is, it is understood that at least the normal driving behavior is not adversely affected. On the other hand, it also shows that it is difficult to control following distance between vehicles only by ON / OFF control of HUD display.

This verification is an initial study conducted for the purpose to confirm the presence of influence of HUD indication to driver's behavior, and it is necessary to present more evidences to contradict the above mentioned concern based on the results of this experiment.

4. Conclusions

We were able to verify one of the harmful influences to the driver. It was found that the presence of HUD indication does not affect the distance between vehicles when they are stopped. The differences between the average values seen in each subject are within the error range.

References

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