Analyzing of Driving Behavior in the Vehicle Following Task

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In this paper, we have investigated and compared the influence on the driving behavior in the vehicle following under the variety of road surface conditions. By applying a driving simulator and an eye mark recorder in our experiment, we have studied that the influences of road damage level to the driver's brake operation, and the visual tracks of driver's eye movement on the different road conditions.

1. Introduction

A driving behavior is a series of process which is including the driver's own perception to recognize information that needs for driving, judge the best driving operation based on the information, and then perform the driving operation. Because 90% or more is visual information which is necessary for driving, the influence for the information acknowledgment by the sight on the driving action is large. Many researches on the visual acknowledgement action are performed in recent years[1]. However, most of the researches are on the route situation and/or the traffic situation, and there are few researches for the road recognition behaviors.

For about 30% of the traffic accident in recent years is a rear-end collision accident, in our research work, we have investigated the influence on the driving behavior under the variety of road surface conditions, by focus on the driver's vehicle following behavior on the expressway. In the experiment, drivers are required to drive as their usual manner using Kitami Institute of Technology Driving Simulator (Hereafter, KITDS) while wearing an eye mark recorder, in order to obtain driving behavior data as well as visual tracks of driver's eye movement.

2. Experimental condition

2.1 Experimental devices

(1). KITDS

As one of the effective tools for the research work, we applied KITDS to study the influence on the driving behavior in different road surface condition. The KITDS is developed as the driving simulator for road surface evaluation and added some new functions as well, such as inputting real road profiles and the friction coefficients[2]. It also allows the study of the driver's behaviors for various situations, which sometimes difficult or impossible to reproduce in an actual road conditions. The KITDS consists of a motion platform, a visual system and a sound system, generating a virtual environment for the driver. As shown in Fig.1, the KITDS system configuration is divided into the main unit, the control panel and the console, using a design that allows easy operation, simple modification and maintenance.

(2). Eye mark recorder

As shown in Fig. 2, Eye mark recorder is an eye movement measurement system which adopted the pupil/cornea reflection method. It is the equipment which displays the gaze point as an eye-mark where the testee is looking at, by using the camera image that corresponds to testee's view and the eyeball movement measured by the near-infrared radiation. As a result, where and how the testee is looking at can be learned, and the tracks of the eye mark as well as the stopping point of eye etc. can be obtained and analyzed.

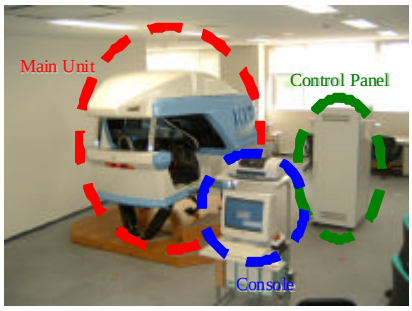

Fig. 1 KITDS system configuration

Fig. 2 EMR-8B Eye mark recorder

Fig. 3 Driving action on KITDS

Fig. 3 shows the driver's driving scene on KITDS, by wearing the eye mark recorder. The information on the driver output to the handle, accelerator and brake is transferred to a PC through the control panel, and the vehicle position and motion are calculated based on these information. On the other hand, visual tracks of driver's eye movement is measured and recorded to a video camera through the Eye mark recorder, these eye mark information can be analyzed with an analytical software.

2.2 Experimental environment

In this research work, we focused on the driver's vehicle following behavior on the expressway with an eye mark recorder.

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The preceding vehicle runs in accordance with the velocity pattern shown in Fig. 4. In order to express the different road condition, two kinds of damage road images with different damage level were prepared: road A represents the road damage is larger, while road B indicates the road damage is smaller. Total running time was set to be 5 minutes. Furthermore, as shown in the figure, by using the data-lodging function of KITDS, we obtained the driver's braking ratio as one of the driving behavior data for analyzing, both on road A and road B.

The weather is assumed to be sunny and the friction coefficient of the road was set to be 0.8. Drivers were provided with the instruction "Follow the preceding vehicle so as not to make contact". Since this instruction is "loose" instruction, the drivers do not concern much about the range and range rate. As the result, each driver can drive as their usual manner.

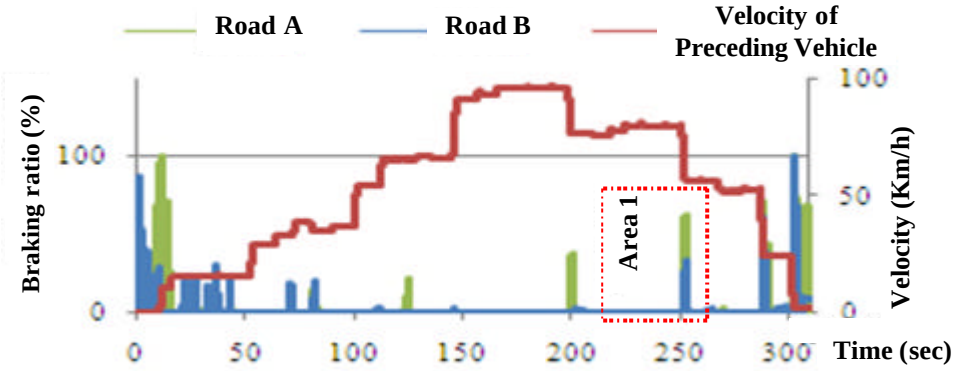


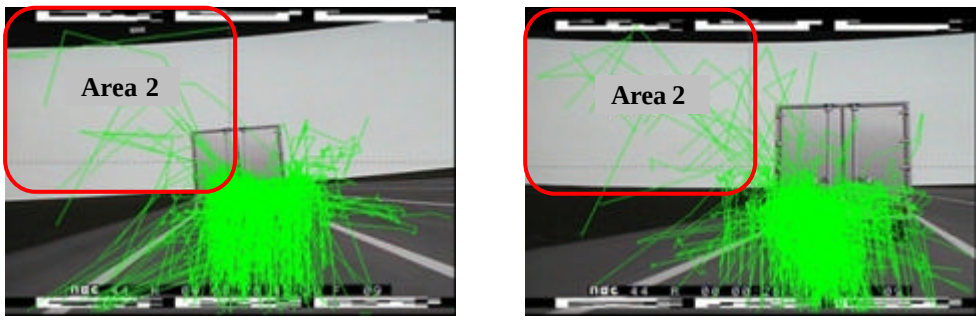
Fig. 4 Profile of the velocity of preceding vehicle and braking ratio of the drivers on different road condition

3. Analysis of the vehicle following behavior

We have analyzed the driving data of nine drivers (age from 20s to 40s). The drivers tried to follow the preceding vehicle which ran according as the velocity pattern in Fig. 4. The input and output data are sampled and collected every 10msec.

As shown in Fig. 4, braking ratio indicated the larger value, mainly when driving is begin and stop running. Comparing the braking ratio in road A and road B, although the brake operation is seen in the figure for both roads in Area 1, the amount of the brake operation in road B is about half of the brake operation in road A. From this we can learn that as the road surface condition become worse, the driver tries to use the brake more for running safety.

The eye mark data analyzed the eye mark tracks with analytical software called EMR-dFactory[3]. In this method, we applied two dimension graph of the XY coordinate system that corresponds to the driver's view, and plotted the eye mark as a point, then draw tracks that connect a consecutive eye mark in the line so that where and how the driver is looking at can be learned. According to the result of the eye mark tracks analysis in the experiment, it is clearly indicated that the drivers gaze at the preceding vehicle and the road surface. Moreover, compared with road A, eye tracks have increased significantly in road B in Area 2, as shown in Fig. 5 which is one of the typical eye mark tracks. From this we can also learn that when the road surface condition is become worse, drivers pay more attention to the running of preceding vehicle.



Road A Road B

Fig. 5 Eye mark tracks analysis

4. Conclusions

In this paper, we have compared the influence on the driving behavior in the vehicle following under the variety of road surface conditions. As a result, we have learned that the road damage influences the driver's brake operation, and the visual tracks of driver's eye movement have changed by the different road conditions.

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