Design and Evaluation of HUD for Motorcycle Using Immersive Simulator

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Abstract

Since the motorcycle rider looks at the road surface constantly while driving the motorcycle, the information display must be designed by considering the visual characteristics of the rider. In this study, the HUD for the motorcycle was developed to display navigation information to the rider, and the immersive motorcycle simulator was constructed to conduct an evaluation experiment safely about the effective method of displaying information. In the experiment, the eye movement of the subject was measured using the eye-mark recorder and the detection time and the observation time were analyzed. From the results of the experiment, several knowledge about the effective position and the effective amount of displayed information were obtained.

CR Categories: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, Augmented, and Virtual Realities;

Keywords: Head-Up Display, Motorcycle Simulator, Virtual Reality

1 Introduction

The motorcycle rider drives a motorcycle while looking at the road surface carefully and this characteristics is different from the vehicle driver. This is caused by the instability of the motorcycle that is directly influenced by the condition of the road surface compared with the four wheel car. Therefore, the conventional car navigation system that is installed near the handle is not desirable for the motorcycle, because the rider has to turn his eyes away from the road surface.

In order to overcome this problem, this study aims at developing a HUD (Head-Up Display) that can be used with the motorcycle. HUD is an information device that displays necessary information overlapped with the user's viewing field. When it is used for the motorcycle, the navigation information can be displayed in the viewing field of the rider who is looking at the road surface. In this paper, design and evaluation of the HUD for the motorcycle are discussed. In particular, an immersive motorcycle simulator was constructed to evaluate the effective representation of the information by considering the visual characteristics of the rider.

2 Design of HUD for motorcycle

Currently, as the HUD for the motorcycle, helmet type system and windshield type system are investigated. In the case of the helmet type HUD, though the information is always displayed in front of the user's eye, the user's view direction must be tracked constantly so that the user sees the information at the correct position in the real space. In addition, the communication with the motorcycle or other instrument is also necessary in order to use the position orvelocity data of the motorcycle. On the other hand, in the windshield type HUD, since the information is displayed at the fixed position relative to the motorcycle, the rider must sit on the correct position for the windshield so that the rider sees the information precisely. But, in this case, the sensor data that is measured by the motorcycle can easily be used.

In particular, in this study, the prototype system of the windshield type HUD was developed [Ito, 2013]. This system consists of micro laser projector (Microvision, Pico Projector SHOWWX+), convex lens (Eschenbach, focal distance: 90.9mm, magnification ratio: 3.8), half mirror (transmittance ratio: 92.6%), and small PC as shown in Figure 1. In the design of the HUD, it is necessary to consider the characteristics of the visual recognition of the rider, because the control of the rider's view is important for the safe riding.

In the HUD, the information is displayed as a virtual image reflected by the half mirror. In this case, it is desirable that the virtual image is located a little nearer than the real object that the rider is looking at. When the distance between the virtual image and the real object is large, it needs a lot of time for the rider to adjust the focal distance of his eyes from the real object to the virtual image. And when the virtual image is displayed far away from the real object, the rider must see the virtual image throughout the real object, and it is not a natural situation.

Therefore, in this system, the enlarged virtual image was displayed 4.0m away from the rider's viewpoint by adjusting the distance between the convex lens and the projection screen. Namely, the rider sees the displayed information at the position where it is a little nearer than the road surface.

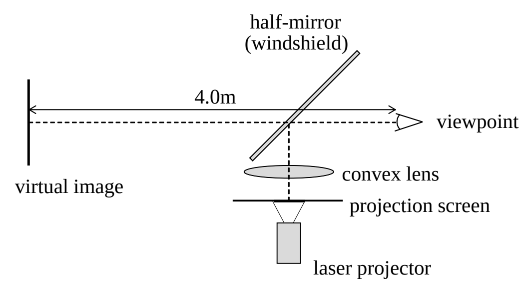

Figure 1. *Structure of Head-Up display.*

3 Immersive motorcycle simulator

The specification of the HUD and the method of displaying information on it should be designed based on the experimental evaluation considering the visual characteristics of the rider. And it is effective to measure the eye movement of the rider by using the eye-mark recorder when he rides the motorcycle. However, from the viewpoint of safety, it is not desirable to conduct an experiment of displaying information while riding on the public road.

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Therefore, in this study, immersive motorcycle simulator was developed to evaluate the method of displaying information on the HUD in the simulation environment.

As a simulation environment, it is necessary to reproduce the eye movement of the rider driving in the real world by representing the realistic image. The immersive motorcycle simulator was constructed by integrating the scooter type simulator and the CAVE display as shown in Figure 2. In the scooter type simulator, the operations of handle, accelerator, and brake are measured, and the movement of the motorcycle is calculated based on the two-wheeled vehicle model. Then, the data of the motorcycle movement is sent to the graphics workstation that renders the computer graphics scene on the CAVE display.

The CAVE system consists of four screens placed at the front, left, right and floor, and the computer graphics stereo images are displayed on them synchronously [Tateyama, 2013]. These stereo images are projected onto the screens by using the stacked liquid crystal projectors (NEC, NP2150J) with circular polarizing filters. And the user can see the stereo image by wearing the same kind of circular polarized glasses. In addition, electromagnetic sensor (Ascension Technology, Flock of Birds) is attached to the 3D glasses of the user, and the computer graphics image seen from the user's viewpoint is generated in real time. Then, the user can see the interactive and wide field of view stereo image, and feels the high presence and realistic sensation in the immersive motorcycle simulator.

By using the immersive motorcycle simulation, it is expected that the visual characteristics of the rider equal to riding in the real world is reproduced, and it can be used for the evaluation experiment.

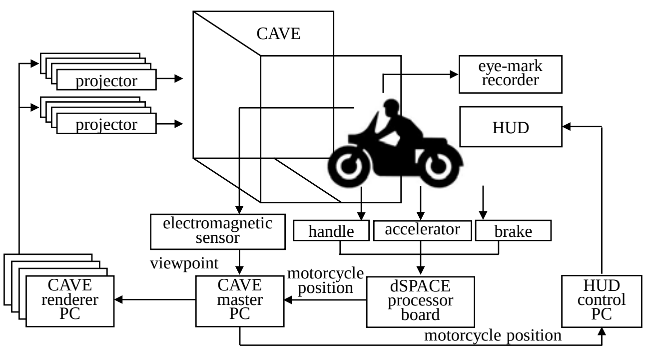

Figure 2. System configuration of *immersive simulator*.

4 Experiment using immersive simulator

In this study, the evaluation experiment for the HUD was conducted using the immersive motorcycle simulator as shown in Figure 3. In the experiment using the immersive simulator, it is expected that not only the operation behavior for the motorcycle but also the eye movement of the rider equal to the real world riding can be simulated. In the experiment, the eye-mark recorder (NAC Image Technology, EMR-9) was used to measure the eye movement of the rider. In the eye-mark recorder, the gaze direction is measured based on the Purkinje method, and the movement of the gaze point is recorded on the visual scene that is captured by the video camera attached to the cap of the eye-mark recorder. Then, the eye movement of the rider who operates the immersive motorcycle simulator can be measured. From the result of the experiment, the gaze point of the subject who operated the immersive motorcycle simulator moved along the road surface, and this movement was similar to the gaze point movement of the rider who rode the motorcycle in the real world.

The immersive motorcycle simulator was used for the evaluation experiment about the method of displaying information on the HUD. In the evaluation experiment, the effective position and the effective amount of the information that was displayed to the user who rode the motorcycle were investigated. In the experiment, the detection time that means the time when the gaze point of the subject moved to the displayed information after it was displayed on the HUD, and the observation time that means the duration time when the subject was looking at the displayed information were measured.

From the results of the experiment, several knowledge such as the optimum position of the displayed information and the restriction of the amount of the displayed information were obtained. For example, we can see that the information should be displayed in the lower side area in the visual field of the HUD. This result means that the HUD can be designed compactly since it does not need the large size of the windshield. In addition, we can understand that when the information is displayed using the Japanese character, the number of characters should be less than five characters.

Figure 3. Experiment of HUD using *immersive simulator.*

5 Conclusion

In this study, the HUD for the motorcycle rider was designed to display information to the rider and the prototype system was developed. In this system, the information is displayed as an enlarged image 4.0m away from the rider's viewpoint. In order to evaluate the usage of the HUD on the motorcycle, an immersive motorcycle simulator was developed, and it was used for the evaluation experiment about the method of displaying information. From the results of the experiments, we could obtain several knowledge about displaying information on the HUD such as the optimum position of displaying information and the restriction of the amount of displayed information.

Acknowledgements

This study was supported by JKA.

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