Head-Up Display for Motorcycle Navigation

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Figure 1: *Motorcycle Head-Up Display used inside the immersive driving simulator.*

Abstract

In this paper, we describe a navigation system for motorcycle using the technology of head-up display. While there are various navigation system products for automobiles, motorcyclist has issues in using currently provided navigation system. It is known from previous researches that motorcycle rider moves their viewpoint in a characterful way while driving, which makes it difficult for the rider to look at small liquid crystal displays. To solve this issue, we propose a navigation system utilizing the technology of head-up display. While considering the motorcycle rider's viewpoint behavior, we constructed a head-up display to conduct experiments and observe the effects by presenting information on the head-up display. Regarding safety, experiments were conducted inside an immersive projection environment using a motorcycle simulator. The results of experiments clarified the preferable display position and the amount of information to present on the head-up display.

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

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1 Introduction

Nowadays, many motorcycle riders demand navigation system for comfortable driving, which many drivers tend to attach a small liquid-crystal display (LCD) to obtain navigation information. While navigation system technology used for automobile cars has been very successful in developing and releasing products to the market for more than twenty years, attaching these components or smart phones to the motorcycle has not been functional enough for the riders. According to a recent research done by the Japan Safe Driving Center [2006], it is reported that motorcycle riders have a hard time looking at the LCD while driving. To solve this issue, we propose a new navigation system using the technology of head-up display (HUD), showing easily legible navigation information for riders while driving.

2 Development

Concerning the presented information legibility while driving, we first conducted an experiment in the real world to observe the motorcycle rider's viewpoint movements. From the experiment, we obtained characterful viewpoint movements alike to earlier researches [Morita 1978; Miura 1979]. Obtained viewpoint movements were then used to design the HUD, to configure the focal distance of the virtual information presented on the HUD.

The HUD was then constructed for experimental purpose to investigate where the navigation information should be presented [Ito et al. 2013]. For the half-mirror we used an ordinary acrylic board which has 92.6% transparency. For projection, we used a laser projector (Pico Projector SHOWWX+, Microvision) and configured the virtual information's focal distance to 4 meters using a lens (Magnifier 2636-11, Eschenbach).

3 Experiments

Utilising the constructed HUD, we conducted two experiments in a phased manner. The first experiment was to uncover the preferred position to display the navigation information, and the second experiment was to clarify the amount of information able to provide while driving. Regarding safety and ethical reasons, experiments

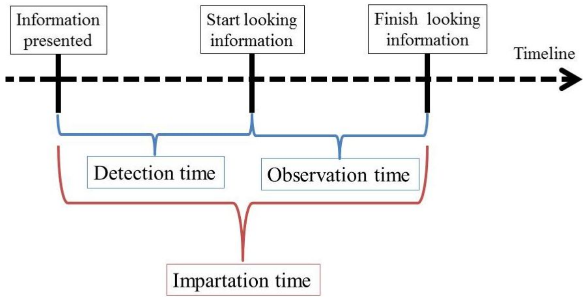

Figure 2: *Measured durations used to analyze the experiments.*

were conducted inside an immersive CAVE environment to consider motorcycle rider's characterful viewpoint movement [Ito et al. 2015].

Each experiment was evaluated by measuring durations of how long it took to obtain the information. Figure 2 shows the defined durations to analyze the experiments. "Detection time" is the duration which the rider spent to move their viewpoint on to the presented information. "Observation time" is the duration the rider spent looking at the presented information. "Impartation time" is the total duration of the rider spent to obtain the presented information.The durations were measured using the eye-mark recorder (EMR-9, NAC).

3.1 Display Position

The first experiment was conducted with 10 subjects, presenting 4 types of signs. The signs give direction information to the rider, whether to turn left, turn right, go straight, or to stop at the next cross-road. The signs were displayed at 9 divided positions on the HUD, as shown in Figure 3.

From the measured data, we performed a two-way ANOVA using the displayed information and divided positions as factors, and we observed significant difference in all three defined durations(Figure 2). Through the Tukey's HSD, the position lower left and lower right (number 3 and 9 shown in Figure 3) was significantly short compared to many of the other positions. Although lower left and lower right was relatively short in all durations compared to other seven positions, there was no statistical difference between each other. Therefore, we considered the preferred display position for navigation information to lower left and lower right.

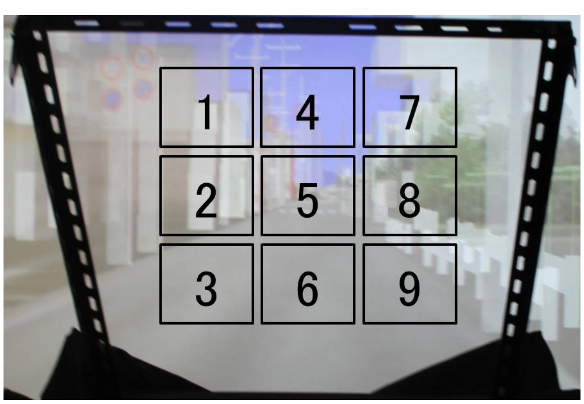

Figure 3: *Nine divided position for the experiment.*

3.2 Information Amount

The second experiment was planned based on the results from the first experiment, to analyze the suitable information amount to present on the HUD. The experiment was conducted with 10 subjects, presenting 1 to 8 lengths of Japanese Hiragana. We prepared two types of strings which are string with meaning and randomly created string without meaning. Same with the first experiment, we measured the duration of the rider spent against the provided information. The experiment was performed only on the lower left and lower right position regarding the results of the first experiment.

We first calculated the presented amount of information based on information theory [Shannon 2001]. Including Hiragana with diacritic signs(Hiragana with *dakuten* and *handakuten*) and the prolonged sound mark(*chōonpu*), we used 72 types of Hiragana characters. Since we included randomly created strings, we assumed that experiment subjects were uncertain condition what character will appear. Hence, the amount of information in bits per letter of Hiragana can be expressed as $\log_2 72$ which calculate to 6.17 bits per letter.

From the experimental results, we obtained the one letter average "Observation time" as 1210.70 ms, and the channel capacity was approximately 5.10 bits per second(bps). To take confirmation, we compared with the first experimental result using data of 9 subjects which participated both experiments. Since we only presented 4 types of sign, the information amount per sign is calculated as $\log_2 4$. From the comparison result shown in Table1, we observed similarity in approximately 5 bits per second channel capacity in the occasion of one letter/sign.

The experimental result also indicated that presenting more letters increase the speed of information bits per second, up to 20.97 bps when presenting 8 Hiragana. On the other hand, spending long durations looking at the displayed information has potential risk of violating safe driving. According to a standard made by the Japan Electronics and Information Technology Industries Association [2008], it is noticed that there are limitations to follow for use of in-vehicle navigation technology, introduced from the National Police Agency of Japan. In the standard specification, it states that it shall not display which requires more than 2 seconds for the driver to understand the information.

Although the limitation only applies to automobiles, especially referring to traditional LCD navigation system for automobiles, regarding that motorcycles lack stability compared to automobiles, it shall be expected that the displayed information should be obtained under 2 seconds. Since the average "Observation time" for presenting 8 Hiragana was 2353.90 ms, we may say that it is taking too much time, even considering the fact you can see road and traffic conditions through the peripheral visual field. Therefore, the fastest speed of information bps under 2 second shall be the most efficient information amount to present, which according to the result of the experiment, was 5 letters of hiragana with 1944.95 ms of "Observation time" which is 15.86 bps.

Table 1: *Information Amount Comparison Between 1 Hiragana and 1 Sign.*

Type	bits per letter/sign	Observation time[ms]	bps
Hiragana	6.17	1196.01	5.16
Sign	2.00	411.07	4.87

4 Conclusion

To solve issues for motorcycle rider wanting to obtain navigation information, we proposed the use of the head-up display. To design the actual navigation applications, we first constructed the head-up display to place emphasis on basic research how the rider will move their viewpoint while driving. We conducted two experiments in the simulation environment, and obtained results about where and how much information to display on the HUD for motorcycle navigation.

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