STUDY OF FACE DESIGN, LIGHTING SYSTEM DESIGN FOR ENHANCED DETECTION RATE OF MOTORCYCLES

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ABSTRACT

The FACE (Facial Attention for Conspicuity Enhancement) design, a lighting system design that enhances motorcycle conspicuity with regard to the detection rate from the view of a driver at night, is described in this paper. Past research has shown that there is part of the human brain that reacts to the image of a face[1] and we thought of a method to enhance the detection rate of a motorcycle by incorporating the element of a face in the front design of the motorcycle. The effect of a simple FACE design, a reverse triangular arrangement of lamps, is evaluated and its effectiveness is shown. Moreover, we develop a simulation method that could be used to evaluate the enhanced detection rate of a FACE design motorcycle under conditions that are close to some real traffic environments. The method is evaluated by comparing it with the results of a full-scale test and demonstrates the method could be used to evaluate the detection rate of a motorcycle

INTRODUCTION

We obtained the motorcycle fatal accident data in which car drivers were deemed most at fault, and thus were designated as the “Primary Party”*, from the database of "Japanese traffic accident statistics"[2]. The data was analyzed to determine the cause of each accident. This analysis resulted in a conclusion that an car driver’s failure to detect the motorcycle was one of the key factors in the accidents. (Fig. 1).

*Primary Party:

: In the Japanese integrated database, vehicles whose drivers were most at fault in traffic accidents are called the “primary party,” and the other vehicles are called the “secondary party.”

Compared to a car, a motorcycle is smaller in size and presentment, and the possibility of non-detection is relatively high in a mixed traffic environment where there are many large-sized vehicles, such as trucks and passenger cars. In Japan, a countermeasure against the lack of motorcycle detection, Automatic Headlight On, was mandated in 1998. Its positive effect has been recognized.

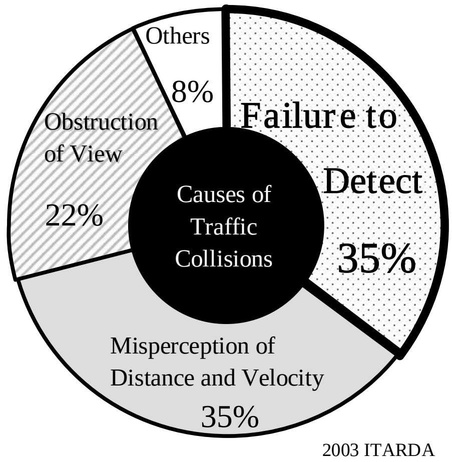


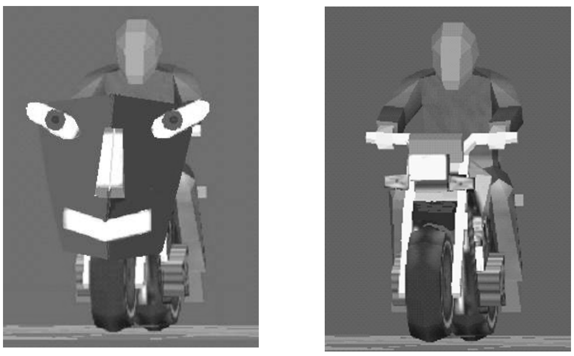
Figure 1. Analysis of motorcycle traffic accidents in Japan.

However, the positive effect of Automatic Headlight On could not be expected at night when cars are also using their headlights. Moreover, recently, many cars and trucks are also equipped with Daytime Running Lights (DRLs) and many countries are considering laws that require use of DRLs. Thus, if more and more various types of vehicles are equipped with DRLs, a further reduction of motorcycle conspicuity is possible. Based on these facts, a countermeasure that enhances the conspicuity of a motorcycle under a complicated mixed traffic environment was sought. To this end, we tried to enhance the detection rate by incorporating the elements of a face in the front design of a motorcycle because it has been found that people naturally show a high recognition capability to specific figures including a "face". We decided to call lighting system designs that utilize the elements of a face to enhance motorcycle detection rate FACE (Facial Attention for Conspicuity Enhancement) design. A simple example of FACE design was evaluated to confirm its effect. The details of the evaluation method developed for this research are also discussed.

Enhancement Effect in Conspicuity of FACE

A "face" is one of the stimuli seen most frequently. Humans are able to understand detailed information, such as visual line and facial expressions, in a "face" instantaneously [3]. Significant research about the high-level facial recognition capability of primates, including human beings, has been performed for many years and several conclusions have been reached. For example, Bruce reported that the part of the brain that reacts to a face picture exists in the lower temporal lobe of a monkey [3]. Recently, research using Functional Magnetic Resonance Imaging (fMRI) has confirmed that the same kind of reaction also exists in a human's brain [1]. It has also been confirmed that the Fusiform Face Area (FFA) of the fusiform gyrus in the temporal lobe and Occipital Face Area (OFA) of the inferior occipital gyrus have a high sensitivity to a face figure[4]. Since part of the human brain specializes in the recognition of a face, it is thought that humans can rapidly recognize a face. Given this, it is reasonable to believe that motorcycle conspicuity might be enhanced by incorporating the elements of a "face" in the front design.

In order to investigate the feasibility of enhanced motorcycle conspicuity by using the elements of a "face" in the front design, we first measured the detection rate of a motorcycle in traffic using an image. Fig. 2a shows the motorcycle that utilized the elements of a "face" in its front design that was used in the experiment. (Hereafter, a motorcycle which uses the elements of a "face" is called a "FACE design" motorcycle.) Fig.2b shows a single headlight motorcycle used as the standard for comparison.

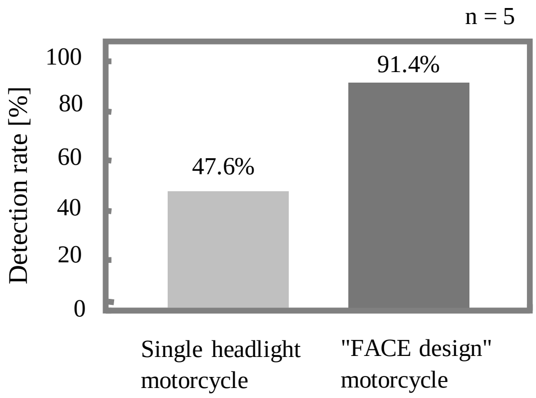


a) "FACE design" motorcycle   b) single headlight motorcycle

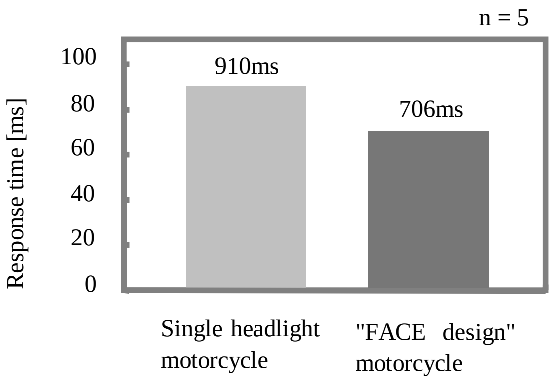
Figure 2 . Motorcycles used for proving our hypothesis that FACE design enhances conspicuity.

Five subjects (four men aged 20 - 40 and one woman in her 20's) were tested. Each subject drives a car daily. The presentation time of the image was 0.5 seconds. After image presentation, a black screen was presented until the subject answers. 144 measurements per subject were carried out. The result of measurement is shown in Fig. 3.

Fig. 3a shows the average motorcycle detection rate by the subjects. The detection rate of a single headlight motorcycle was 47.6% and the detection rate of the FACE design motorcycle was 91.4%. Fig. 3b shows the time after a subject was shown the image until a reply button was pushed. The average response time in the case of the single headlight motorcycle was 910ms, while the average response time in the case of FACE design motorcycle was 706ms. These results show that the conspicuity of a FACE design motorcycle was increased compared to a single headlight motorcycle and this may enhance the motorcycle's detection rate by drivers of other vehicles.



a) Detection rate of motorcycle



b) Response time

Figure 3. Enhanced conspicuity by FACE design.

Motorcycle Detection Rate Evaluation Method

In a past study, Sugawara et al. confirmed that cerebral activation could be measured by using fMRI. So, it is possible that a quantitative evaluation of Facial levels of the front design of a motorcycle could be carried out [5]. However, fMRI equipment is large-scale and cannot be used for measurement in a real traffic environment. On the other hand, it is difficult to measure the detection of a motorcycle under the actual traffic environment in which large-sized vehicles, such as trucks, and passenger cars are driving. Therefore, we developed a simulation method that can measure the detection rate a similar, real traffic environment. This section reports on the simulation technique.

For an enhancement in conspicuity at night, the key point of motorcycle front design is the lighting system. It is difficult to recognize the form of a vehicle emitting high luminous intensity light, such as from a headlight, due to the vision phenomenon referred to as “glare” The overall evaluation of conspicuity requires the evaluation of the lighting system and how it was seen. In this method, paying close attention to "contrast ratio" and "expression of glare", and by calibrating them to a real traffic environment, computer graphics (CG) that is equivalent to a real traffic environment was produced. In order to evaluate the simulation method , a CG of the test track was created, and comparison with a real vehicle was performed. The creation method of the CG and the comparison result between the full-scale test and the simulation test are described below.

<u>Contrast Ratio</u> - In past research it has been shown that the detection rate of a motorcycle during a short-time presentation can be measured using a simulated computer graphic image as long as the contrast ratio of the real environment and the simulated environment are matched. [6][7][8]. This information was used to create CG of various vehicle arrangements to be used in the evaluation of the FACE design motorcycle.

First, we created CG of the test track. The reason was it then easy for a real vehicle to perform the same test as the simulation. Thus, it was possible to verify the validity of the simulation method that used CG instead of actual environments.

In creating CG, the important elements are the position of the display and its hi-resolution performance. The display was set at a 1.3m distance from the subject in order to set the horizontal field angle at 45 degrees. The viewing height of the CG was 1.2m from the ground. The actual measurement luminosity of the test track was 1 cd/m2 for the dark part of the road surface and 1500 cd/m2 to 3000 cd/m2 for a headlight. A display that could reproduce 3000 or more contrast ratios was required. We used a plasma display to satisfy the requirements. The size of this display was 50 inches, luminosity was 0.1 cd/m2 for the dark area and 400 cd/m2 for the bright area, and it has 4000 contrast ratios. The contrast ratio of the CG of the simulated test track was calibrated with the real environment on this display.

<u>Glare</u> - Another visual phenomenon important in this research is glare. Glare is the light that appears to be generated around a light source, causing things in the area around the light source to fade to white, such as when people look at a bright light. Since the physical luminosity of the display was limited, it was difficult to actually generate this glare. As an alternative, expressing a high-intensity light in simulation is often performed by adding glare artificially with CG [9][10][11][12][13]. This research utilized a method of inserting a mathematically generated glare pattern.

The pattern of the glare was verified by comparative experiments with a real vehicle that is described in the next part of this paper.

CG of the simulated test track is shown in Fig. 4.

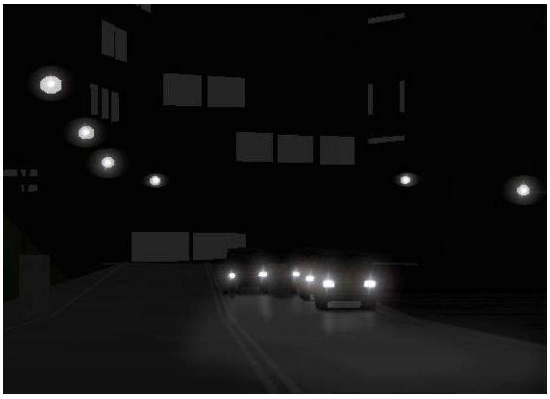
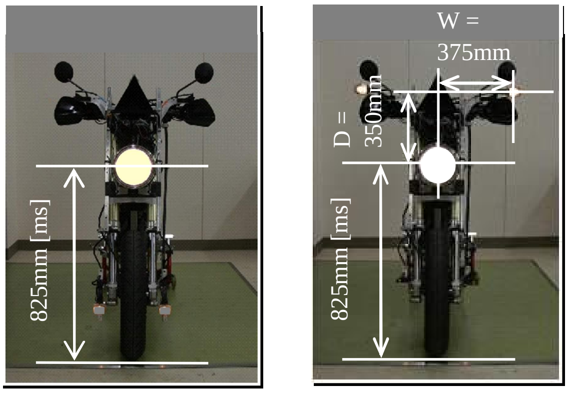


Figure 4. CG example of test track.

<u>Comparative experiments with a real vehicle</u> - In order to verify whether the simulation method was an effective way to evaluate motorcycle conspicuity, we conducted an experiment comparing a simulation environment to one with real vehicles. Fig. 5 shows the experiment scenery in a real vehicle. The vehicles used for the experiment are four cars and one motorcycle.

Figure 5. Experiment scene at the test course.

The motorcycles used were a single headlight motorcycle and a motorcycle with a three light, inverted triangle arrangement formed by the headlamp and two auxiliary lights (5W 16cd for each) (Fig. 6). The reason for using three lights, inverted triangle arrangement was that it was reported to be one of simple arrangement that was reminiscent of a face [14].



a) Single headlight motorcycle

b) FACE design Motorcycle (Three light, inverted triangle arrangement)

Figure 6. The motorcycles used for the experiment.

There were three arrangements of vehicles utilized for the test. The first included a single headlight motorcycle, the second included a FACE design motorcycle, and the third did not include a motorcycle. The first two are shown in Fig.7.

The subjects were 16 men aged 20 – 40 who operate a car daily. Each subject was shown a vehicle arrangement at random. Each arrangement was shown two times for 0.5 sec per a metronome. The subject then had to identify the number of vehicles and how they were arranged. Twenty-four measurements were taken for each subject.

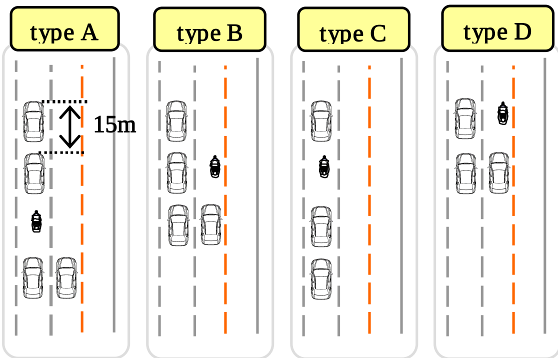


Figure 7. Arrangements of vehicles used for test.

Fig. 8 shows a comparison of the FACE design detection rate between tests using actual vehicles and the simulation tests. In order to cancel the influence of the environmental factor, such as the numbers of vehicles, the detection rate of a FACE design motorcycle was shown divided by the detection rate of a single headlight motorcycle.

The result shows that there was no significant difference in 5% level, so it was concluded that the simulation can be used as for a test method.

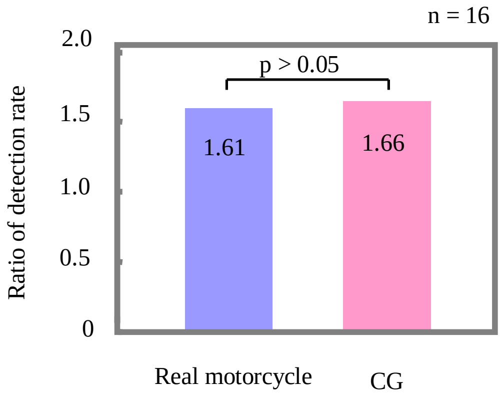


Figure 8. Comparison of detection rate between real motorcycle and CG.

Actual Traffic Environment for Comparison Experiment

Next, in order to carry out the evaluation in the real traffic environment, the image of actual intersection was created with CG. The intersection has 4 lanes in each direction, and has heavy traffic, including many motorcycles. (Fig. 9)

Fig. 10 shows examples of CG. The viewpoint position in the simulations was a car driver who was waiting to make a right-turn in the center of an intersection. Two intersections were simulated, and for each intersection images of seven different car and truck traffic arrangements were created.

Figure 9. View of an intersection.

a) Example A

b) Example B

Figure 10. Examples of CG simulations.

The motorcycle was placed 20 to 140 meters from the viewpoint of the car driver. In each of the 14 traffic arrangements, 1 to 3 motorcycles were introduced in the traffic mix for a total of 28 different images. Finally, 84 images were created; 28 with a standard single headlight motorcycle, 28 with a "FACE" design motorcycle and 28 with no motorcycle were included.

Effect of Face Element

By using the CG simulations described in the preceding section, the detection rate of the FACE design was measured. The measured FACE design was a lighting-system of three lights in an inverted triangle arrangement. Horizontal distance W from the headlight to the additional light was set to 375mm, and perpendicular distance D was set to 350mm. The measured control motorcycle utilized a lighting-system arrangement in which W was set to 375mm and D was set to 0mm as a control condition. Luminous intensity of the additional lights was set to 16 cd. The luminosity of the additional light was adjusted based on the distribution of luminous intensity characteristic of position lamps. The composition of test equipment is shown in Fig. 11.

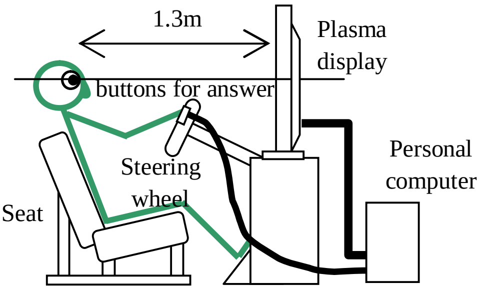


Figure 11. Composition of the experiment system.

Twelve men aged 20 - 40 who drive a car daily were selected as subjects. Subjects were shown each of the 84 traffic simulation images for 0.5 seconds at random, and then answered whether a motorcycle appeared on the screen by pressing either Yes or No button on the steering wheel. After the CG was shown, a black screen was presented until the subject answers. Each traffic simulation image was shown 2 times for a total of 168 answers per subject.

Only the cases where the distance of the motorcycle was 80m or more from the driver were included in the final results. This is because our past research has shown that traffic at 80m distance from a car turning right is the threshold for making the turn or not [15].

The results are shown in Fig. 12. The graph shows the increase in detection rate of motorcycles with additional lighting compared to a standard single headlight motorcycle.

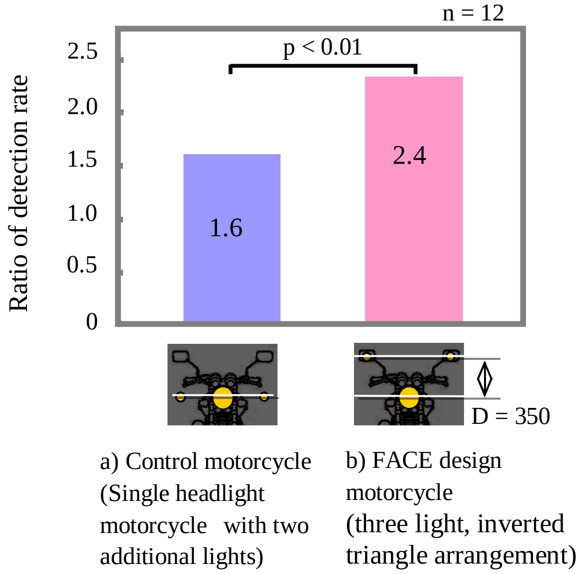


Figure 12. Comparison of detection rate between FACE design and control motorcycle.

The FACE design (W=375mm, D=350mm) was detected 2.4 times more often than the standard motorcycle. The control motorcycle lighting system design (W=375mm, D=0mm) was detected 1.6 times more often than the standard single headlight motorcycle.

CONCLUSION

Under the limited scope of study reported here, it was shown that the FACE design using three lights, inverted triangle arrangement, which was one of the simple figures reminiscent of a face, could enhance the detection rate of a motorcycle from the point of view of a car driver.

In order to evaluate the detection rate of the motorcycle by a car driver, a simulation method that reproduced real traffic environments was developed. A comparison between actual vehicles and the simulation was carried out, and it was shown that the simulation was effective.

Additionally, the effect on the detection rate of motorcycles using FACE design motorcycles (using a lighting design of three lights, inverted triangle arrangement) was measured using this simulation. It is shown that the detection rate of a FACE design is 2.4 times greater than that of a single headlight motorcycle.

We would like to make an effort to further advance "FACE design", to enhance the detection rate of motorcycles in various traffic environments, in the future.

REFERENCES

[1] Kanwisher, N. et al. 1997. "The fusiform face area : A module in human extrastriate cortex specialized for face perception." Journal Neuroscience, Vol.17, 4302-4311.

[2] Institute for Traffic Accident Research and DataAnalysis (ITARDA) (in Japanese). 2003. "The annual traffic accident statistical database." Edition (2004).

[3] Bruce, C. et al. 1981. "Visual properties of neurosin a polysensory area in superior temporal sulcus of the macaque." Journal Neurophysiology, Vol.46, 369-384.

[4] Haxby, J. V. et al. 2000. "The distributed human neural system for face perception." Trends in Cognitive Science, Vol.4, 223-233

[5] T. Sugawara et al. 2006. “Enhancement of Motorcycle Conspicuity Using Brain Activities.” Review of Automotive Engineering, VoL.27, No.3.

[6] Blackwell, H. 1946. "Contrast thresholds of the human eye." Journal of the Optical Society of America, 36, 624-643

[7] Witus, G. and G. Gerhart and R. Ellis. 1858-1868. "Contrast model for three-dimensional vehicles in natural lighting and search performance analysis." Optical Engineering, 40.

[8] Arnow, T. and W. Geisler. "Visual detection following retinal damage." "Predictions of an inhomogeneous retino-cortical model." Proceedings of SPIE, 2674, 119-130.

[9] M. Shinya and T. Saito and T. Takahashi. 1989. "Rendering techniques for transparent objects." Proc. Graphics Interface ’89, 173-182.

[10] E. Nakamae and K. Kaneda and T. Okamoto and T. Nishita. 1990. "A lighting model aiming at drive simulators.” Proc. SIGGRAPH 1990, Vol. 24, August:395–404.

[11] G. Spencer and P. Shirley and K. Zimmerman and D. P. Greenberg. 1995. "Physically-based glare effects for digital images." Proc. SIGGRAPH, August:325–334.

[12] P. Rokita. 1993. "A model for rendering high intensity lights." Computers & Graphics, Vol. 17, No. 4, 431–437.

[13] P. E. Debevec and J. Malik. 1997. "Recovering High Dynamic Range Radiance Maps from Photographs." Proc. SIGGRAPH, August:369–378.

[14]Yamane,S. 1994. ":Population of neurons descriminate human faces." Information Processing in Brain, 665-671

[15] Y. Tsutsumi and K. Maruyama. 2007. "Long lighting system for enhanced conspicuity of motorcycles." ESV2007, 07-0182