Trial Development the Evaluation Method of Quantification the Feeling of Preventing Visibility by Front A Pillar

T. Arakawa, H. Sato

Abstract—There are many drivers who feel right A pillar of Japanese right-hand-drive car preventing visibility on turning right or left at intersection. On the other hand, there is a report that almost pedestrian accident is caused by the delay of finding pedestrian by drivers and this is found by drivers' eye movement. Thus, we developed the evaluation method of quantification using drivers' eye movement data by least squares estimation and we applied this method to commercial vehicle and evaluation the visibility. It is suggested that visibility of vehicle can be quantified and estimated by linear model obtained from experimental eye fixation data and information of vehicle dimensions.

Keywords—Eye fixation, modeling, obstacle feeling, right A pillar.

I. INTRODUCTION

IN this paper, we show the method of quantification the feeling of preventing visibility by right A pillar of Japanese right-hand-drive car. The report shows that there are many drivers who feel right A pillar preventing visibility on turning right or left at intersection [1], [2]. On the other hand, there is a report that almost pedestrian accident is caused by the delay of finding pedestrian by drivers and this is found by drivers' eye movement [3]. The monitor system showing the pedestrian or obstacle of blind corner is developing in order to improve the visibility on turning right or left at intersection [4]-[7], however, this device is costly that it takes long time to equip this device to commercial vehicle. Thus, it is important to design front pillar by driver's seat quantitative and it is suggested that eye movement can estimate the feeling of preventing visibility by right A pillar and it is useful if the method of quantification by data of eye movement. Engineers may be able to design the pillar efficiently by using this data and it may be bring the efficiency of design and development a vehicle.

Thus, we developed the evaluation method of quantification using drivers' eye movement data by least squares estimation and we applied this method to commercial vehicle and evaluation the visibility.

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II. EXPERIMENT

A. Hypotheses

In this paper, we defined the feeling of preventing visibility by right A pillar as "obstacle feeling". We set up following two hypothesizes as "obstacle feeling".

<Hypothesis 1>

Eye fixation duration near right A pillar becomes longer if driver strongly feel "obstacle feeling" because that the direction that driver recognize visually is superposed with right A pillar. In addition that, due to "obstacle feeling", driver tends to move eye from nearby pillar to windshield by drivers' seat and recognize visually obstacles such as an oncoming vehicle through windshield by drivers' seat. Thus, the longer the eye fixation time near pillar becomes, the more driver feels "obstacle feeling". Fig. 1 shows this situation. In Fig. 1, encircled part means eye fixation duration due to "obstacle feeling", and driver seems to move his eye like orange-colored arrow under this situation.

Fig. 1 Eye movement around right A pillar

<Hypothesis 2>

The factors affecting visibility of right A pillar are dead angle of right A pillar, the angle between straightforward and right A pillar and the angle between straightforward and meter face.

Following these hypotheses, in this paper, experiment and modeling were done.

B. Experimental Procedure

Experiment was done in order to measure the eye movement and eye fixation duration of drivers on driving vehicle. 3 persons were joined as subjects of this experiment. Each subject drove 5 kinds of C-segment vehicle and they wore Eye-mark recorder (EMR-9 of NAC Image Technology, Inc.) [7]. Subjects wearing Eye-mark recorder was measured their eye movement and eye fixation time. On the other hand, 3 parameters of 5 kinds of C-segment vehicle, which was used in the experiment, are the angle between straightforward and right A pillar, dead angle of right A pillar and the angle between straightforward and meter face, were measured. We verified about "obstacle feeling" from the point of correlation between 3 parameters and eye movement and eye fixation time of 5 kinds of C-segment vehicle.

Eye movement and eye fixation time were measured at winding course of Subaru Research and Development Center, located in Sano-city Tochigi Japan. 3 subjects of this experiment are instructed to wear Eye-mark recorder and drive the course in 5 kinds of C-segment vehicle and their eye movement and eye fixation time were measured. In advance of the experiment, we explained about the content of experiment to the subject of this experiment and get their consensus to be subject. In addition, we taught subjects not to move their head on driving because traffic accidents happen when drivers don't move their head so that data of eye movement and eye fixation time were measured.

III. RESULTS

A. Experiment and Sensory Evaluation

We defined "eye fixation rate" as following formula:

$$\text{Eye fixation rate} = \frac{\text{EFT}}{\text{TT}} \qquad (1)$$

where
EFT: eye fixation time to A pillar and windshield by drivers' seat
TT: the total time of turning the steering wheel on driving each curve line

Table I shows "eye fixation rate" on driving the course. Furthermore, we watched the movie of driving recorded by Eye-mark recorder as frame-by-frame playback and calculated eye fixation rate.

TABLE I
VISUAL FIXATION RATE OF EACH SUBJECT (UNIT: %)

Subject	Vehicle				
	A	B	C	D	E
1	42.25	45.08	44.09	45.24	39.54
2	49.93	49.84	52.54	58.06	45.58
3	51.86	53.44	61.87	32.99	41.21

Next, each subjects evaluated subjectively the visibility around right A pillar of each vehicle. Each subjects score units of 0.5 point, and they scored 4 point if they felt visibility best

and 1 point if they felt visibility worst. Table II shows the result. Table II shows that the difference of score between evaluators is not larger from the point view of standard deviation.

TABLE II
RESULT OF SENSORY EVALUATION

Vehicle	Subject			Average	S. D.
	1	2	3		
A	2.5	2.5	2.0	2.3	0.1
B	3.0	3.0	2.5	2.8	0.1
C	1.5	2.0	1.5	1.7	0.1
D	3.5	3.5	3.0	3.3	0.1
E	4.0	4.0	3.5	3.8	0.1

B. Modeling Using Result of Experiment

Dependent variable and independent variable was set as following and estimated average eye fixation rate, that is to say "obstacle feeling", was calculated by least squared method. Here, suffix i means the number of 5 vehicles used experiment. For example, R_A means the angle between straightforward and right A pillar of vehicle A.

<independent variable>
average eye fixation rate: y_i
<dependent variable>
the angle between straightforward and right A pillar: R_i
dead angle of right A pillar: B_i
the angle between straightforward and meter face: L_i

The result of applying by least squared method, estimated average eye fixation rate ($\hat{\mathbf{y}}$) was expressed as (2).

$$\hat{\mathbf{y}} = (-2.3934)\mathbf{R} + 5.0427\mathbf{B} + (-0.3719)\mathbf{L} + 48.003 \qquad (2)$$

where
$\hat{\mathbf{y}} = [y_A, y_B, \ldots, y_E]^T$, $\mathbf{R} = [R_A, R_B, \ldots, R_E]^T$,
$\mathbf{B} = [B_A, B_B, \ldots, B_E]^T$ and $\mathbf{L} = [L_A, L_B, \ldots, L_E]^T$.

Coefficient sign of (2) means that estimated average eye fixation rate is get to be small and that means "obstacle feeling" is get to be reduced if dead angle of right A pillar is reduced. In addition that, estimated average eye fixation rate is get to be small and that means "obstacle feeling" is get to be reduced if the angle between straightforward and right A pillar and the angle between straightforward and meter face get to be increased.

IV. CONSIDERATION

A. Correlation between the Result of Sensory Evaluation and Modeling

Fig. 2 shows the correlation between estimated average eye fixation time of 5 vehicles calculated by (2) and sensory evaluation of 3 subjects. Fig. 2 means that the linear model fits subjectivity of subjects in our case and eye fixation time seems to comparative with actual visibility.
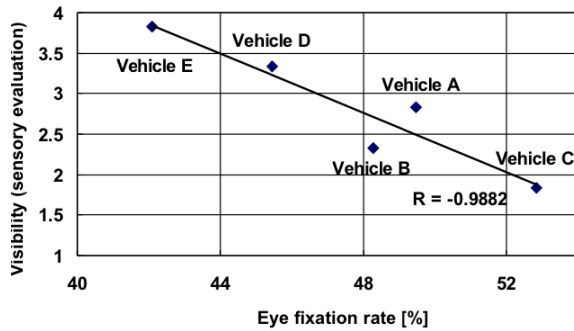
Fig. 2 Correlation between experimental eye fixation rate and sensory evaluation

B. Comparison between the Result of Experiment and Modeling

R_i, B_i, L_i is substituted for linear equation (2) and estimated average eye fixation rate is compared to the eye fixation rate obtained by experiment (Fig. 3). Fig. 3 means that estimated eye fixation rate have a strong correlation with visual fixation rate obtained by experiment (R=0.9611), so that linear model we constructed seems to express actual eye fixation rate.
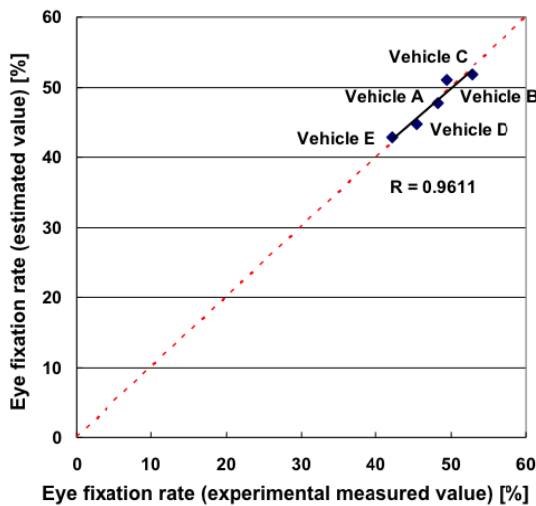

Fig. 3 Correlation between experimental measured value and estimated value

C. Applying the Model to Evaluate Visibility other Commercial Vehicle

Eye fixation rates of vehicle A-E and vehicle F and G, which are not used in experiment and are C-segment vehicle, are estimated by linear model (Fig. 4). Fig. 4 suggests that ye fixation rate classified into around 50%. We can say "Bad visibility vehicle" if the eye fixation rate is over 50%, on the other hand, we can say "Good visibility vehicle" if the eye fixation rate is less 50%. Actually, vehicle F and G is said that their visibility is good by Japanese consumers [8].
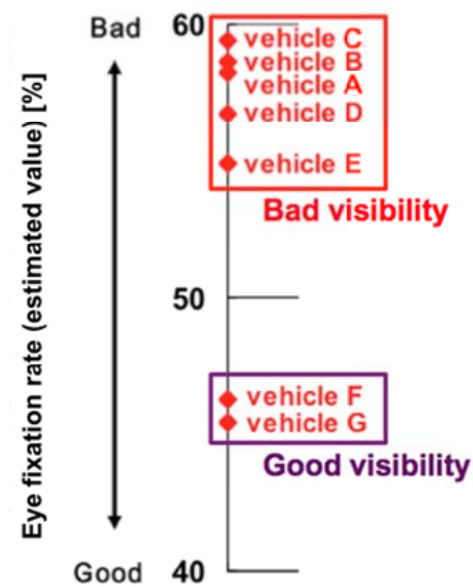

Fig. 4 Estimated value of eye fixation rate (vehicle A-G)

V. CONCLUSION

In this paper, we constructed linear model that means "obstacle feeling" by eye fixation rate measured by eye-mark recorder and the parameters, such as the angle between straightforward and right A pillar, dead angle of right A pillar and the angle between straightforward and meter face. In addition that, it is suggested that visibility of vehicle can be quantified and estimated by this linear model and using information of vehicle dimensions. This result seems to contribute the efficiency designing, however, we evaluate only C-segment vehicle in this paper and the experimental data of only 3 subjects are used so it is future study to acquire data of more subjects and apply this method to other segment vehicle.

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