Glare and visibility by headlight for pedestrian and elderly driver

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National Traffic Safety and Environment Laboratory

Background of study

The traffic accident number s on the decline from around 2001 in Japan. But accident number by aged driver is rising about 2.2 times from 15 years before.

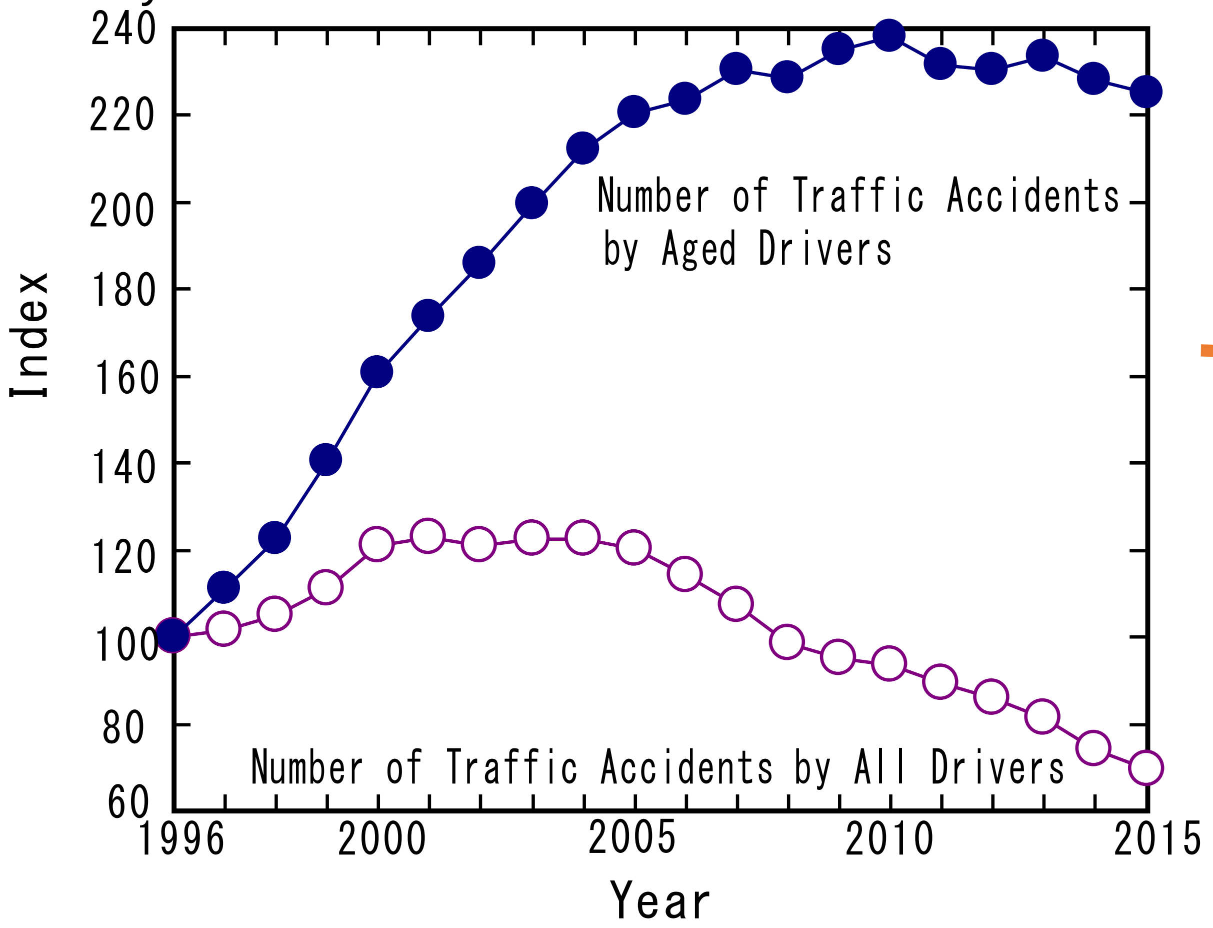
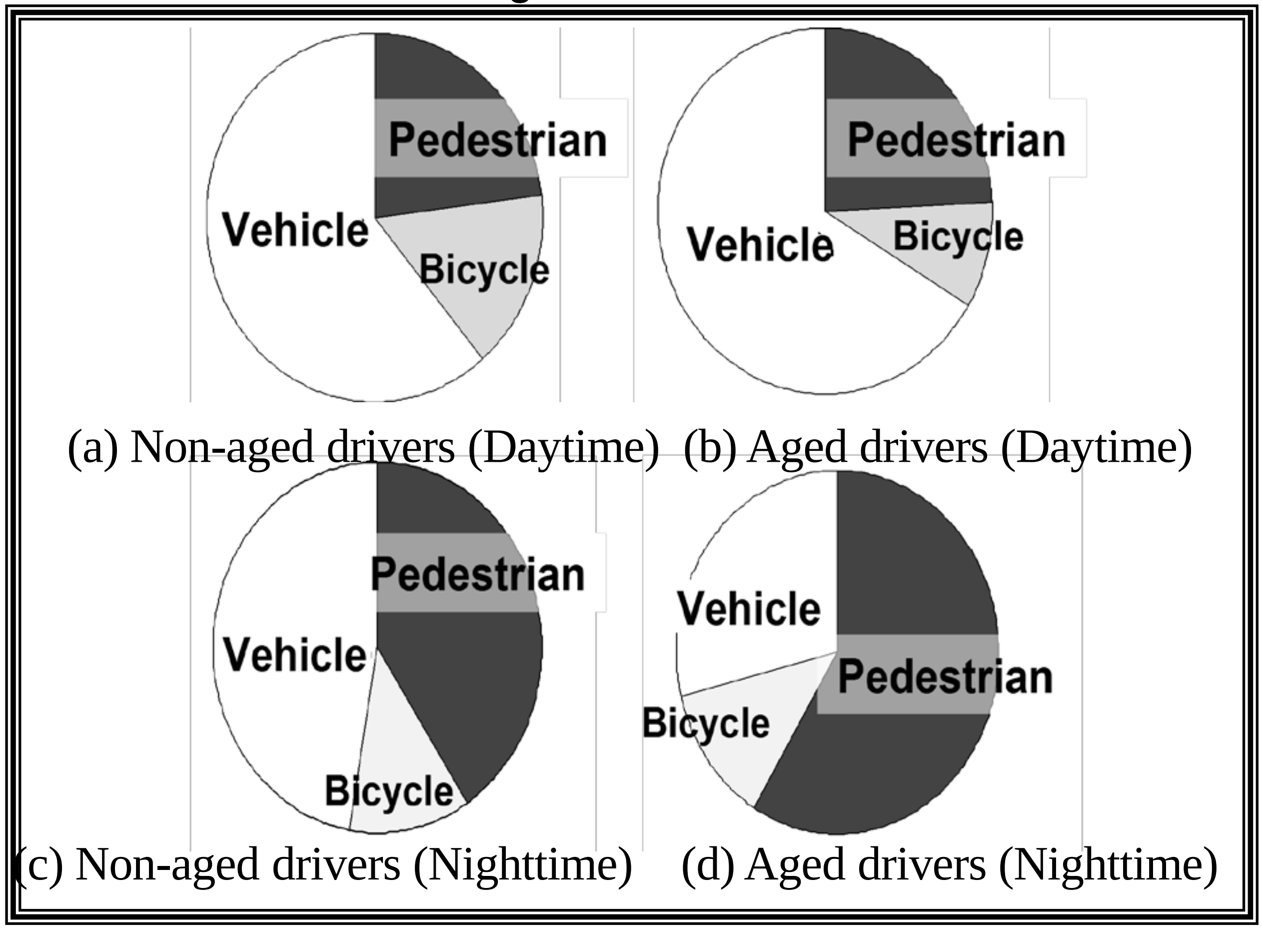


Fig. Change of the traffic accident number in Japan

We researched the accidents of the aged driver. It became clear that that the accidents have a high percentage of the pedestrian accidents in night as the result.



The pedestrian accident tends to lead to the fatal accident in particular, so the measure is needed.

Background of study

The reason which the aged driver often causes pedestrian accident in night

〇Decline of the visual ability of the aged driver

- Decline of the vision of the night → The risk which will overlook pedestrian rises for driver.
- Rise of the glare sensitivity → Influence of an oncoming vehicle headlight rises (Evaporative phenomenon of pedestrian).

The purpose of study

For reduction in further traffic accident, reduction of night pedestrian accident by the aged driver is important..

・Analysis about the night visual characteristics of the aged driver

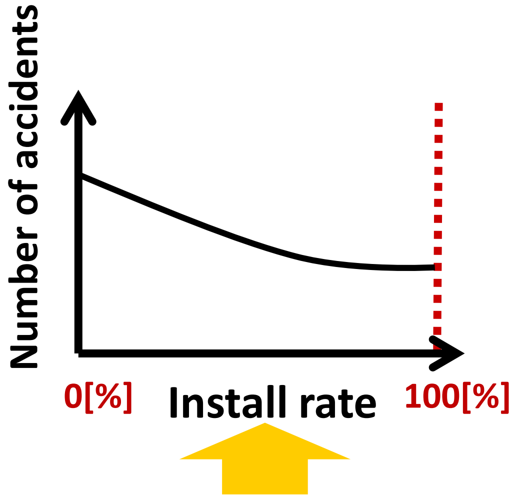
→Change in how to be seen by headlight and aging

We have developed a simulator with a name as "ASSESS" which can analyze road safety based on the data.

・Simulation analysis of change of pedestrian accident number by headlight and aging

・The Safety effect evaluation of the new headlight (ADB)

Overview of ASSESS



ASSESS

A Survey Simulator to Evaluate Safety Systems

The recognition algorithm for pedestrian(driver model)

The driver model calculates the pedestrian's contrast ratio ε_l to judge whether a pedestrian can be recognized or not by the following equation.

$$\varepsilon_l = \frac{P_l - B_l}{P_l + EV_l}$$

P_l : Pedestrian luminance

B_l : Background luminance

EV_l : Equivalent Veiling luminance

The driver model can detect a pedestrian, when this contrast ratio exceeds the contrast threshold value.

Equivalent Veiling luminance

There is a case that the driver cannot be to detect a pedestrian by the influence of the glare which is caused by the headlight of the oncoming vehicle.

Pedestrian‘s contrast ratio is influenced by glare which changes with the scattering particles size and density in driver’s eyeball.

○ **Equivalent veiling luminance is the value which reflects this influence to the driver by glare headlight.**

$$\varepsilon_l(\downarrow) = \frac{P_l - B_l}{P_l + EV_l(\uparrow)}$$

ε_l : Pedestrian's contrast ratio

P_l : Pedestrian luminance

B_l : Background luminance

EV_l : Equivalent Veiling luminance

When glare occurs, the pedestrian's contrast ratio decreases.

Equivalent Veiling luminance

ASSESS can simulate the change of glare with the aging on the basis of medical data

○ Simulation examples of glare based on the medical data of the eyeball state

Non-aged driver

Aged driver

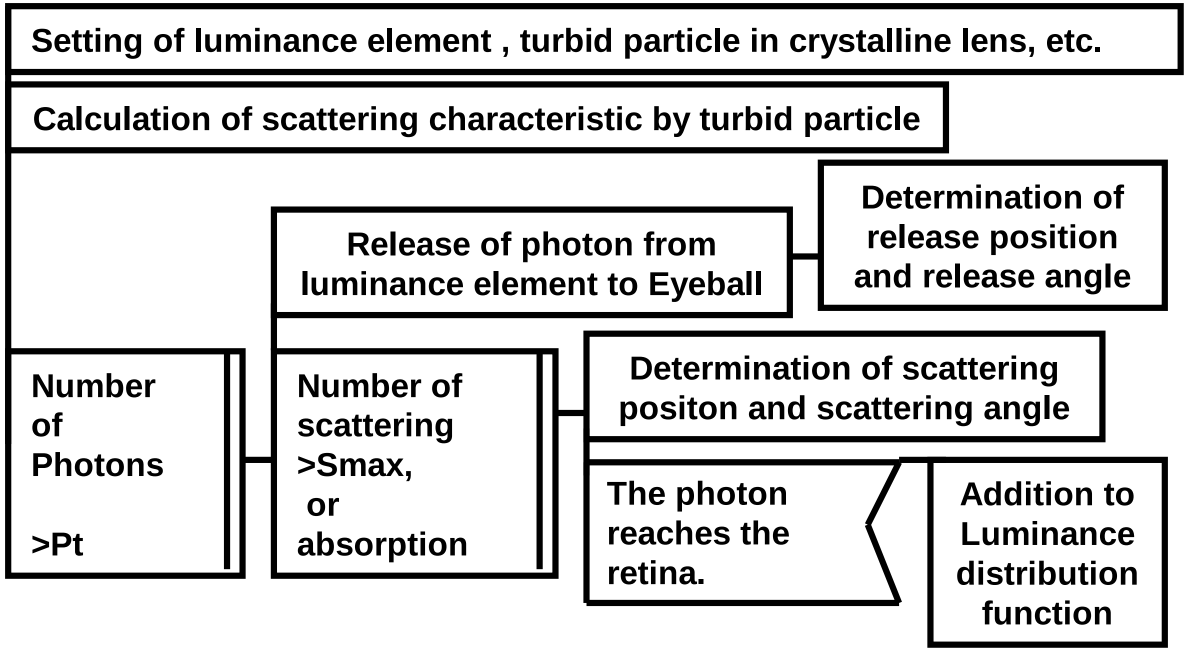


Fig.3 Light scattered analysis flow chart in crystalline lens

Equivalent Veiling luminance

$$\varepsilon_l(\downarrow) = \frac{P_l - B_l}{P_l + EV_l(\uparrow)}$$

ε_l : **Pedestrian's contrast ratio**

P_l : **Pedestrian luminance**

B_l : **Background luminance**

EV_l : **Equivalent Veiling luminance**

$\varepsilon_l < \varepsilon_{lt}$ **(Contrast threshold of pedestrian)**

→ Driver can't visually recognize pedestrian.

This contrast threshold of pedestrian also change by aging.
We researched this contrast threshold by a subjective experiment in the darkroom.

Experimental method（Equivalent Veiling luminance）

Subjects observe the imitation pedestrian image projected by projector light on the screen and conduct visibility evaluation.

○subjects: 30 drivers (15 non-aged drivers and 15 aged driver)

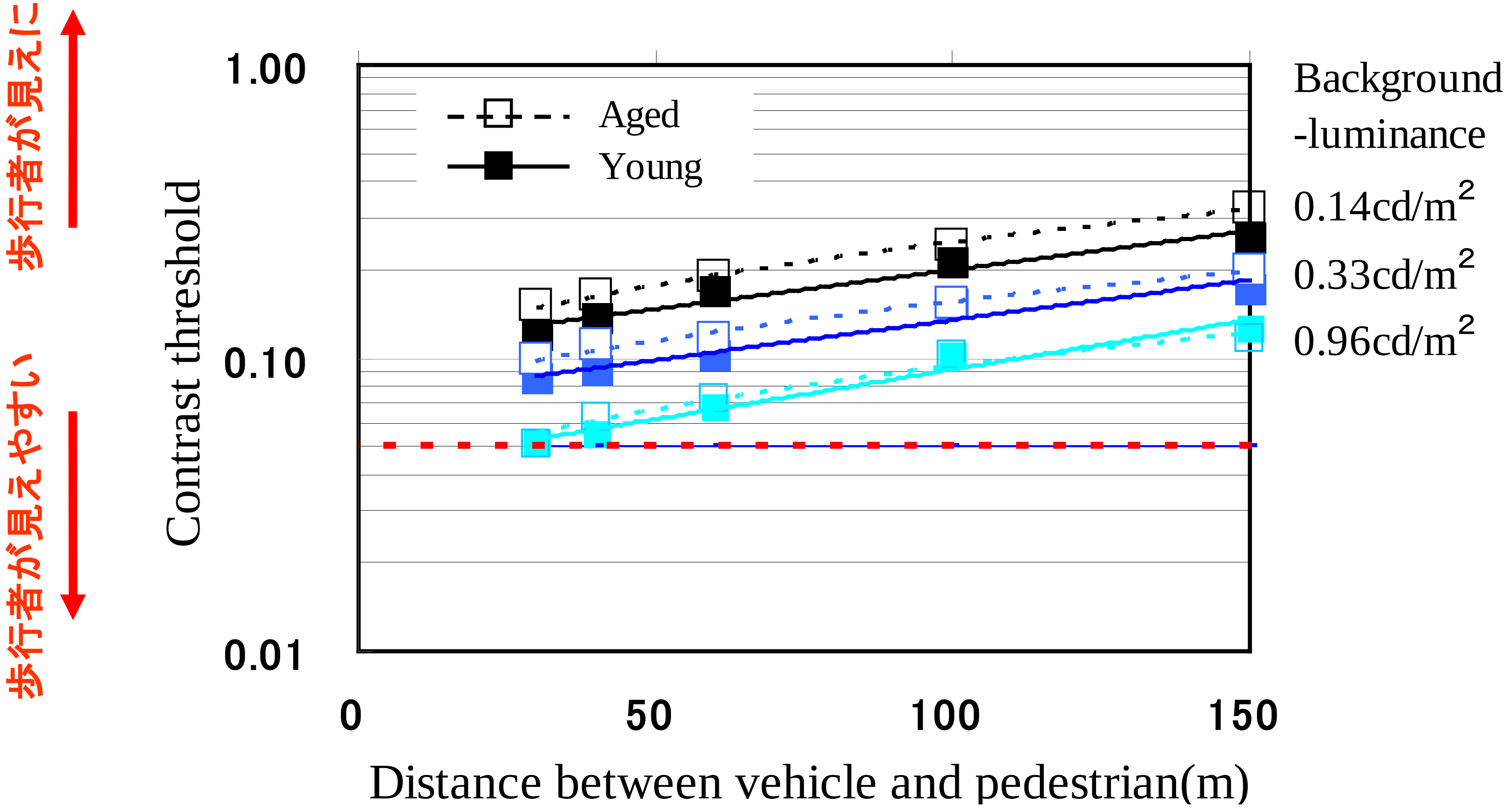
○Average eyesight：Non-aged drivers (left:0.98, right:0.98) Aged drivers(left:0.98, right:0.90)

darkroom

imitation pedestrian image

Experimental result

○ **Change in a contrast threshold by aging**



○Contrast threshold changes with aging and background luminance.

○ The aged drivers reduce visibility for the pedestrian with reduction of background luminance than non-aged driver and raise the contrast threshold.

（Contrast threshold of pedestrian）

【Non-aged driver (30-years-old) 】

$$\log_{10}(\varepsilon_{lt}) = -0.971 + 0.00293 \times R - 0.400 \times B_l$$

【Aged driver (70-years-old) 】

$$\log_{10}(\varepsilon_{lt}) = -0.869 + 0.00271 \times R - 0.480 \times B_l$$

ε_{lt} : **Contrast Threshold value of pedestrian**

B_l ： **Back ground luminance of the pedestrian**

R ： **Distance between the pedestrian and the vehicle**

Pedestrian model

(Simulate the crossing a street)

▪

The following judgment equation of crossing a street which change depends on the type of an approaching vehicle's headlights and pedestrian's position for this vehicle is set based on the analysis of the subject experiment data in nighttime.

【Low-Beam, Left-side pedestrian】 $y = 0.71x + 24.8$

【Low-Beam, Right-side pedestrian】 $y = 0.74x + 30.3$

【High-Beam, Left-side pedestrian】 $y = 0.45x + 36.4$

【High-Beam, Right-side pedestrian】 $y = 0.57x + 38.7$

x ： vehicle speed[km/h]
y ： distance between vehicle and pedestrian by which crossing is possible[m]

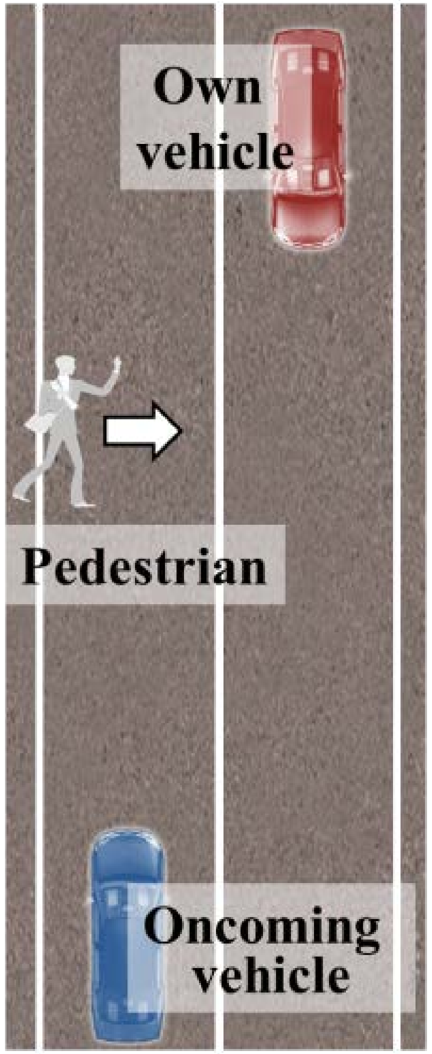
Subject experiment in nighttime

When y is shorter than the distance to an approaching vehicle, the pedestrian model judges not to cross a street, .

The situation of the evaluation

【Headlight type】
High beam, ADB, Low beam

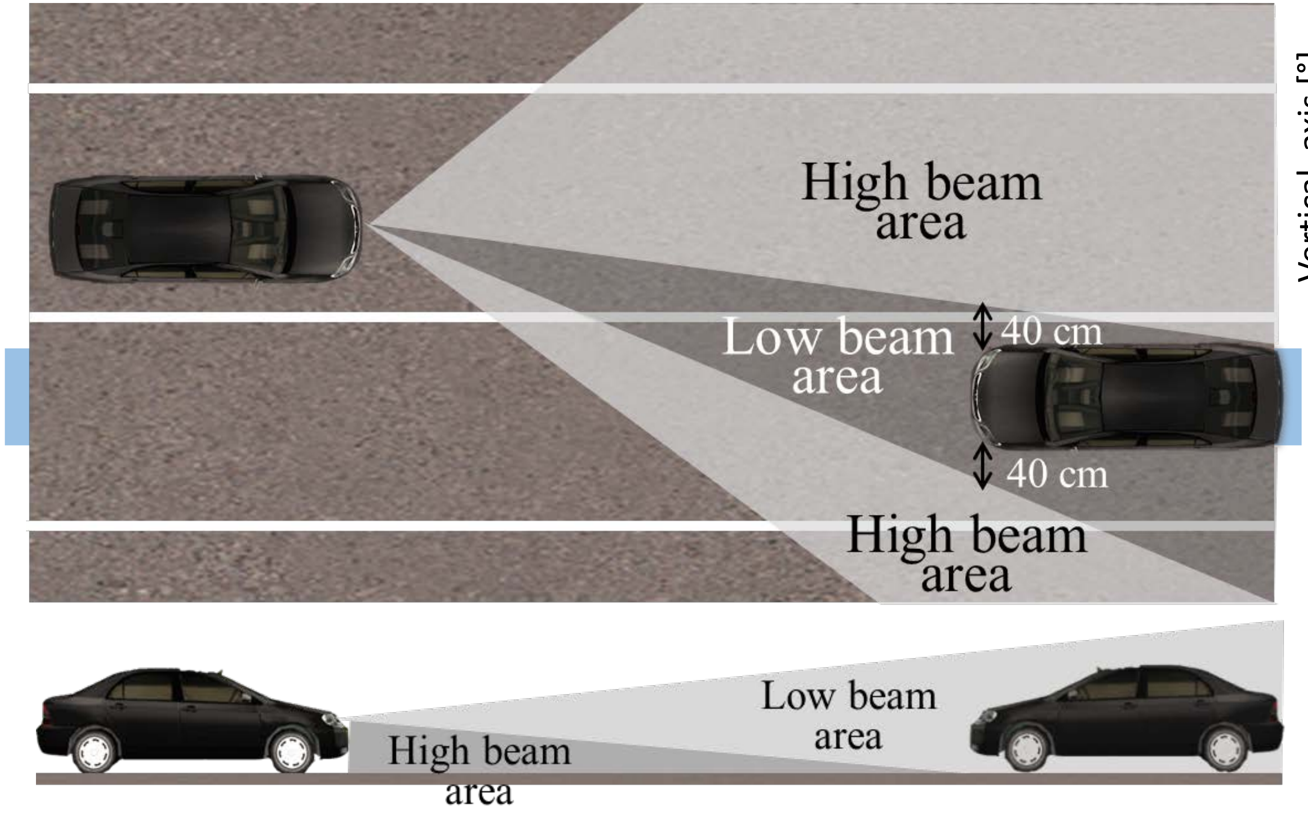
The Example of simulation

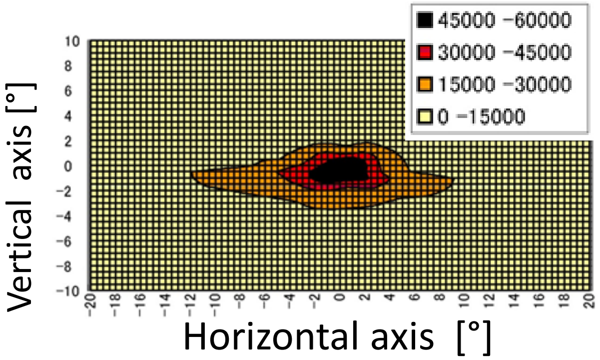


The combination patterns of the headlight type

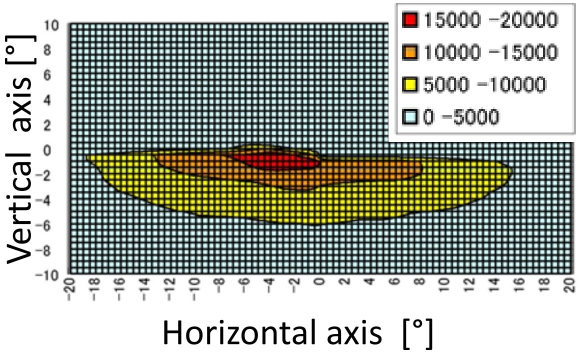
Headlight type	
Own vehicle	Oncoming vehicle
High beam	High beam
High beam	ADB
High beam	Low beam
ADB	High beam
ADB	ADB
ADB	Low beam
Low beam	High beam
Low beam	ADB
Low beam	Low beam

Adaptive driving beam (ADB)

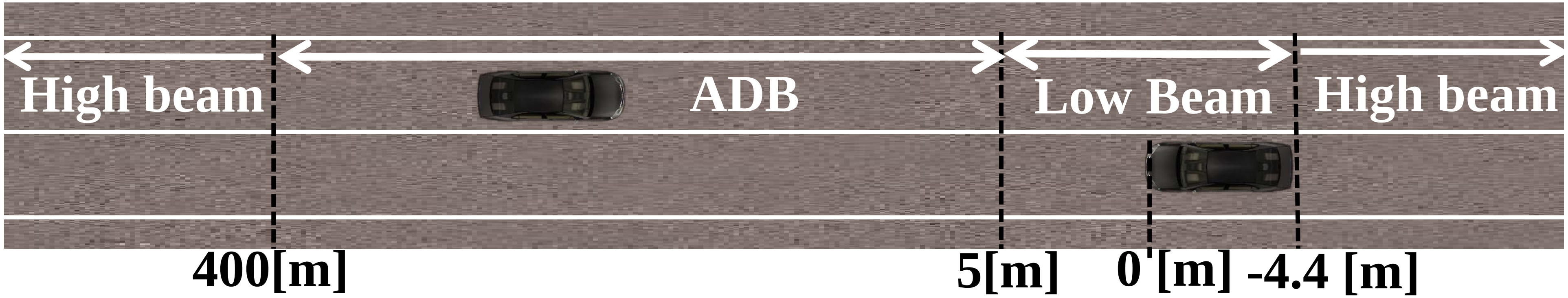




Luminosity of High beam [cd]



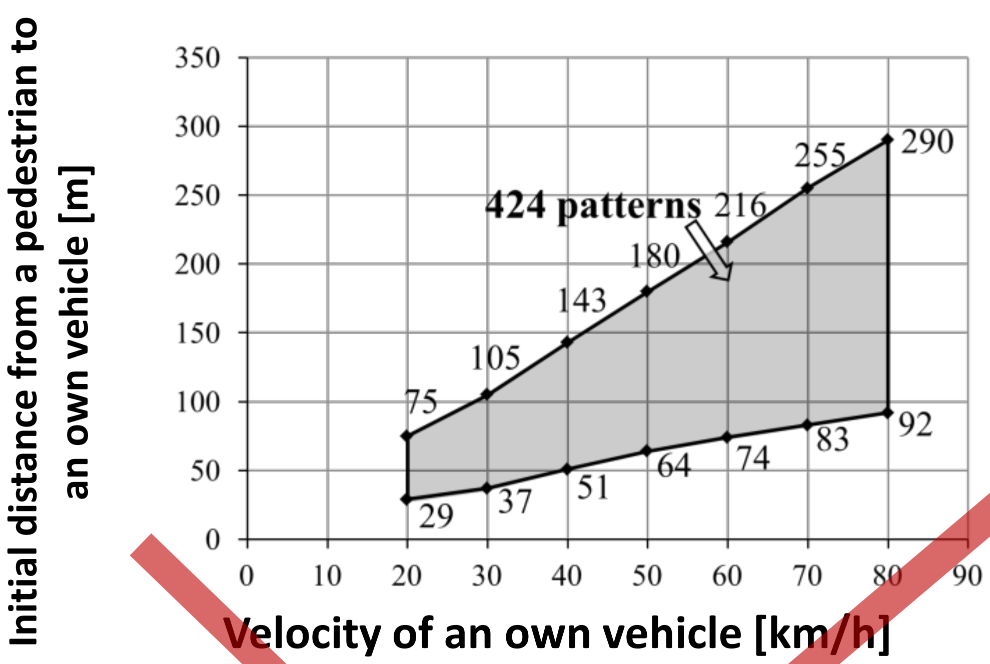
Luminosity of Low beam [cd]

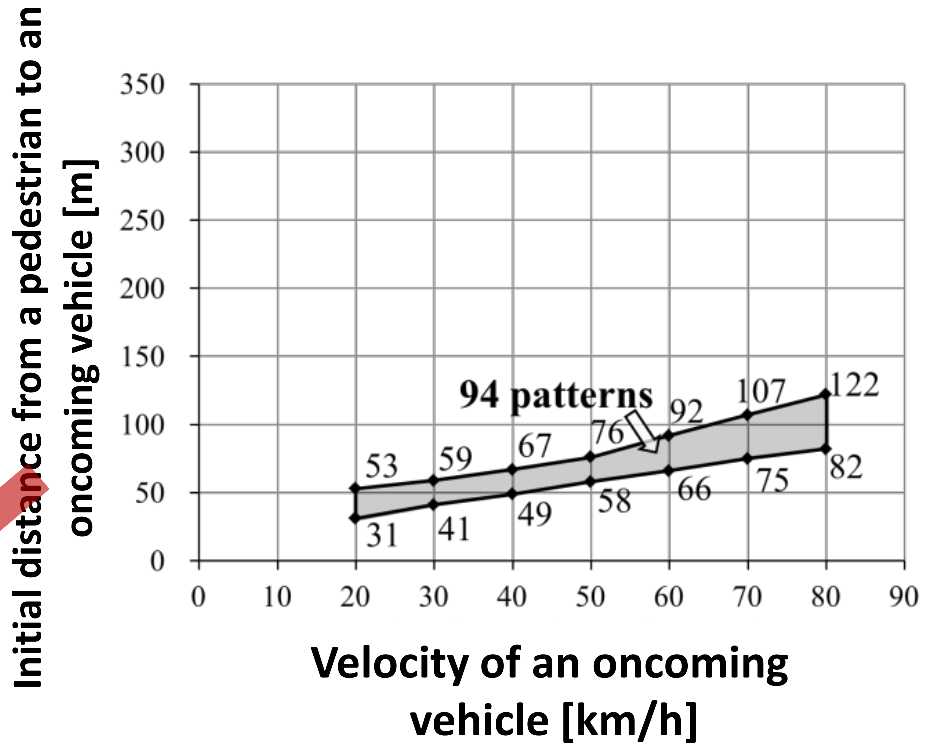


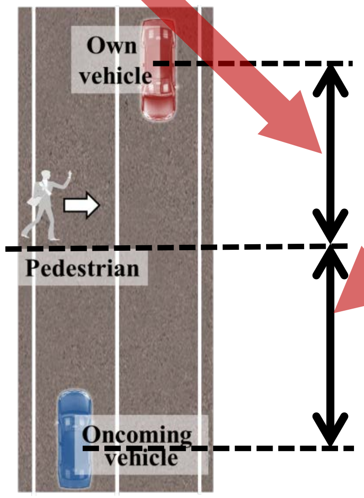
○ Case which pedestrian accident doesn’t occur by ADB.

○ Case which pedestrian accident occurs by low beam.

The conditions of evaluation







【 Velocity of the pedestrian 】

7.2 km/h, 5.4 km/h, 3.6 km/h

【 Age of Driver (influence of glare) 】

Young people(30-years-old), Elderly person (70-years -old)

【 Judgment of crossing a street 】

y intercept of the judgment equation : Average, ±σ, ±2σ

ASSESS simulation result

Table 2. Number of collisions and near-miss incidents in the case of the driver's age 30

Headlight type		The velocity of a pedestrian							
		5.4 [km/h]				3.6 [km/h]			
		Collision		Near-miss incident		Collision		Near-miss incident	
own vehicle	oncoming vehicle	own vehicle	oncoming vehicle	own vehicle	oncoming vehicle	own vehicle	oncoming vehicle	own vehicle	oncoming vehicle
ADB	High beam	270	0	613	0	2,693	0	2,283	0
ADB	ADB	0	0	0	0	4	0	45	0
ADB	Low beam	0	0	0	0	15	0	59	7,049
Low beam	High beam	510	0	1,275	0	4,080	0	3,113	0
Low beam	ADB	510	0	1,122	0	4,029	0	2,751	0
Low beam	Low beam	570	0	1,254	0	4,503	0	3,061	7,125
High beam	High beam	201	0	615	0	1,871	0	1,710	1,127
High beam	ADB	0	0	0	0	0	0	0	2,663
High beam	Low beam	0	0	0	0	0	0	0	7,049

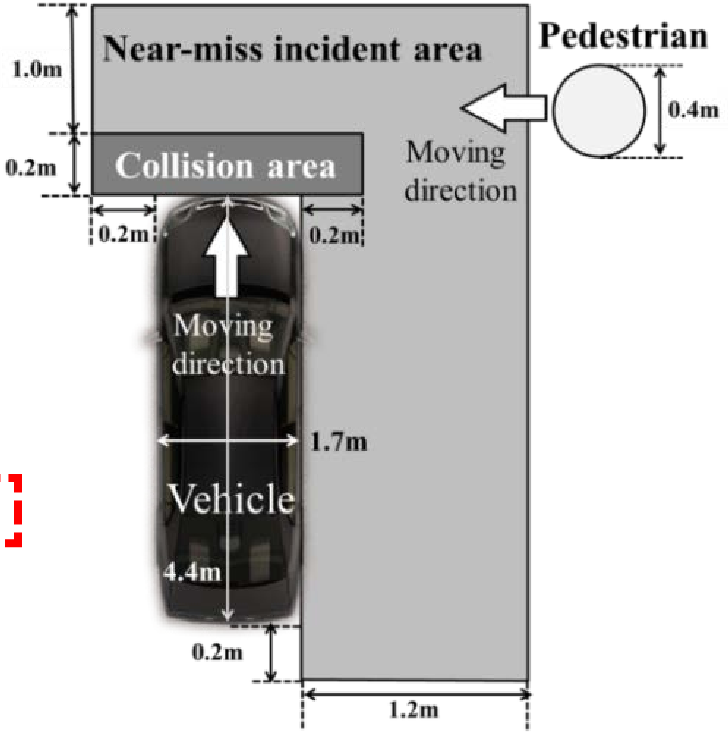


Fig. Areas for judging collision and near-miss incident

ASSESS simulation result

Table 4. Number of collisions and near-miss incidents in the case of the driver's age 70

Headlight type		The velocity of a pedestrian							
		5.4 [km/h]				3.6 [km/h]			
		Collision		Near-miss incident		Collision		Near-miss incident	
own vehicle	oncoming vehicle	own vehicle	oncoming vehicle	own vehicle	oncoming vehicle	own vehicle	oncoming vehicle	own vehicle	oncoming vehicle
ADB	High beam	1,240	0	1,919	0	5,034	0	5,713	0
ADB	ADB	0	0	17	0	287	0	520	0
ADB	Low beam	0	0	5	0	291	0	713	12,023
Low beam	High beam	1,650	0	2,250	0	6,579	0	5,570	0
Low beam	ADB	1,575	0	2,100	0	6,150	0	5,266	0
Low beam	Low beam	1,638	0	2,184	0	6,396	0	5,464	12,054
High beam	High beam	1,166	0	1,947	0	4,146	0	5,142	8,343
High beam	ADB	0	0	0	0	1	0	25	10,301
High beam	Low beam	0	0	0	0	0	0	35	13,002

There is a possibility that the pedestrian accident night of the aged driver decreases remarkably by the spread of ADB.

Summary

1. **The aged drivers are rised the contrast threshold so that background luminance becomes low compared with non-aged driver. →The aged driver has high dangerous degree on a dark road surface in particular.**

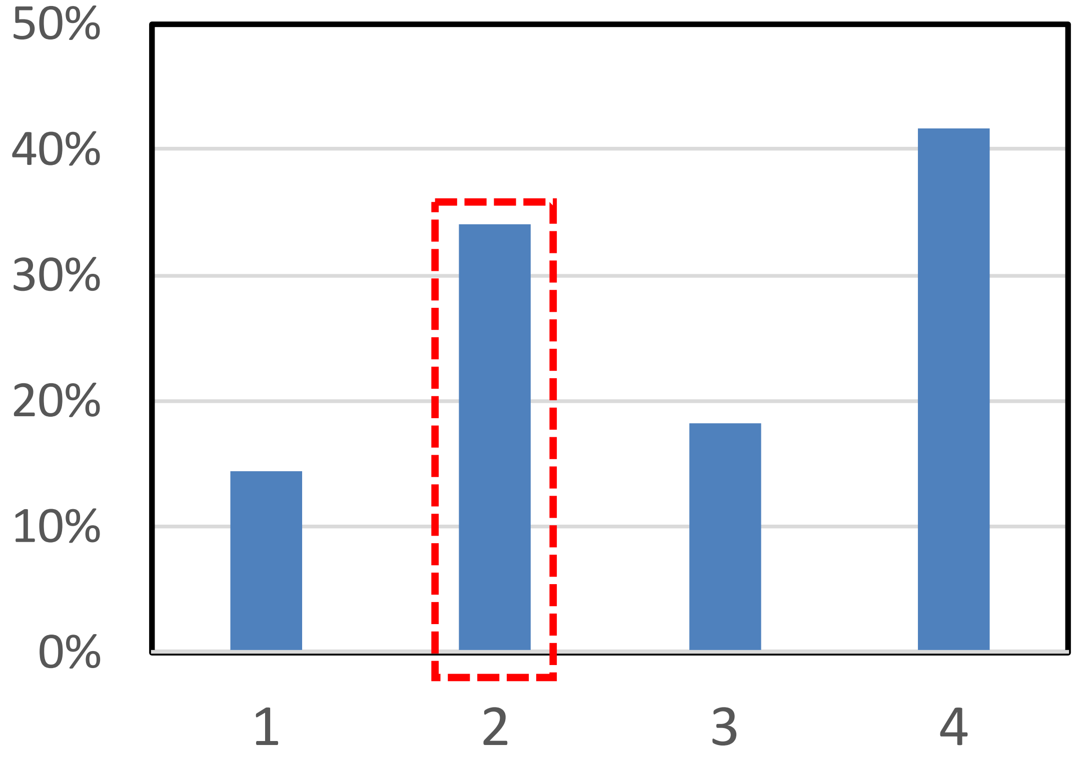
2. **The number of the collision and the near miss for night pedestrian were analyzed by ASSESS. It became clear that the case for which 2 vehicles which pass each other use ADB together has the lowest dangerous degree of the night pedestrian. It became clear that the spread of ADB is able to expect the reduction effect of the accident.**

Future research task

(1)The safety evaluation according to the ADB performance （Because it was analyzed in ADB with the ideal performance this time）

(2) Consideration of glare control to pedestrian as well as an oncoming car

→The percentage of the pedestrian who feels dangerous is quite large when headlight is glare.



1 : The pedestrian who has the experience which felt danger because the brightness of headlight wasn't enough at a dark night

2 : The pedestrian who has the experience which felt danger during crossing because the headlight was too glare.

3 : The pedestrian who has not felt danger even if the headlight feels glare

4 : The pedestrian who has not felt danger in particular

Fig.3 Questionnaire result of the pedestrian safety by a headlight （Q About a headlight of a close vehicle at night.）

Thank you for listening

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