Simulation of Detection Performance by LIDAR Location in Automated Vehicles

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Contents

1. Introduction

Goals of automated driving

- Reduction of traffic accidents

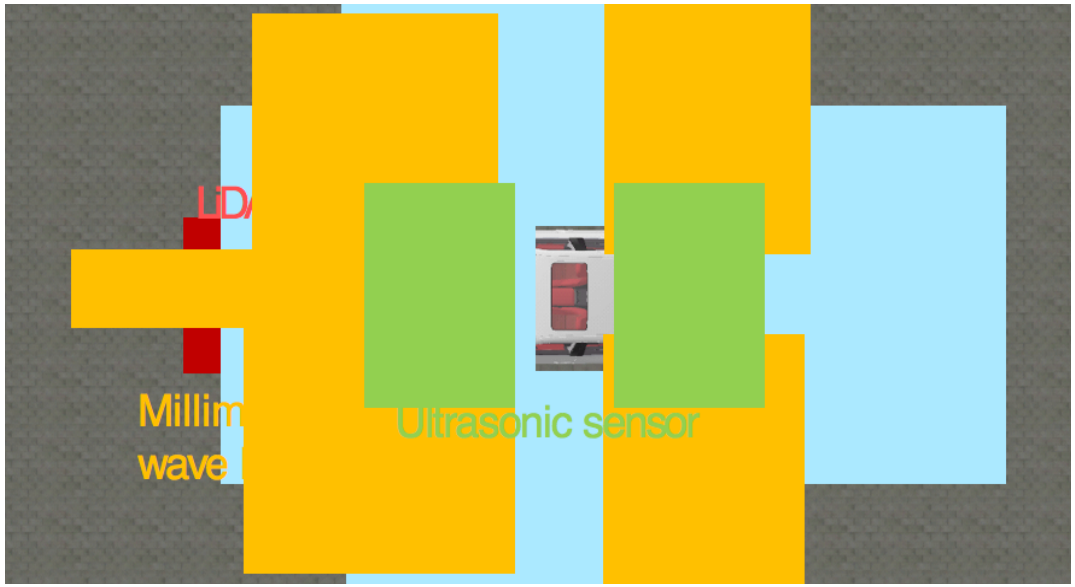
- Mitigation of congestion

- Environmental pollution measures

- Relief of vulnerable road users

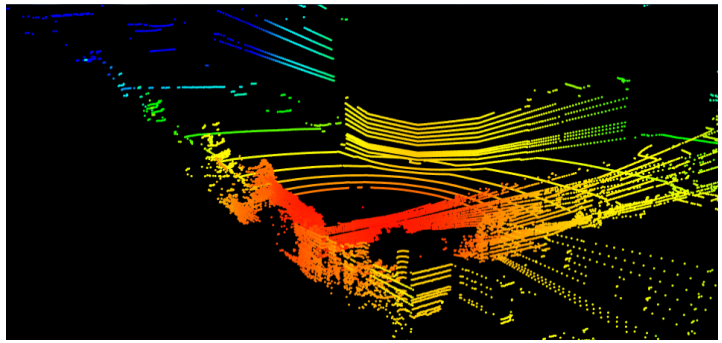
For automated driving

Automated vehicles will be equipped with many sensors



1. Introduction

LiDAR (Light Detection and Ranging)



Various locations for installing the LiDAR

- Roof
- Bumper
- Front grille
- Headlamps

The LiDAR detection range varies

Examine differences in the detection ranges due to the LiDAR location using…

- LiDAR location: 3 types(Roof,Bumper,Headlamps)

- In driving scenes and parking scenes

2. Simulations of driving scenes

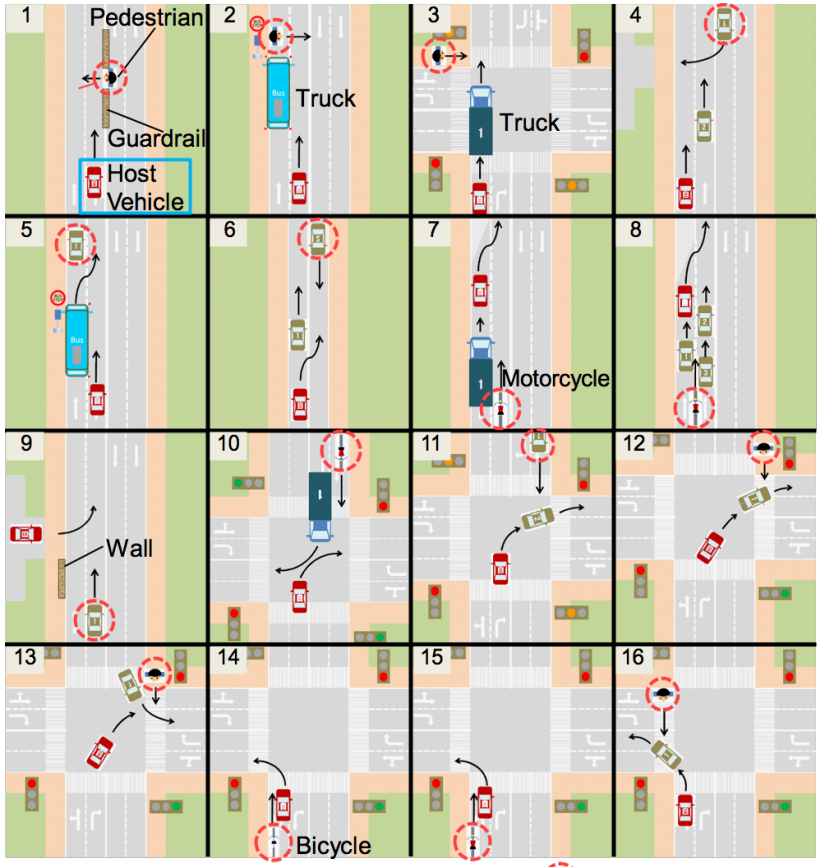
Driving scenes: Setups

JARI (Japan Automobile Research Institute) categorized all types of traffic scenes into 310 scenes[1] with degree of danger

16 scenes were selected

- Blind spot by obstacles
- High degree of danger

All scenes were left-hand traffic

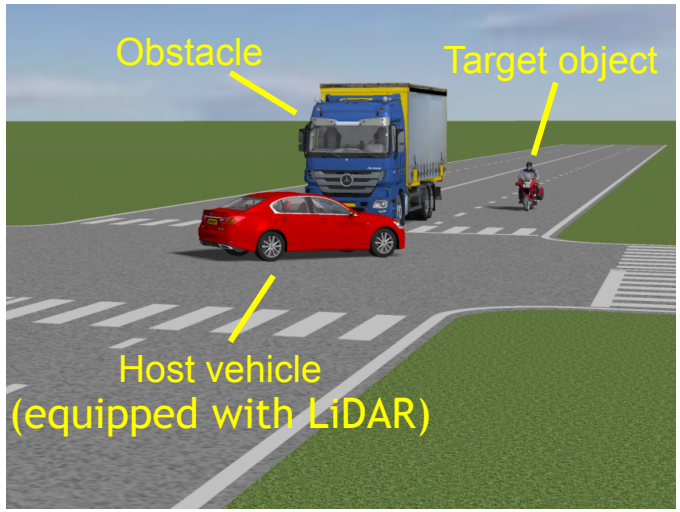


: Target Objects

[1] Japan Automobile Research Institute: "Safety Design of Automated Vehicle" of Research, Development and Demonstration projects of Smart Mobility Systems commissioned by Ministry of Economy, Trade and Industry (METI), 2016.

Driving scenes: Setups

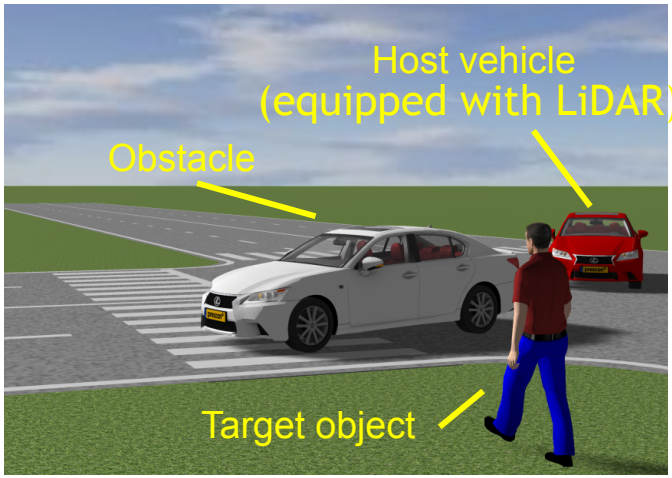
- Simulate 10 seconds to collision



Example: Scene No. 10

Driving scenes: Setups

- Simulate 10 seconds to collision
- Pedestrians: adults, children



Example: Scene No. 12

Driving scenes: Setups

Object dimensions

Vehicle

4.85 x 2.07 x 1.47 (m)

Truck

9.99 x 3.00 x 4.24 (m)

Motorcycle

2.22 x 0.82 x 1.69 (m)

Bicycle

1.81 x 0.91 x 1.85 (m)

Pedestrian

Adult

0.36 x 0.52 x 1.76 (m)

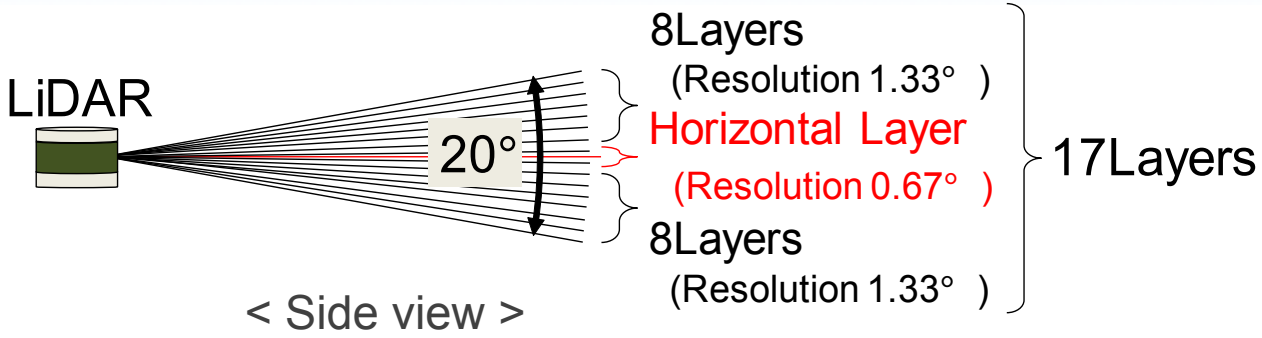
Child

0.20 x 0.29 x 0.98 (m)

Driving scenes: Setups

LiDAR specifications

- Rotating LiDAR was replicated
- 16 + horizontal layer



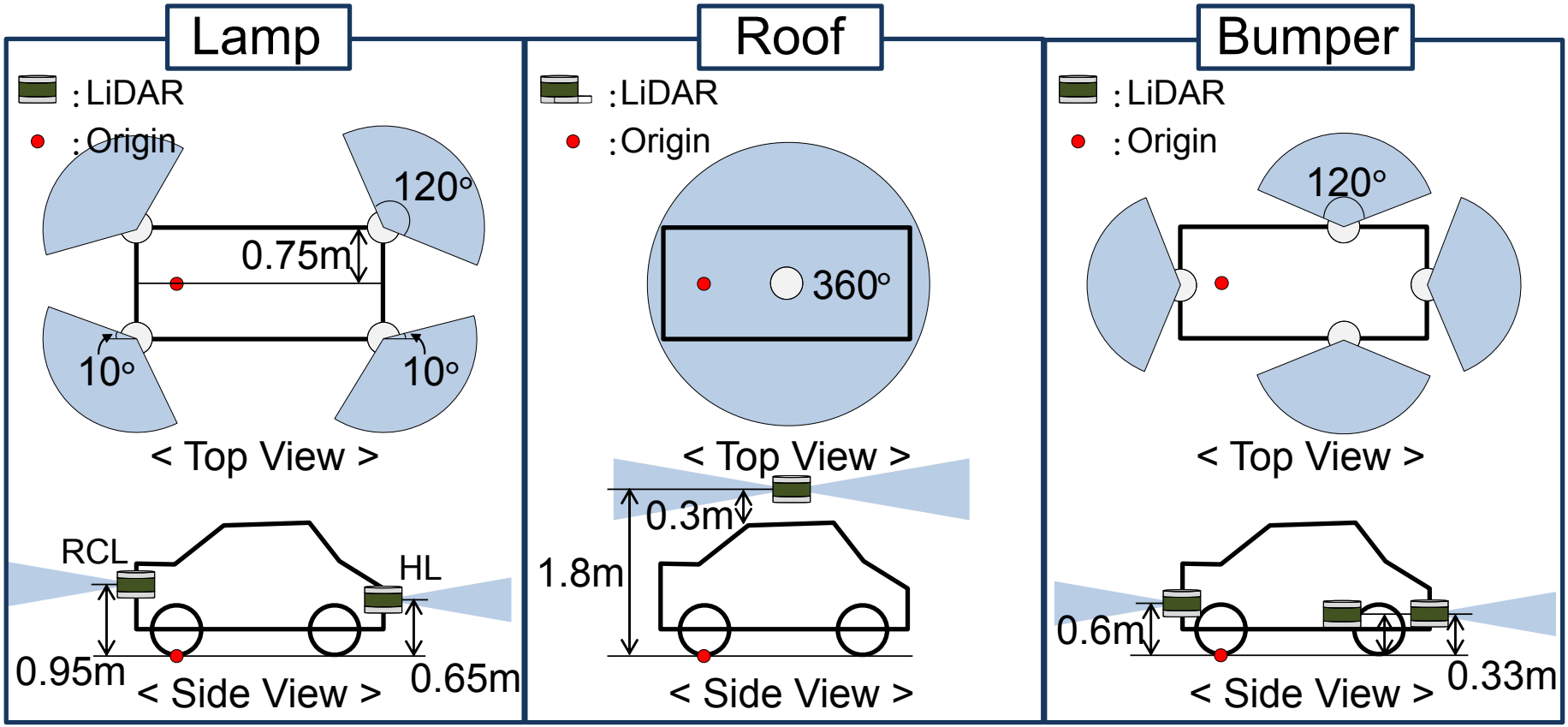
< Side view >

LiDAR configuration

FoV	Horizontal	360° or 120°
	Vertical	+10.0° to -10.0° (20°)
Angular Resolution	Horizontal	0.2°
	Vertical	1.33° (0.67° at horizontal)
Simulation Rate		10 Hz
Measurement Range		1 m ~ 100 m

Driving scenes: Setups

LiDAR locations

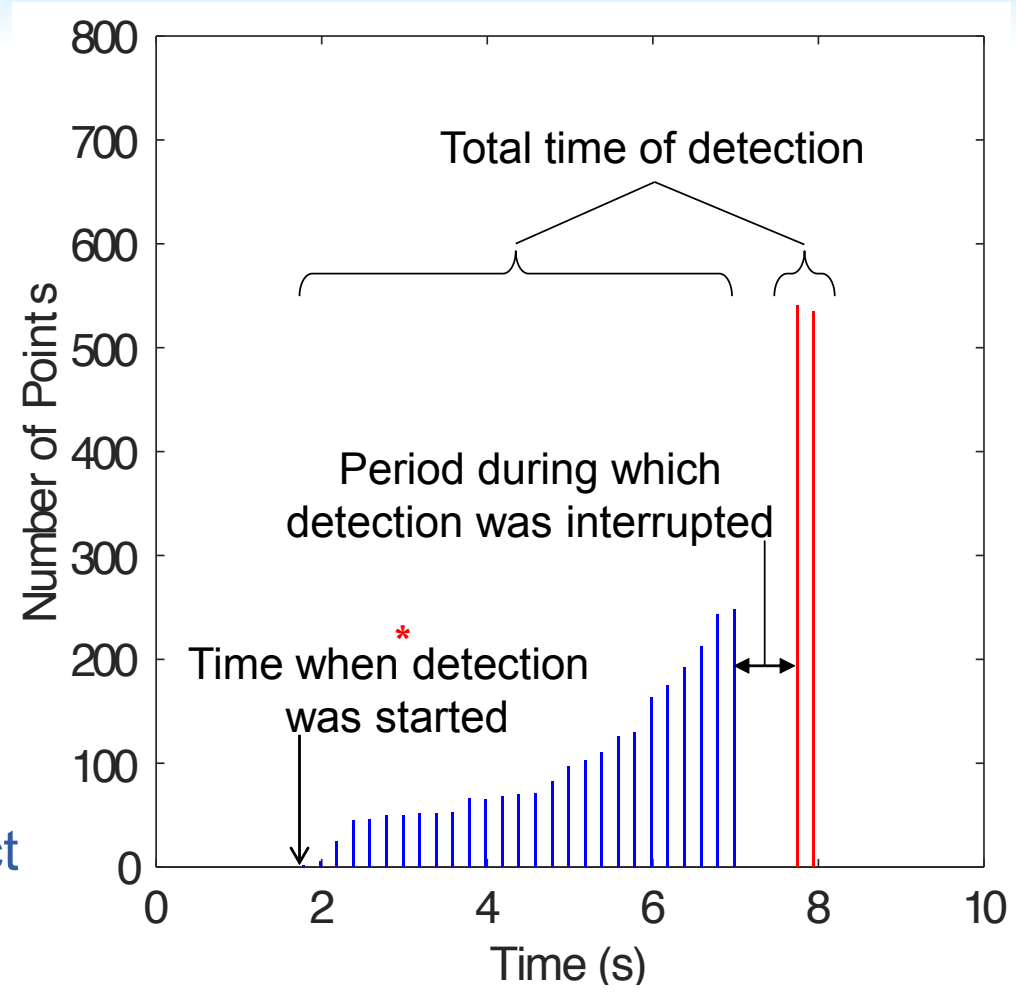


Driving scenes: Results

Evaluation criteria

To detect target objects

<u>early and longer duration</u>



*Detection:
A state in which at least
one LiDAR point has hit a target object

Driving scenes: Results

Among the 16 driving scenes (first, pedestrian was a adult)**,**

11 scenes that produced different results were examined by classifying them into three types

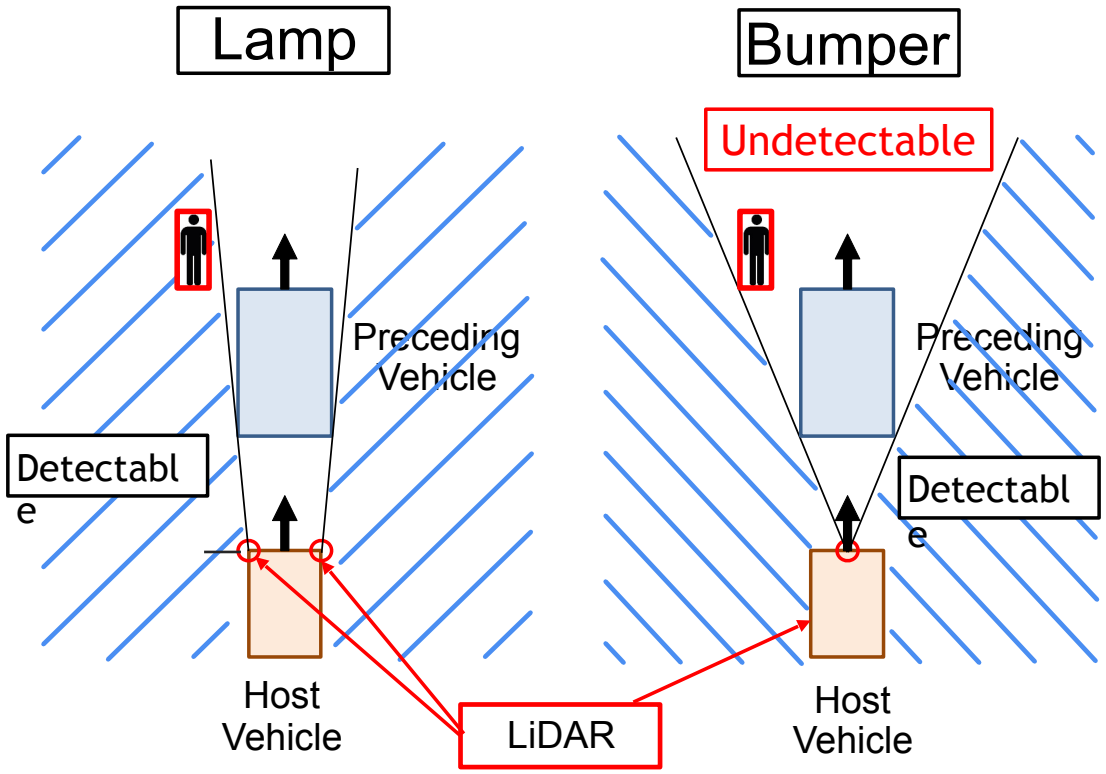
(A) Advantage of corners

(B) Difference of height

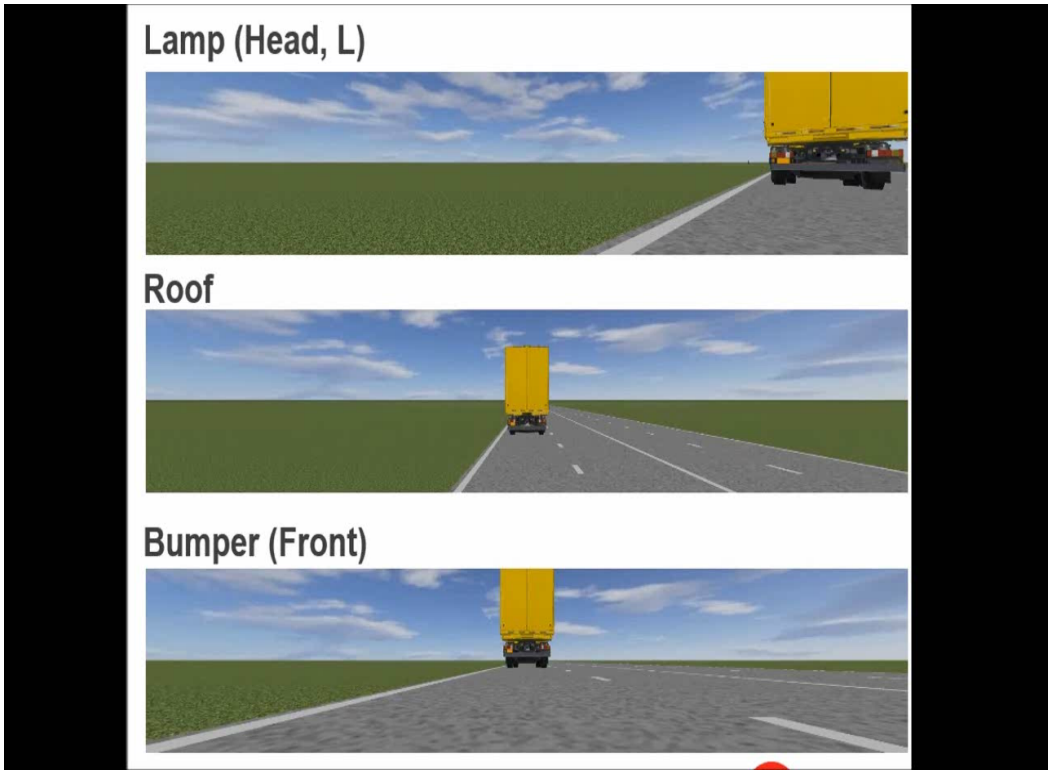
(C) Other scenes

Driving scenes: Results

(A) Advantage of corners (Scene No. 3, 5, 7, 8, 10)

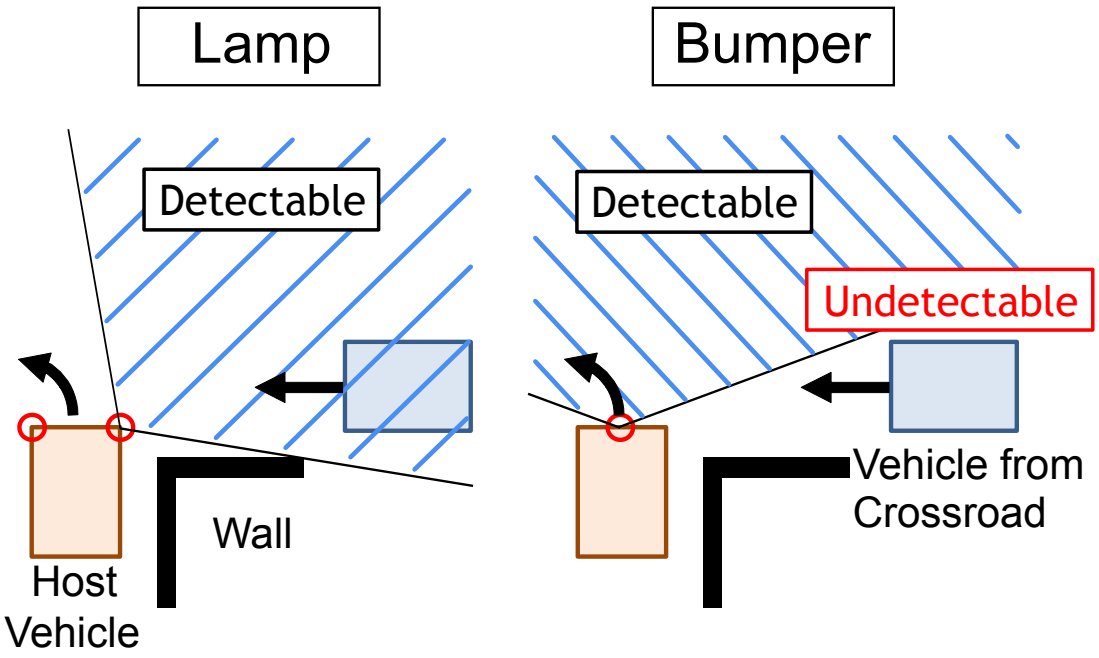


The view from LiDAR (Scene No. 3)

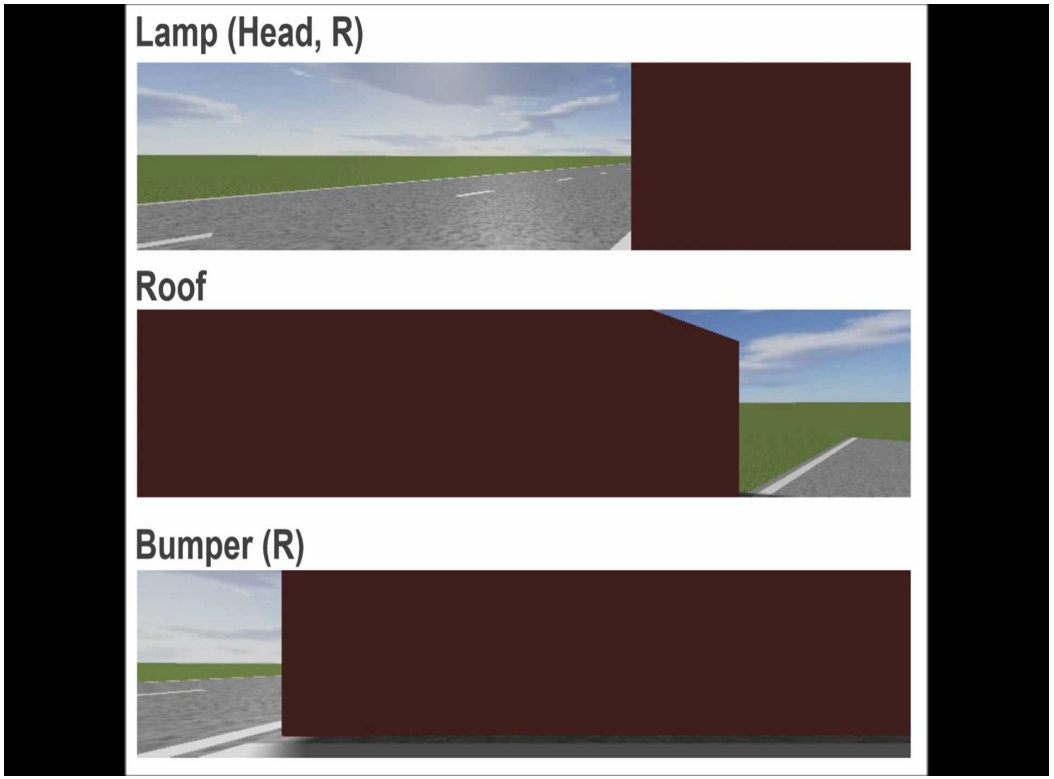


Driving scenes: Results

(A) Advantage of corners (Scene No. 9)

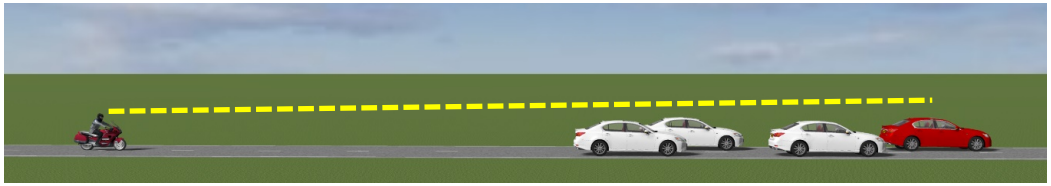


The view from LiDAR (Scene No. 9)



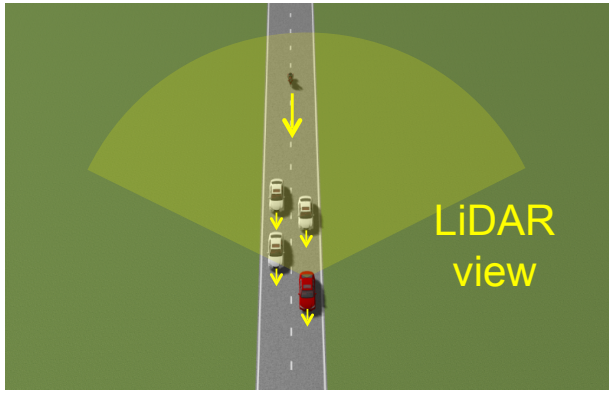
Driving scenes: Results

(B) Difference of height (Scene No. 8, 12, 13, 16)

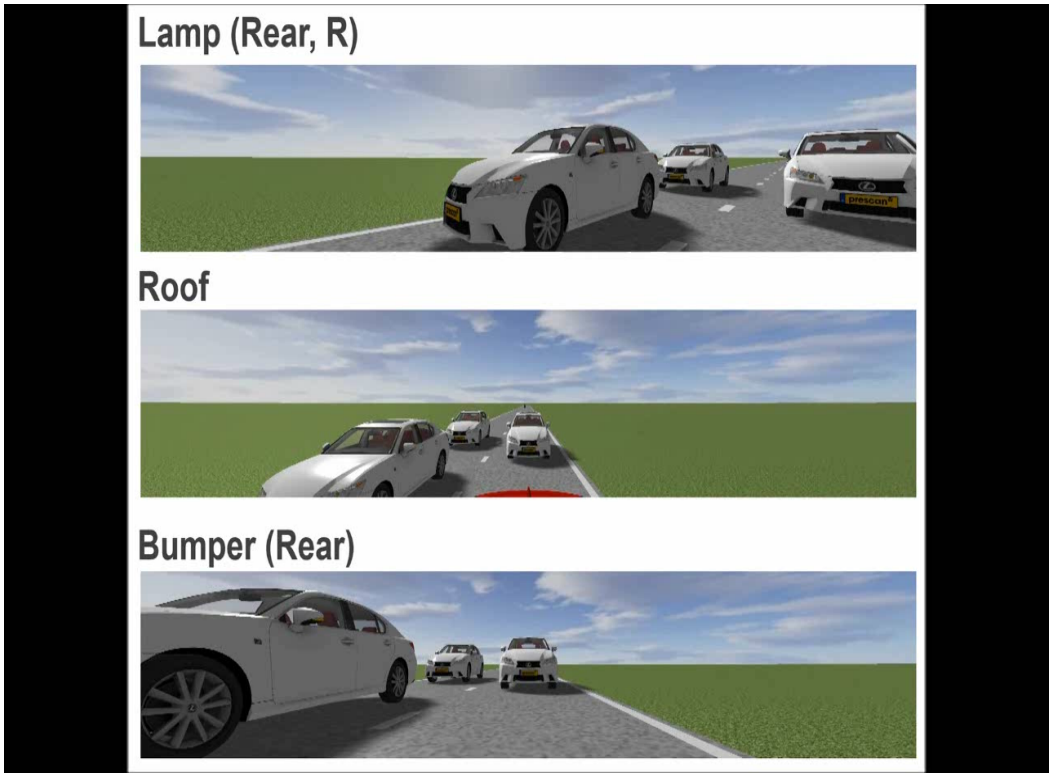


Motorcycle (Target Object)

Host Vehicle



The view from LiDAR (Scene No. 8)

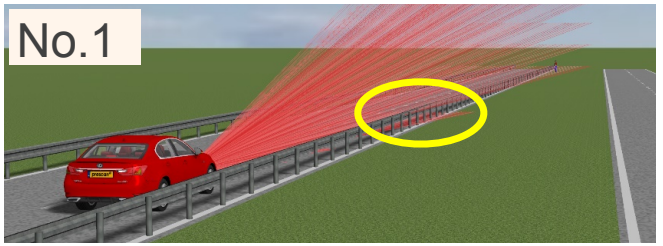


Driving scenes: Results

(C) Other scenes

Scene No.1

Bumper： LiDAR beams were blocked by the guardrails



Scene No.2

Lamp： LiDAR beams travelled underneath a truck and detected a pedestrian

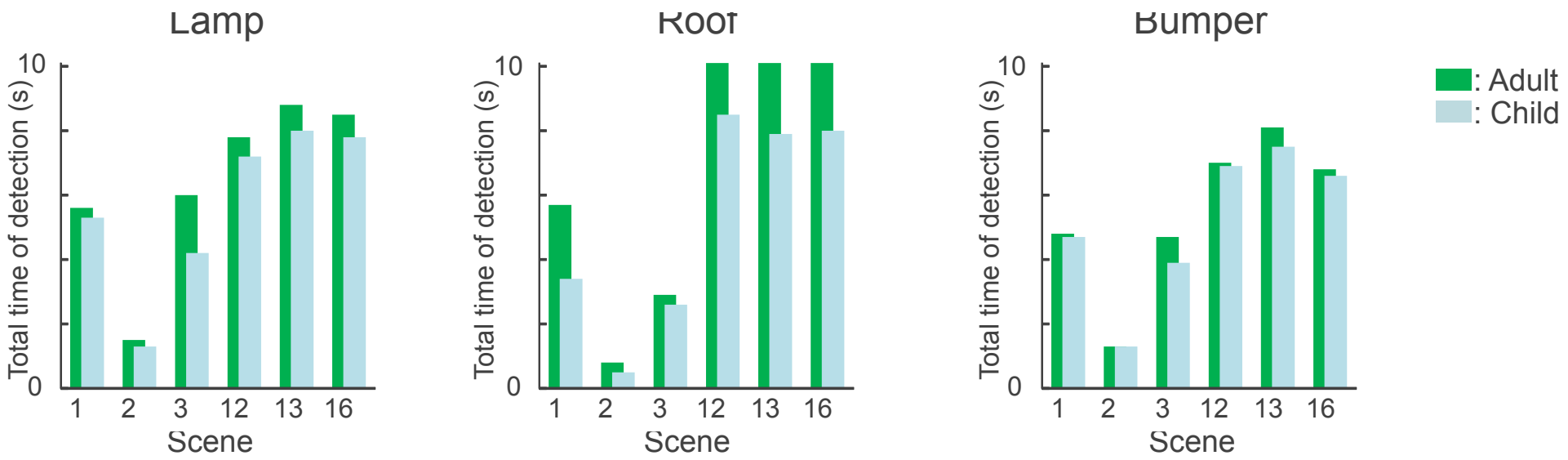
Issue

Some real-world situations were not able to be reproduced by the simulation

- **Whether these simulation results can actually occur needs to be verified**

Driving scenes: Results

Comparison: adults, children



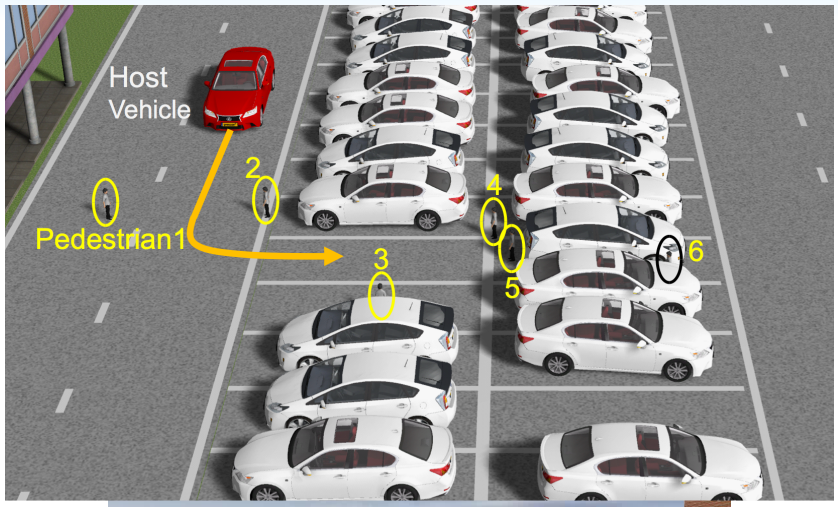
In the case of the children

- Total time of detection decreased, significantly when the LiDAR was on the roof

2. Simulations of parking scenes

Dangers in parking lots

- Many obstacles
- Sudden rushing out of pedestrians

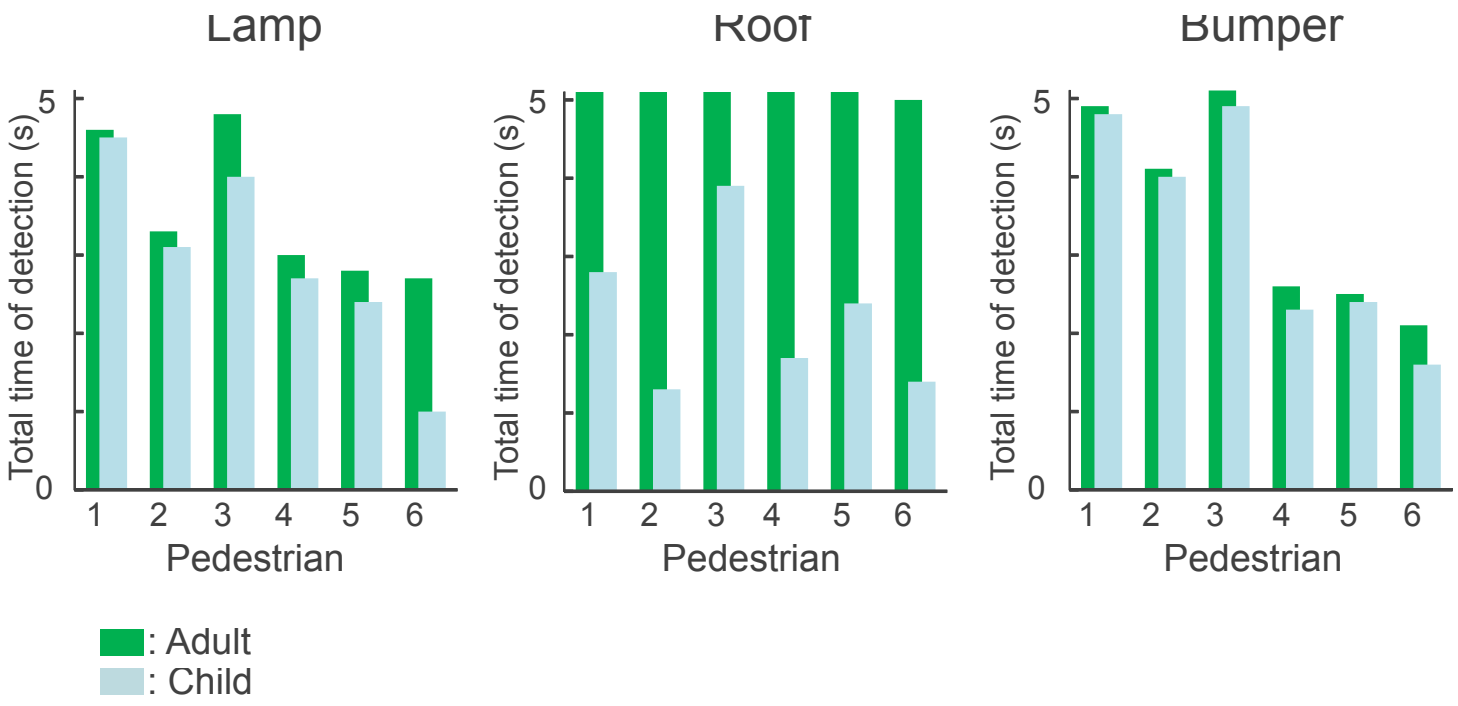


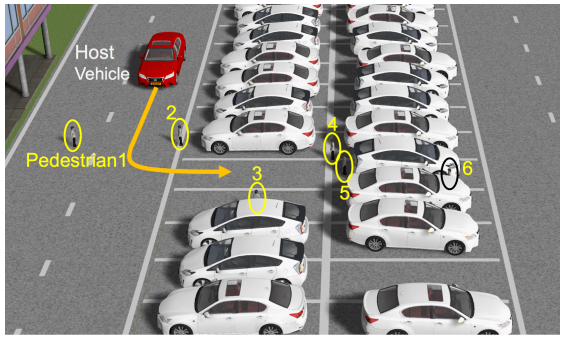
Setting

- Pedestrians: near the traveling route of the host vehicle
- Simulation travel time: 5 seconds
- Pedestrians: adults, children

Parking scenes: Results

Comparison: adults, children





In the case of the children,

On the roof

- Total time of detection was shortest in some cases

It is difficult to detect a child around the host vehicle

4. Conclusions

How the LiDAR's detection performance changes with the LiDAR's position was verified through simulations.

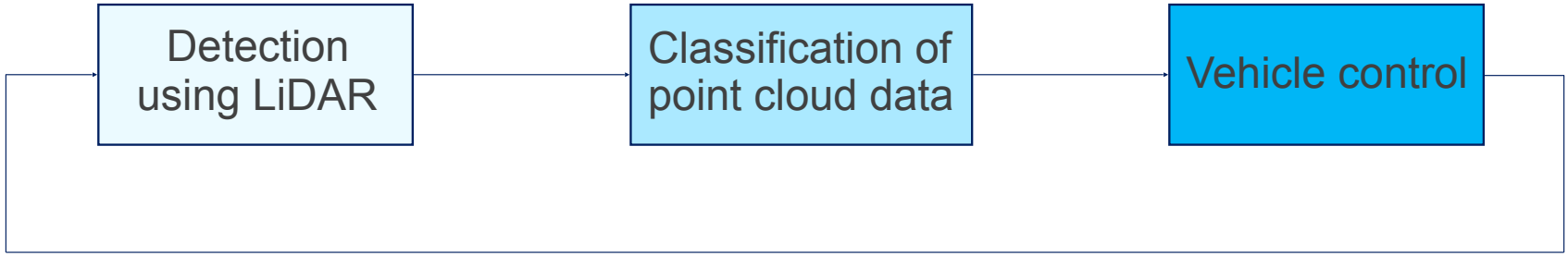
- The LiDAR units in the lamps could detect front and rear objects in a wide range even if there were obstructions in the surroundings.
- If the LiDAR was located at a higher position such as on the roof, it was able to detect objects over surrounding obstructions in some cases. On the other hand, it was sometimes difficult for the LiDAR on the roof to detect a child near the host vehicle.

5. Future works

The verification focused on the *detection of objects using the LiDAR and examined differences in the field of view depending on the position of the LiDAR.

*A state in which at least one LiDAR point has hit an object

In actual automated driving



- The next challenge is the verification of how the difference in the LiDAR's position will impact object classification, in addition to its impact on detection.