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# Establishing Safer Human–Vehicle Visual Interaction at Night*

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***Abstract*— We have attempted to model the interactions between pedestrians and vehicles to create mechanisms that prompt safer interactions. In this paper, we discuss human–vehicle visual interactions that are effective at night and introduce our proposed framework and robotic platform.**

## I. TOWARD BETTER COOPERATION BETWEEN HUMANS AND DRIVING INTELLIGENCE

Intelligent vehicles are rapidly evolving; however, pedestrian accidents have hardly decreased. This is because it is difficult not only for the drivers but also the vehicles to predict pedestrians' behaviors by passive observations, especially at nighttime. In addition to detecting pedestrians using distance measurement sensors that do not rely on visible light, active sensing technologies for improving their saliency and visibility are required to support the vision capabilities of drivers and vehicles. It is also necessary to support the pedestrians such that they can visually recognize vehicles. We consider establishing visual interactions between intelligent vehicles, drivers, and pedestrians as the key method to achieve cooperation. The question that we ask here is as follows: What visual interaction do humans need with the vehicles to realize safer and more comfortable traffic cooperation? The solution to this question should also address the problem that pedestrians may not be able to interact with future autonomous vehicles.

## II. FRAMEWORK

This work focuses on advanced support for human operation of vehicles, including personal mobility vehicles. We assume that future headlight technology can project light in various spatio-temporal patterns, and design visual interactions consisting of the following phases (Fig.1).

1) Detection: the vehicle detects a pedestrian by LiDAR, estimates the saliency, and helps the driver detect the pedestrian with a flickering light projection, which simultaneously makes the pedestrian find itself easier.
2) Recognition: the vehicle tracks the pedestrian, estimates the visibility, and helps the driver and an onboard vision system recognize the pedestrian's pose and behavior with spotlight projection, which simultaneously makes the pedestrian trust itself.
3) Intention expression: the vehicle determines a control intervention based on behavior prediction of the pedestrian and the driver and conveys this intention to both with road-surface projection for smooth negotiation.

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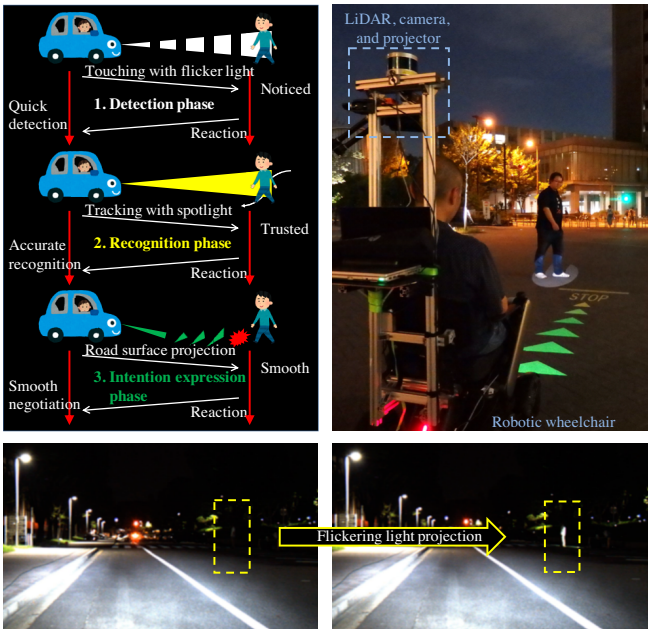


Fig. 1. Proposed visual interaction and robotic platform (upper left: three phases, upper right: robotic wheelchair with sensors and a projector, bottom: local light projection on a pedestrian in the real-world experiment).

The basic principle is proactive interaction from a vehicle according to the state of a pedestrian and the driver.

## III. PRELIMINARY EXPERIMENTS

We conducted a preliminary experiment to selectively project light on a pedestrian in a real setting and investigated the relationship between lighting patterns and pedestrian detectability from a driver (Fig.1)[1]. We also conducted another experiment with various ambient light conditions in a virtual environment and measured the time required for drivers to detect the projected pedestrian. From these results, we confirmed that light with a flickering frequency of 4 Hz improved the detectability most.

## IV. PLAN

We have developed a robotic wheelchair as a research platform (Fig.1) to measure the three-dimensional environments, estimate its own position, recognize pedestrians, and project various lighting patterns on objects and on the road surface. We will analyze when and how the vehicle should project this light and establish a computational model for the visual interaction between all the traffic participants.

## REFERENCES

[1] T. Maeda, et al., Analyzing headlight flicker patterns for improving the pedestrian detectability from a driver, Proc. 21st IEEE ITSC, 2018.