Development of Safety Measures of Bicycle Traffic by Observation with Deep-Learning, Drive Recorder Data, Probe Bicycle with LiDAR, and Connected Simulators

Nagahiro Yoshida[*], Hideo Yamanaka[#], Shuichi Matsumoto[†], Toshihiro Hiraoka[††], Yasuhiro Kawai[†††], Aya Kojima[††††], Tomoyuki Inagaki[†††††]

[*] Graduate School of Engineering
Osaka Metropolitan University
Sugimoto 3-3-138, 558-8585, Osaka, Japan
email: Yoshida-na@omu.ac.jp

[#] Graduate School of Advanced Technology and Science
Tokushima University
2-1 Minamijyousanjima-cho, 770-8506, Tokushima, Japan
email: yamanaka.hideo@tokushima-u.ac.jp

[†] Faculty of Information and Communications
Bunkyo University
1100 Namegaya, Chigasaki-shi, 253-8850, Kanagawa, Japan
email: shuichi@bunkyo.ac.jp

[††] Institute of Industrial Science
The University of Tokyo
4-6-1 Komaba Meguro-ku, 153-8505, Tokyo, Japan
email: thiraoka@iis.u-tokyo.ac.jp

[†††] Faculty of Information and Communications
Bunkyo University
1100 Namegaya, Chigasaki-shi, 253-8850, Kanagawa, Japan
email: kawai@bunkyo.ac.jp

[††††] Graduate School of Science and Engineering
Saitama University
255 Shimo-okubo, Sakura-ku, 338-8570, Saitama, Japan
email: akojima@mail.saitama-u.ac.jp

[†††††] Faculty of Architecture and Urban Design
Tokyo City University
1-28-1 Tamazutsumi, Setagaya-ku, 158-8557, Tokyo, Japan
email: inatom@tcu.ac.jp

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1 INTRODUCTION

This research outlines the development of evaluating safety measures for bicycle traffic using state-of-the-art technology, which was started since 2020 as a four-year project. The project is funded by the Commission on Advanced Road Technology in the Ministry of Land, Infrastructure, Transport and Tourism(MLIT).

While Japan has a high bicycle modal share of 12% (2010), bicycle-related fatalities are relatively high among other countries in the IRTAD database (2019). Under these circumstances, since 2007, various measures for bicycle traffic measures have been implemented to improve the safe bicycle traffic environment, including the revision of the Road Traffic Act and the formulation of a national plan to promote bicycle use.

However, serious accidents involving bicycles are remained in some specific cases. According to the government's traffic accident analysis results (2019), right-hook crash at signalized intersections are one of the most serious types of collision involving bicycles, along with accidents at unsignalized intersections involving vehicles turning left, rear-end collisions, and single vehicle accidents due to off-road deviation. In particular, proactive safety measures are required at signalized intersections along arterial roads, where electric personal mobility vehicles traveling at speeds of up to 20 km/h are expected to share with bicycles in the future.

In order to evaluate safety measures for bicycle-vehicle crashes, this project set the following goals.

1) Identify factors influencing near-miss incidents and collisions through analysis of drive recorder data and accident statistical data.

2) Detailed analysis of traffic conditions from the cyclist's perspective using a probe bicycle equipped with a LiDAR sensor.

3) Development of an experimental environment using a connected simulator for evaluation of cooperative driving behavior.

4) Clarification of experimental conditions to evaluate different scenarios and conditions with and without intervention.

5) Proposal of effective interventions to improve crash cases based on experiments.

2 DEVELOPMENT OF TOOLS

For this project, several engineering tools to perform simulator experiments with greater accuracy were prepared.

2.1 Trajectories extracted from Faster R-CNN method

Image analysis using deep learning techniques was conducted to understand the collision situation between le ft-turning vehicles and bicycle traffic from the observed data. Using the extracted trajectory data, potential co llision risks were calculated for each bicycle traffic pattern. Crash scenarios for simulator experiments were c reated by adding the result of accident statistics data and drive recorder data of occupational drivers.


Picture 1 A Case in Kameido

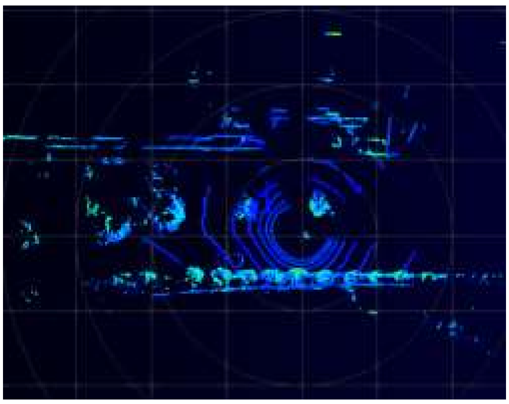

Picture 2 A Case in Oomorikita


Picture 3 A Case in Shibuya

2.2 Probe bicycle with the LiDAR sensors

A probe bicycle is a bicycle equipped with a GPS unit, video cameras, and the Velodyne Lidar VLP-16. the Lidar outputs three-dimensional point data that can reveal the shape and relative position of surrounding vehicles and other objects within 100 meters. By using this bicycle to collect data in actual conditions, it is possible to understand the requirements for inter-vehicle communication to prevent collisions. It can also be used to verify the accuracy of experiments in virtual space by obtaining data such as trajectories and relative distances from the actual road environment and comparing the data on the simulator.


Picture 4 Prove bicycle.


Picture 5 Example data from Lidar on Bicycle.

2.3 Connected simulator system

Two types of simulators were prepared for virtual experiments. The first one is a 180-degree cylindrical screen type with an additional rearview monitor, side mirror monitors, and a rear side window that can be projected by a projector. The second one is a head-mounted display that provides a 360-degree field of view. Driving simulator and cycling simulator are connected in the system allowing the user to freely drive each in the same virtual space, as well as generate other computer-operated vehicles. These simulator systems can be used for evaluation tests of cooperative behavior between subjects in situations where collisions are expected. An example of a virtual road space is to vary the corner components of a protected intersection to evaluate what combination of conditions is a reasonable measure of ensuring safety.

Picture 6 Connected Simulator system with screen type.

Picture 7 Connected Simulator system with HMD type.

3 CONCLUSIONS

This paper provides an overview of the study and its component tools. Each progress result for this project will be shared at the conference.

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