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# “Technical Research and Development for Road Policy Quality Improvement”
# Study Summary

| No. | Title | Principal Researcher |
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| No.2021-2 | Development of a next-generation traffic measurement system based on camera images and multiple observation data | Tokyo University of Science<br>Assoc. Prof.<br>Hideki YAGINUMA |

The research aims to develop a next-generation traffic measurement system that utilizes multiple observation data, such as CCTV and ETC2.0 probes, along with AI technology to achieve continuous traffic monitoring on road networks. Furthermore, the research and development seek to quickly apply these results to practical use, promoting the digital transformation (DX) of road infrastructure.

## 1. Backgrounds and Objects

In future road development, as outlined by WISENET2050, new measures aimed at improving service levels will be implemented. Designing, evaluating, and operating new services such as mobility hubs and TDM/TSM require high-resolution spatiotemporal data. This study aims to develop a next-generation traffic measurement system using multiple observation data and AI technology. Additionally, by implementing this system on the cloud, we aim to reduce data acquisition costs in practical applications and promote road DX.

## 2. Activities in Research Period

This study set three specific research tasks, which were implemented in an integrated manner to achieve the objectives:

[A] Examining and Verifying Data Utilization for Road DX Promotion through Next-Generation Traffic Measurement: We identified the needs and requirements that the proposed system should meet by targeting practitioners nationwide. We then developed a prototype system and demonstrated its effectiveness through case studies.

[B] Developing High-Precision Detection Methods for Traffic Mobile Objects Using AI Analysis and Camera Images: We develop a traffic measurement-specific AI model compatible with existing CCTV cameras on roads. We proposed efficient and effective model training methods and verified their accuracy improvement effects.

[C] Developing Methods for Generating and Correcting Traffic Volume Data by Integrating Multiple Observation Data: We develop models to generate and correct traffic volume data from the detection results in [B] and ETC2.0 probes. Specifically, we targeted both micro-data (traffic volume, speed, vehicle trajectories at the camera level) and macro-data (link and OD traffic volume at the network level) and verified their accuracy.

## 3. Study Results

The main findings and outcomes obtained from this study are as follows:

[A] Conducted more than 40 meetings with government, academia, and industry. Identified the needs related to (1) current issues in traffic data acquisition, (2) performance requirements for AI analysis, (3) data required for future policy evaluation, and (4) functional requirements for the next-generation traffic measurement system. Based on these findings, implemented a cloud-based system designed with “human-centered design” and “user experience improvement based on pain relievers”. The GUI, which integrates AI processing and visualization based on maps, was evaluated as useful and practical by practitioners (Fig. 1).

[B] The traffic measurement-specific AI, based on Convolutional Neural Networks (CNN), was expanded to address significant accuracy declines due to traffic, environmental, and installation conditions and to classify various modes (motorcycles, pedestrians) and vehicle types (Fig.2). For the practical issues of constructing and training learning datasets, we

proposed (1) strategic transfer learning using Explainable AI (XAI), (2) self-learning methods based on domain adaptation, and (3) virtual learning methods using digital twins. As a result, we achieved a detection accuracy within ±10% in many locations and time-period, effectively drawing out performance suitable for practical use.
[C] At the micro-level within camera images, we mainly obtained (1) vehicle trajectory data, (2) lane-specific and vehicle-type-specific traffic volume data through automatic optimization of the passage count line, and (3) lane-specific and vehicle-type-specific travel speed data using satellite and aerial images for real-space distance measurement. At the macro level targeting the entire network, we mainly fused census, and probe data to (1) predict time-specific link and OD traffic volumes by integrating time-series LSTM and Gaussian process regression and (2) generate attribute-specific activity data using Generative Adversarial Networks (GANs).

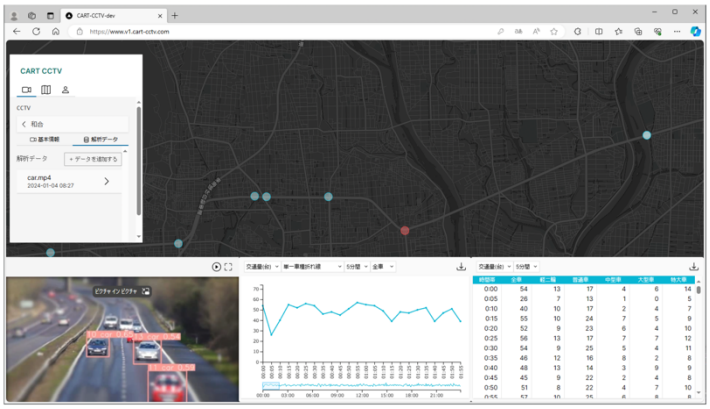


Fig1：Proposed system user interface

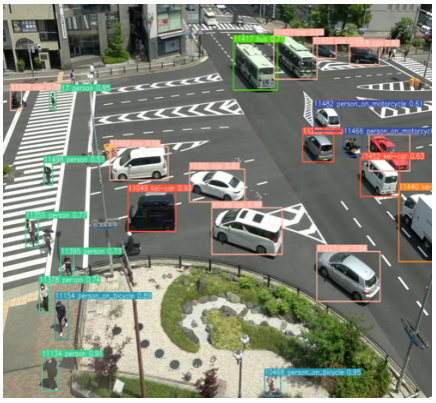

Fig2：Proposed AI system

## 4. Papers for Presentation

- Obara, K., **Yaginuma, H.**, Terabe, S., Uno, H., Suzuki, Y., Proposal of Self-Learning Algorithm Based on Domain Adaptation for Vehicle-Specific Traffic Measurement AI, *Transportation Research Board 103rd Annual Meeting*, No.24-21013, 2024.
- Ishijima, Y., **Yaginuma, H.**, Terabe, S., Uno, H., Suzuki, Y.: Interpretability of machine-learning based travel behavior models using XAI, *16th International Conference on Travel Behavior Research IATBR*, 2022.

## 5. Study Development and Future Issues

The next-generation traffic measurement system proposed in this research has achieved the necessary requirements based on practitioner needs, but there is room for improvement based on practical operations. Specifically, improving the measurement accuracy of the traffic-specific AI model at night and further improving the efficiency and accuracy of location-specific learning. Additionally, aim to integrate as a sub-application of data platform xROAD by the MLIT.

## 6. Contribution to Road Policy Quality Improvement

This research developed theories and implemented systems integrating multiple data and AI technologies for traffic volume measurement using AI, essential for future introduction, with practical use in mind. This enables quick deployment in practical applications such as introduction in the next road traffic census and partial continuous monitoring during disasters, achieving high-precision, high-quality, low-cost traffic measurement compared to manual observation. Additionally, some parts of this research are already being utilized in studies by the NILIM and regional development bureaus, contributing to practical fieldwork.

## 7. References, Websites, etc.

Nothing in particular