"Technical Research and Development for Road Policy Quality Improvement"
Study Summary

No.	Title	Principal Researcher
No.28-1	Research and Development of "Data-Driven" Travel Demand and Spatial Management Utilizing ETC2.0 Probe and Other Big Data Sources	Tokyo Institute of Technology Assoc. Prof. Daisuke Fukuda

This project comprehensively explored "data-driven" travel demand and spatial management methodologies and applications by utilizing ETC2.0 probe vehicle trajectory data as well as other transportation-related big data sources jointly with various types of multi-scale traffic and/or travel choice models. More specifically, we carried out various types of applications of the proposed methodologies for Kanto, Hokkaido and Okinawa Regions in Japan. Some of research outputs have been implemented in practice of road transport policy-making in these areas.

1. Backgrounds and Objectives

Traditional large-scale travel surveys in Japan, such as road traffic census and person trip surveys, have been suffering from some difficulties for their implementations such as: low-rate of survey participation leading the accuracy decrease in the estimation of OD travel demand; and the gap between long survey intervals (e.g. 5-10 years) and transportation policy needs which are expected to be more prompt for social implementations. Consequently, travel demand forecasting or cost-benefit analysis by using these survey outputs are also wrongly affected.

In the field of medicine or education, so called "evidence-based" policy prediction and evaluation has become very popular with many substantial achievements, though such application examples in road transportation administration are very few. It would be necessary to develop evaluation methods of transport policies that can appropriately reflect practical needs by especially utilizing "transportation-related bigdata" which have been rapidly accumulated. By doing so, we would explore evidence-based transportation policy evaluation methodologies.

With these specific motivations, this research projects comprehensively explore "data-driven" travel demand and spatial management methodologies and applications by utilizing ETC2.0 probe vehicle trajectory data as well as other transportation-related big data sources jointly with various types of multi-scale traffic and/or travel choice models. More specifically, we carry out various types of applications of the proposed methodologies for Kanto, Hokkaido and Okinawa Regions in Japan.

2. Activities during Research Period

Theme 1: Methodological development of travel demand and spatial management methodologies for metropolitan area

We target Kanto Area as some case studies. In this area, some large-scale transportation projects and remarkable transportation policies are being planned or conducted. We have explored some evidence-based transport policy evaluation tools or methodologies mainly for the evaluation of "multi-modal connectivity improvement policy", "next-generation tolling policy for the three ring urban expressways", and "possible travel demand management or transport system management measures for dealing with traffic during Olympic 2020".

Theme 2: Methodological development of uncovering tourists' travel behavior in rural areas

We target tourist travel behavior in Hokkaido and Okinawa Areas of which are regarded as the place where the market penetration of ETC2.0 is relatively low and the utilization of other data sources would be essential for better policy making. In Hokkaido, we focus on how to understand actual tourists' behavior mainly utilizing Wi-Fi packet scanning technologies for data collection jointly with travel choice optimization models as well as machine learning methodologies. In Okinawa, we analyze spatio-temporal travel behavior of rent-a-car users by jointly utilizing Wi-Fi data and ETC2.0 data for evaluating congestion-mitigation tourism policies. Furthermore, a new methodology of travel data collection using Bluetooth sensing technologies are also experimentally investigated.

3. Study Results

1-1) Evaluation methodologies of modal-connection transport policies for metropolitan area

- Analyzed stay-duration of tourist at a large coach station with Wi-Fi packet sensing and statistical modeling.
- Developed a real-time traffic station estimation system with ETC2.0 under emergency conditions.
- Developed bus-operation assisting system and evaluated modal-connection policies based on survey data analysis.

1-2) Route choice modeling for ring-road policy evaluation
- Developed a dynamic route choice model by utilizing ETC2.0 probe vehicle data.
- Theoretical analysis of the first-best congestion tolling under dynamic route choice decisions.

1-3) Modeling and evaluation of downtown traffic mitigation
- Developed and applied the 3-dimensional macroscopic fundamental diagram for bi-modal policy evaluation.
- Practical implementation of an activity-based travel simulation system for Tokyo's rail commuters.

2-1) Modeling tourists travel pattern with ETC2.0 probe data
- Discovered a pattern-mining approach for extracting typical tour behavior of drivers with ETC2.0 data.
- Developed and calibrated mathematical models of tourist travel choices for policy evaluations.

2-2) Exploring the data fusion between ETC2.0 probe and other data sources
- Sought applicability of Wi-Fi based continuous monitoring technology for collecting tourists' travel behavior through the data analysis from two large-scale field experiments conducted in Okinawa and Hokkaido.
- Examined data fusion of Wi-Fi and ETC2.0 with the consideration of appropriate information provision to tourists.
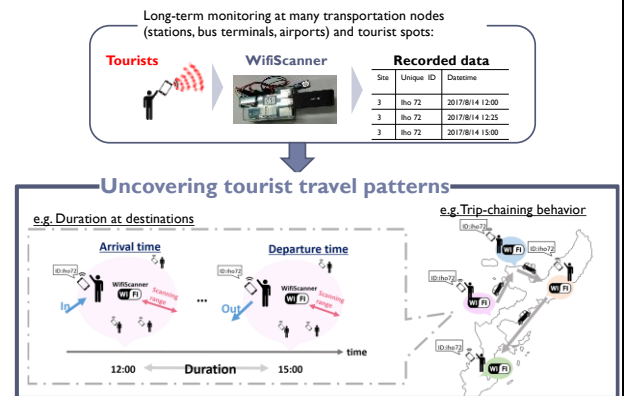- Demonstrated travel speed/time estimation with Bluetooth sensing technologies for arterial roads.

Fig. Principle of Wi-Fi based Data Collection

4. Papers for Presentation

(1) Ge, Q., **Fukuda, D.**, Han, K., Song, W.: Reservoir-based surrogate modeling of dynamic user equilibrium. *Transportation Research Part C: Emerging Technologies*. (accepted)

(2) Tani, R., Owada, T., Uchida, K.: Path travel time estimating method by incomplete traffic data, *International Journal of Intelligent Transportation Systems Research*. (accepted)

(3) Tanaka, K., Kamiya, D., **Fukuda, F.**, Ihoroi, N., Yaginuma, H., Suga, Y., Yamanaka, R.: Analysis of the tourists' travel behavior using Wi-Fi packet sensor: A case study in Okinawa Main Island. *Journal of Japan Society for Fuzzy Theory and Intelligent Informatics*. (accepted)

(4) Dantsuji, T., **Fukuda, D.**, Zheng, N.: Dynamic congestion pricing in a bi-modal transportation system: 3D-MFD based simulation approach. Journal of the Japan Society for Civil Engineers: Series D3. (accepted)

(5) Kaneko, N., Oka, H., Chikaraishi, M., Becker, H., **Fukuda, D.**: Route choice analysis in the Tokyo Metropolitan Area using a link-based recursive logit model featuring link awareness. *Transportation Research Procedia*. Vol. 34, pp. 251–258, 2018.

(6) Hidayat, A., Terabe, S., Yaginuma, H.: WiFi scanner technologies for obtaining travel data about circulator bus passengers: Case study in Obuse, Nagano Prefecture, Japan. *Transportation Research Record*, Vol. 2672, pp. 45–54, 2018.

5. Study Development and Future Issues
- Theme 1: It is necessary to conduct further in-depth analysis on how to integrate developed several simulation models for more comprehensive evaluation of transport policies.
- Theme 2: It is necessary to cope with "anonymization" of unique identifies emitted from mobile applications which might happen in the future and then to discover new methodology for travel behavior analysis.

6. Contribution to Road Policy Quality Improvement
- The results of the research 1-1) were implemented as "Real time bus location system for expressways" that was developed jointly with Kanto Branch of MLIT. Further, social experiments of modal-connection at the service area of intercity expressway in Kanto was jointly conducted them.
- The results of the research 2-2) were extensively demonstrated in Hokkaido for traffic management or traffic information provision policy by providing real-time congestion or traffic speed information collected from Wi-Fi packets and/or Bluetooth sensing technologies.

7. References, Websites, etc. [None]