

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

No.	Title	Principal Researcher
No.29-4	A Study on Dynamic Traffic and Passenger Flow Estimation System for Identifying Tourist Flow Patterns	Kyoto Univ. Prof. N. Uno

This study is aimed at developing a dynamic traffic and passenger flow estimation models for identifying both trip pattern (OD demand) and trip chain in urban area. Utilizing various data such as ETC 2.0 data and Wi-Fi packet sensor data, the estimation models are expected to contribute to effective traffic and transportation management for tourism.

1. Backgrounds and Objects

It is inevitable for us to develop a system for estimating both traffic and passenger flows and to evaluate their changes so as to make tourist trip smooth and efficient by applying travel demand management including a temporal dispersion of tourist demand. Conventional surveys such as Road Traffic Census are aimed at investigating average traffic condition and demand, and hereby it is difficult to identify traffic demand with seasonal variations and inbound tourist demand from abroad by the conventional survey. It is expected that a development of system to estimate dynamic traffic and passenger flow utilizing available Big Data may contribute to continuous improvement in traffic and transportation management for tourism. Based on the above, this study aims to develop a dynamic traffic and passenger flow estimation models for identifying both trip patterns and trip chains in an urban area, utilizing various traffic and transportation data.

2. Activities in Research Period

This study consists of the following themes. 1) Observations of traffic and passenger flow during the peak season and the period when a traffic and transportation management is conducted by using mobile communication data. We have gathered ETC 2.0 data, traffic detector data, data of route searches and so on, and conducted the survey using Wi-Fi packet sensors installed at major stations and sightseeing spots to observe the flow of people including tourists. 2) Development in estimation model of trip patterns of automobiles. This study has developed a model to estimate OD volume of automobiles by applying a least-squares estimation method. The model is composed of a main model representing spatial traffic flow on network and a sub model to consider continuous temporal changes in traffic condition. 3) Development in estimation model of passenger trip patterns. This study has developed a model to estimate trip patterns of bus passengers. The model consists of two stages, namely the first stage to estimate the volume of Leg OD representing a pair of origin-destination along a certain bus route, and the second stage to estimate the volume of Journey OD representing a true pair of O-D including transfer between bus routes. 4) Development in estimation model of trip chains. This study has developed a model to estimate trip chains by utilizing the estimated trip patterns of both automobiles and passengers as its inputs.

3. Study Results

The major outcomes are as follows. 1) The representative tourist flows are estimated by applying the Sequential Pattern Mining method for Wi-Fi packet sensor data (Figure 1). 2) It is confirmed that the estimation model of trip patterns of automobiles can provide us with estimation of dynamic ones of which daily trip generation and temporal pattern change according to the input data and which matches with the observed traffic volume (Figure 2). 3) This study constructs the estimation model of passenger trip patterns for Kyoto city bus network and evaluates the estimation accuracy based on numerical experiments using hypothetical input data. Also, the estimation model is applied for identifying passenger trip patterns in November 2018. 4) By utilizing the estimated trip patterns of both

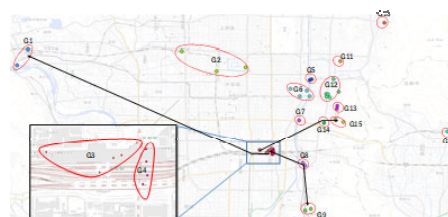


Figure 1 Representative Flow patterns of tourists

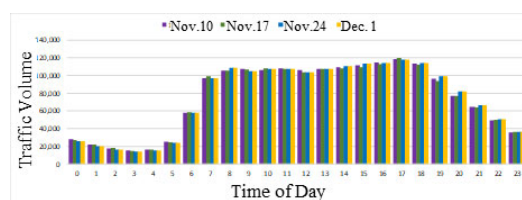


Figure 2 Temporal Changes in Trip Generation (Saturday)

automobiles and passengers as the inputs, this study develops the estimation model of trip chains considering passenger attributes. Through numerical experiments, it is confirmed that the proposed model can represent difference in preference of trip among passengers and seasonal variations in trip chains. 5) This study evaluates the effects of traffic and transportation management for tourism in Kyoto city by utilizing the developed methodologies above. The major findings are as follows. It is suggested that the slight improvement in traffic smoothness in Higashiyama area and the reduction in demand in Arashiyama due to the traffic and transportation management are confirmed by MFD (Macroscopic Fundamental Diagram) analysis. We investigate a possibility of temporal dispersion in tourists demand to Kiyomizu district based on behavioral classifications along an axis of time of day using Wi-Fi packet sensor data.

4. Papers for Presentation

- 1) I. Hirai and H. Shimamoto: Accuracy Verification of Two-Stage Passenger Trip Pattern Estimation Model in Large-Scale Network, Proceedings of Infrastructure Planning, Vol. 60, CD-ROM, 2019 (in Japanese).
- 2) A. Higashikawa and Y. Kimura: Method for Analyzing Pedestrian Flow on Streets around Tourist Spots Using Wi-Fi Packet Sensor, Proceedings of Infrastructure Planning, Vol. 60, CD-ROM, 2019 (in Japanese).
- 3) S. Myoko, F. Kurauchi and S. Ito: Mining Typical Tourists' Travel Patterns Using Wi-Fi Packet Sensor, Proceedings of Infrastructure Planning, Vol. 60, CD-ROM, 2019 (in Japanese).
- 4) K. Satake, **N. Uno** and T. Nakamura: Analysis of Representative Flow of Tourists Considering Observation Intervals Using Wi-Fi Packet Sensor Data, Proceedings of Infrastructure Planning, Vol. 60, CD-ROM, 2019 (in Japanese).
- 5) H. Asao, **N. Uno**, Y. Kimura and J. Nishida: Possibility of Cross-Use of Big Data, Proceedings of Infrastructure Planning, Vol. 60, CD-ROM, 2019 (in Japanese).
- 6) Y. Gao and J.-D. Schmoecker: Tourist Route Choices and Short-Term Flow Predictions in Tourist Areas Based on Wi-Fi Packet Data, Proceedings of Infrastructure Planning, Vol. 60, CD-ROM, 2019.
- 7) T. Asai, S. Sugiura and F. Kurauchi: Estimating Trip Chains Using Move/Stay Data and Mode-Specific OD Traffic Volume, Proceedings of Infrastructure Planning, Vol. 60, CD-ROM, 2019 (in Japanese).
- 8) **N. Uno**, J. Nishida, F. Kurauchi, J.-D. Schmoecker, T. Nakamura, H. Shimamoto, S. Sugiura and Y. Kimura: Identifying Tourists' Behaviour with Multifaceted Big Data, Traffic Engineering, Vol. 55, No.4, 2020.

5. Study Development and Future Issues

Due to progresses in ICT and ITS, there have been drastic improvements in quality and quantity of data available for traffic and transportation studies. Because of rapid accumulations of data, it is difficult to tell that the accumulated data have been well utilized in traffic and transportation studies yet. This study develops a series of estimation models of trip patterns and trip chains effectively utilizing traffic and transportation big data, and these models are expected to contribute to identify dynamic traffic flows on road and public transportation network. In other words, these models can be utilized as the core of traffic and transportation monitoring system and hereby they have a potential to evaluate the effects of traffic and transportation management based on the changes in estimated OD volume and trip chains.

There are two major research subjects. 1) It is necessary to improve the calculation efficiency of the estimation models of both trip patterns and trip chains. One of the possible directions is to incorporate the parallel computing approaches into the computing algorithm. 2) It is necessary for us to define the effective traffic and transportation management for tourism by continuously evaluating the effects of management with the proposed models in this study.

6. Contribution to Road Policy Quality Improvement

The objectives of this study are widely overlapped with the ones of Council of Experiments for Mitigating Traffic Jams Caused by Tourism in Kyoto Area (Kyoto National Highway Office, MLIT). Since the PI of this study is in charge of chairperson of the Council, it is relatively easy for us to work with the Council for the common interests. For example, we could conduct the tourist flow survey using Wi-Fi packet sensor jointly with the Council and JR west, and hereby the survey could cover the major sightseeing spots and stations widely in Kyoto city. There is a possibility that we will do some further collaborations such as evaluating the traffic and transportation managements proposed by the Council in both qualitative and quantitative manners using the estimation models of trip patterns and chains.

7. References, Websites, etc.

Information on the survey using Wi-Fi packet sensor is provided at http://www.gi.ce.t.kyoto-u.ac.jp/wifi/cart_wifi.html