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論文題目	Estimation of Tourist Travel Patterns with Recursive Logit Models based on Wi-Fi Data with Kyoto City Case Study（Wi-Fi データを用いた再帰的ロジットモデルによる観光行動パターンの推定に関する研究―京都市を例として―）		

（論文内容の要旨）

Estimating traffic flows is the foundation of solving related problems in transportation. However, there are limited methods to do so economically and without invading privacy. In particular this is the case for investigating the behavior of specific population groups other than residents or goods. In Kyoto tourists form such a population group for which few data regarding their tour patterns in the city are available. Based on two experiments with Wi-Fi sensors in Kyoto City, this research establishes a methodology that allows understanding and predicting tourist flows by this, relatively low-cost, Wi-Fi sensing technology. Both temporal and spatial aspects of tourist behavior are modelled in that it is predicted where a tourist will move next to as well as how long a tourist stays at a particular location.

The thesis is organized as follows.

Chapter 1 Introduction

Chapter 1 describes the background and motivation of this research. It reviews the methodologies to investigate traffic flows. The advantages of electronic footprints, compared to conventional questionnaire surveys, for understanding flows of minor traffic groups such as tourists are discussed. Then the objectives, contributions of the thesis as well as the thesis outline are illustrated.

Chapter 2 Literature review

Chapter 2 reviews the research of characteristics of city-tourists and clarifies the research needs. With the development of statistical models and computing, researchers have applied a variety of methods to model and simulate city-tourists. Types of data source for studying travelers in the city, especially tourists, are also discussed. Taking into account the characteristics of the Wi-Fi packet sensing data, the main problem which this dissertation addresses, is defined as understanding tourists' behavior over time periods of several hours up to a day. Thus, the goal is estimating route choices with joint consideration of touristic behavior and the goal of the trips. For this it is discussed that the recursive logit (RL) model is an appropriate tool.

Chapter 3 Tourism in Kyoto City, data description

Chapter 3 presents a general introduction to the tourism industry in Kyoto City. Tourist flows bring congestion to the city but details of the tour patterns are not understood. This motivates two Wi-Fi packet sensing experiments. The first experiment looks at small-scale specific route choices, and successfully captures the trips inside the touristic area. The second one focuses on city-scale travel patterns. The limited number of sensors leads to information gaps that prevent the modelling of detailed travel patterns. To overcome this problem, a commercially available GPS-based sample is obtained for enriching the Wi-Fi sample. Conclusions are drawn that although neither only using GPS nor Wi-Fi data separately is enough, a fusion of the two data may help interpret completed tourist travel patterns.

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Chapter 4 Small-scale, compact sensing experiment: investigating pedestrians in a touristic area of Kyoto City

Chapter 4 proposes the methodology to utilize Wi-Fi packet sensors to model behavior of pedestrians in a touristic area. As preparation, a reduced network that is fit for the sensing data is reconstructed from the real network. Tourist tours with information of travelling and staying are identified based on data cleansing and clustering analysis. RL models are then employed to formulate tourists' route choice behavior. The existence of different kinds of POIs is shown to explain route choice as well as whether a person stays on a link for an extended period of time or passes through it in a short time. The proposed Stay-Links perform well in both reducing computational effort and to distinguish tourists staying in an area or just passing through it.

Chapter 5 Inferring City-scale trips based on Wi-Fi sensing with aid of small sample of GPS footprints

Chapter 5 proposes a data fusion approach for the enrichment of Wi-Fi data by GPS observations. Vectorized operations are implemented for efficient similarity evaluations between trajectories inferred by Wi-Fi and GPS observations. Then based on the evaluation one of the most similar GPS trajectories, a complete record is selected to fill in the missing observations for its target Wi-Fi trajectory. The fused data are referred to as "enriched Wi-Fi traces". The enrichment approach developed in this chapter lays the groundwork for tour-based modelling of urban tourists in the next chapter.

Chapter 6 Modelling tourist flow in Kyoto City

Chapter 6 proposes a methodology to model city-scale tourist flows based on these enriched Wi-Fi traces. Different from the first study, models are established on a time-expanded network since time-of-day depending values measuring attractiveness of an area are defined. Further specific dummy links are defined as cases when a person appears to visit locations different to those captured by the sensors. The results illustrate temporal and spatial features of tourists' travel patterns over the city. Values of time and the value of POIs to travel to a touristic area in Kyoto as well as to stay another hour are derived.

Chapter 7 Conclusions

Chapter 7 summarizes main findings of this research and points out the limitations of what can be achieved with Wi-Fi data. In addition, based on the findings, this chapter specifically discusses recommendations as to when the usage of time-expanded networks versus simpler networks with "stay" and "move" links is beneficial in the modelling of the data since both structures have their advantages and disadvantages. Finally, it provides future research directions in light of the contributions of this research.