

## 論文の内容の要旨

### 論文題目

A Markovian route choice analysis for trajectory-based urban planning  
(行動軌跡に基づく都市計画のためのマルコフ型経路選択分析)

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Route choice analysis predicts which route a given traveler takes to go from a location to another, and it evaluates the flow pattern on a transportation network. It is one of the most important issues of urban and transport planning; however, the evaluation of path choice probabilities is not a trivial task due to the requirement of the path set generation.

Markovian route choice model is an approach that avoids to enumerating the path set by evaluating path choice probabilities as the products of link transition probabilities. Because of its consistency with the logit-type route choice model, recently, it is gathering much attention again.

In addition to its high operability, this thesis focuses on that the Markovian route choice model describes the sequence of decision-making process, which becomes important for the future urban planning, and we aim at developing a framework of Markovian route choice analysis.

The Markovian route choice model mainly retains the following challenges: 1) it includes the biases in observing route choice behavior and in estimating parameters of route choice model, which are caused from the initial parameter settings, 2) it is based on the assumption of global optimal decision, that is, travelers are assumed to have knowledge of the entire network and evaluate utilities of all links with the equivalent weight, and 3) there is the computational instability of the expected maximum utilities, which are the core idea of the Markovian route choice model, dependently on the network structure. Therefore, 4) the application of the model is restricted into the description of vehicle route choice behavior.

This thesis presents the following several new methods for solving the above challenges and develops an integrated framework of the Markovian route choice analysis.

1) For reducing the biases in estimating parameters caused from the initial parameter settings, we propose a novel route measurement model and an estimation method. The sequential link measurement model identifies link-specific variance of GPS measurement error, which has been assumed as the given and constant value over the network. The structural estimation method removes the bias that is included in the prior information, which is used for correcting the measurement probability in the case that the measurement error is large. We have some numerical experiments and validate the effectiveness of the proposed methods. We also apply them to a real pedestrian network of the city center in Matsuyama city, Japan. This study is addressed in Chapter 3.

2) We propose a dynamic sequential route choice model with the discount factor to describe sequential and somewhat forward-looking decisions of travelers. It models the myopic route choice behavior, which is dependent on only link utility that is directly connected with the current state link of a traveler, and it also includes the previous Markovian route choice model referred to as the recursive logit model as a special case. We show the model properties through illustrative examples. We also apply it to a case study using taxi probe data collected in the Tokyo network on the day of the Great East Japan Earthquake and clarify drivers' myopic decisions in the gridlock network. This study is shown in Chapter 4.

3) Focusing on that the computational problems of the Markovian route choice model are caused from the consideration of paths with infinite cycles, we propose several methods to solve the problems. The time-structured network is the network that consists of decomposed networks by decision-making timing, and a route is described as a sequence of states in the time-structured network in this study. Moreover, we propose a method of restricting path set based on the time-space prism, that is, only paths included in the time-space prism are considered in the route choice model. Thanks to these methods, infinite cyclic paths are removed, and it is possible to calculate the expected maximum utilities regardless of network structures, using the backward induction algorithm. We present some illustrative

examples to show that the computational challenges of the Markovian route choice model are solved. This work is shown in Chapter 5.

4) Using the proposed framework of a Markovian route choice analysis, we propose an activity path choice model, which describes a route choice behavior in time-space networks. The activity assignment with the activity path choice model evaluate not only the spatial flow pattern but also the use of time at each node. We apply the activity assignment model to a pedestrian network design problem and investigate the Pareto front solutions of widening the sidewalk width, based on a framework of multi-level and multi-objective programming.