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Development of a Network Traffic Simulator for the Entire Inter-urban Expressway Network in Japan

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Abstract

This paper describes the development of a network traffic simulator for the entire inter-urban expressway network in Japan. With recent developments, the network topology is getting more complex, and traffic prediction based on statistical analysis is becoming harder since it does not take into account the drivers' behavioural changes on the network. Looking at the issue from the seeds and needs perspective, there would be needs to develop a network traffic simulator dealing with traffic flow dynamics and driver behaviors. From the seeds side, road operators are now motivated to utilize the electronic toll collection (ETC) trip data collected every time a vehicle passes an ETC tollgate located at interchanges. Fully using ETC data is expected to improve the accuracy of time-dependent O-D matrix and route choice behavior model which is important in simulation studies. In this paper, the concept of traffic modeling and route choice behavior modeling in the expressway network simulation will be described, followed by calibration of time-dependent O-D matrix.

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Keywords: traffic simulation, expressway network, O-D matrix calibration, route choice behavior;

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1. Introduction

This paper describes the development of a network traffic simulator for the entire inter-urban expressway network in Japan (Fig. 1). Inter-urban expressways stretch for more than 8,000 km over Japan and serve approximately 5 million trips per day. There are more than 20,000 detectors installed on the expressways, collecting vehicle counts and speeds every 5 minutes.

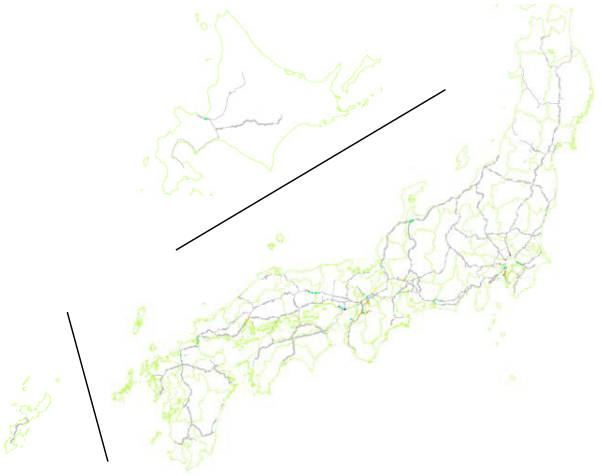

Fig. 1. Inter-urban expressway network in Japan

The road-operator companies use this traffic sensor data to predict traffic congestion caused by weekend leisure traffic, road works, incidents, etc. So far, they simply apply statistical analysis of the travel purposes and their expertized heuristic knowledge to make the prediction. With recent developments, however, the network topology is getting more complex, and traffic prediction is becoming harder since statistical analysis does not take into account the drivers' behavioral changes on the network. Therefore, there is a need to develop a network traffic simulator based on traffic flow dynamics to deal with traffic congestion, considering driver behaviors.

Looking at the issue from the seeds side, road operators are now motivated to utilize the electronic toll collection (ETC) trip data, collected every time a vehicle passes an ETC toll gate located at interchanges. Nowadays, ETC is used in close to 90% of the total number of trips on expressways. Fully using ETC data, therefore, is expected to improve the accuracy of time-dependent O-D matrix and route choice behavior model which is important in simulation studies.

In the following chapters, the concept of traffic modeling and route choice behavior modeling in the expressway network simulator (ENS) will be described, followed by calibration of time-dependent O-D matrix.

2. Modeling concept of the Expressway Network Simulator

The ENS is developed based on a mesoscopic traffic simulation model, SOUND [SOUND, 2014], which was developed at the University of Tokyo [Yoshii and Kuwahara, 1995] and has been revised through its use in many practical studies. This chapter outlines major modeling components in SOUND and their modifications for the ENS.

2.1. Discrete vehicle trip generation with time-dependent O-D matrix

SOUND deals with the discretized trip of each vehicle attributing its origin, destination, departure time, vehicle type, etc. The trip generation number of each vehicle type is aggregated to time-dependent O-D matrix with designated time interval. At the beginning of each interval, all generated vehicles are accumulated into the departure