Chapter VI
Core Models for State-of-the-Art Microscopic Traffic Simulation and Key Elements for Applications

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ABSTRACT

This chapter summarizes fundamental models for microscopic simulation (such as vehicle generation model and car-following model) and other critical models (such as lane-choice model, lane-changing model, and route-choice model). Most of the critical models introduced in this chapter reflect the latest research results by the author. The primary purpose of this chapter is to provide fundamentals for better understanding of the travel behaviors that are modeled for traffic simulations. To facilitate the applications of traffic simulation models, several key elements for applying state-of-the-art computer traffic simulation tools are summarized. They include the procedure for building models, model calibration and validation. Further more, techniques for collecting vehicle trajectory data, critical elements used for model calibration and validation, are also introduced.

INTRODUCTION

Crime preventive measures somehow influence several elements of transport behavior, such as the choice of the number of trips, the destination and the mode of transportation. For example, increased crime offense rates likely lead to decreasing of trips as a consequence of crime-related reputation of an area. The choices of transportation modes, routes, and destinations may also be influenced by the crime rates of an area. Quantitative relationships between criminal behaviors, criminal

opportunities, and transportation environments may provide insight into how to design better crime prevention strategies. Among the factors constituting the transportation environments, travel behaviors over the transportation network play a key role in representing operations of the transportation systems. Microscopic simulation modeling is a significant approach to provide understandings of traffic characteristics and travel behaviors as required by the analysis of on-street crime preventive measures.

Microscopic traffic simulation models are computer models that "mimic" the movements of individual vehicles traveling around a roadway network and effect of traffic control operations. The simulation models are composed of multiple travel behavior models, such as car-following and lane-changing models, gap acceptance rules, signal control operation schemes, and so forth. Those models are coded into computer algorithms which are then embedded within a computer software system. The integration of those models enables simulating vehicle-by-vehicle based traffic by updating position, speed, acceleration, lane position, and other state variables on time steps, as the vehicles interact with traffic signals, signs, other vehicles, and roadway geometrics. The time steps are usually designed on a second or smaller time interval basis in order to implement a more accurate behavioral analysis.

Microscopic simulation models aim at providing a representation of actual driver behaviors and network performance. They are therefore viewed as an effective tool for analyzing a wide variety of dynamical problems which are not amenable to study by other means. The purpose of this chapter is to introduce major microscopic simulation models that are viewed as the core of simulation modeling and key elements for simulation application in traffic and safety operations. The chapter is organized as follows: (1) core microscopic traffic simulation models, (2) procedure for building models, (3) techniques for vehicle trajectory data collection, (4) calibration and validation of applying advanced microscopic simulation software, (5) summary and conclusions, and (6) future research directions.

CORE MICROSCOPIC TRAFFIC SIMULATION MODELS

This section presents fundamentals of core models for microscopic traffic simulation modeling, including vehicle generation model, car-following model, lane-choice model, lane-changing model, and route-choice model.

Vehicle Generation Model

A vehicle generation model addresses methods for creating vehicles to enter a simulated network which is assumed "empty" at the beginning of a simulation run. While numerous methods in terms of computer programs have been developed to generate random numbers, these numbers only "appear" to be random, sometimes called "*pseudo-random"* numbers (Lieberman & Rathi, 2000). Departing time models attempt to represent a pattern of how travelers choose a time to hit the road based on their daily travel decisions on the experience gathered from repetitively traveling through the transportation network (Ettema, Tamminga, & Timmermans, 2003).

Random variants in traffic simulation are used to generate a stream of vehicles. According to headway distribution based on specified volumes, vehicles are generated at origin points, usually at the periphery of the analysis network, that is, the shifted negative exponential distribution will yield the following expression (Lieberman & Rathi, 2000).

$$h = (H - h_{\min})(-\ln(1-R)) + H - h_{\min} \qquad (1)$$

Where,