Preface

Road traffic flow is intrinsic with stochastic and dynamic characteristics so that traditional deterministic theory no longer satisfies requirements of the evolution analysis. Stochastic traffic flow modeling aims to study relationships of transportation components. The kernel is an investigation of both stochastic characteristics and traffic congestion evolution mechanism using headway, spacing, and velocity distributions. The primary contents include empirical observations, connections with microscopic and macroscopic traffic flow models, and traffic breakdown analysis of highway bottlenecks.

The book first analyzes characteristics of empirical traffic flow measurements to reveal the underlying mechanism of complexity and stochastic evolutions. By using Eulerian measurements (e.g., inductive loop data) and Lagrangian measurements (e.g., vehicular trajectory data), we study headway-spacing-velocity distributions quantitatively and qualitatively. Meanwhile, disturbances of congested platoons (jam queues) and time-frequency properties of oscillations, which establish the empirical foundation for stochastic traffic flow modeling.

Then we establish a Markov car-following model by incorporating the connection between headway-spacing-velocity distributions and microscopic car-following models using the transition probability matrix to describe random choices of headways/spacings by drivers. Results show that the stochastic model more veritably reflects the dynamic evolution characteristics of traffic flow. As discussions of the connection between headway-spacing-velocity distributions and the macroscopic fundamental diagram model, we analyze the probability densities and probabilistic boundaries of congested flow in flow-density plot by proposing a stochastic extension of Newell’s simplified model to study wide scattering features of flow-density points.

For applications to highway on-ramp bottlenecks, a traffic flow breakdown probability model is proposed based on headway/spacing distributions. We reveal the mechanism of transitions from disturbances to traffic congestion, and the phase diagram analysis based on a spatial-temporal queueing model that is beneficial to obtain optimal control strategies to improve the reliability of road traffic flow.
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