DRISI
Caltrans Division of Research, Innovation and System Information

Research Results

CTM-based Optimal Signal Control Strategies in Urban Networks

Derived invariant averaged models to help analyze delays using CTM simulation on a signalized ring road.

Design

MAY 2019

Project Title:
Cell Transmission Model, CTM-based Optimal Signal Control Strategies in Urban Networks

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WHAT IS THE NEED?

Traffic in urban network is getting more and more congested due to rapid increase in travel demand. Most of the prevailing signal control strategies do not work properly when traffic is congested during peak hours as most of the model vehicles are considered as queues and failed to capture important traffic flow characteristics. To tackle the problems, Cell Transmission Model (CTM) has been used to simulate the evolution of patterns of vehicles on the road to correctly approximate the traffic condition and signal settings. The task provides a systematic framework to determine optimal signal settings for urban networks.

WHAT WAS OUR GOAL?

The goal of the research was to develop optimal signal control strategy in urban network based on Cell Transmission Model. Insights from this project aimed to help traffic engineers to design on optimal allocation of green times in large-scale networks.

WHAT DID WE DO?

- Performed comprehensive review on the state-of-the-art traffic flow models for urban networks and the signal control strategies developed particularly in the framework of CTM.
- Introduced a novel analytical framework in deriving invariant averaged models for signalized intersections in urban networks, using the capability of the cell transmission model (CTM) to capture the detailed traffic dynamics such as the formation, propagation, and dissipation of congestion arising at network junctions.
- Derived invariant averaged models to eliminate the binary variables introduced by the traffic signals. For the purpose

of simplicity, the approach emphasizes on a signalized linear junction connecting one upstream link with one downstream link.
- Demonstrated that the invariant averaged model is a reasonable approximation to the original supply-demand model with binary signals.
- Introduced two new terms: Effective Demand and Merging Priority. With these two new terms, we follow similar procedures as those in the linear junction, and derive the corresponding invariant averaged model for the merging junction.

WHAT WAS THE OUTCOME?

- Insights from a comprehensive review on the traffic flow models and signal control strategies for urban traffic networks.
- Signal control strategies on the CTM with a summary on the following aspects: the network representations, the junction models, the objective functions, and the optimization methods.
- Knowledge of major issue in the signal optimization of large-scale.
- Provided a systematic and comprehensive study on deriving and analyzing invariant averaged models for signalized junctions.
- Developed a systematic framework to determine optimal signal settings for urban networks.

WHAT IS THE BENEFIT?

In summary, the contributions of this project are in two parts. First, it provides researchers and engineers a comprehensive review on the state-of-the-art traffic flow models for urban networks and the signal control strategies developed particularly in the framework of CTM. Second, it derives algorithm to test on computer models for signalized intersections. The insights obtained from this project produce an efficient solution of optimal green times in urban networks.

IMAGES

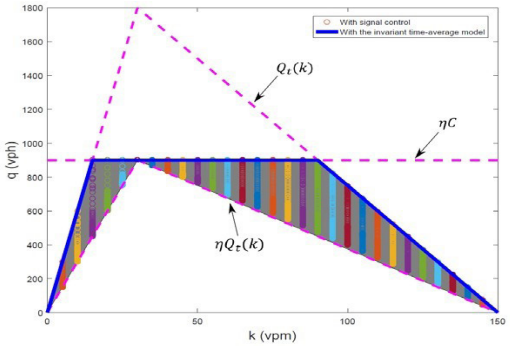

FIGURE 1: Macroscopic fundamental diagrams of the signalized ring road (triangular fundamental diagram)

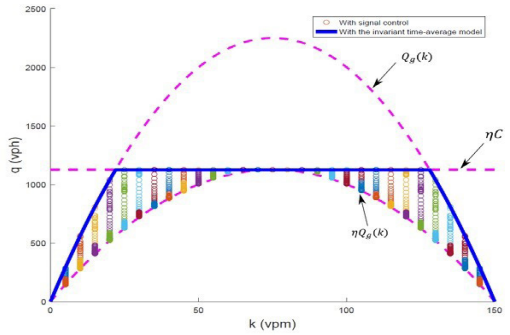

FIGURE 2: Macroscopic fundamental diagrams of the signalized ring road (Greenshields' fundamental diagram)

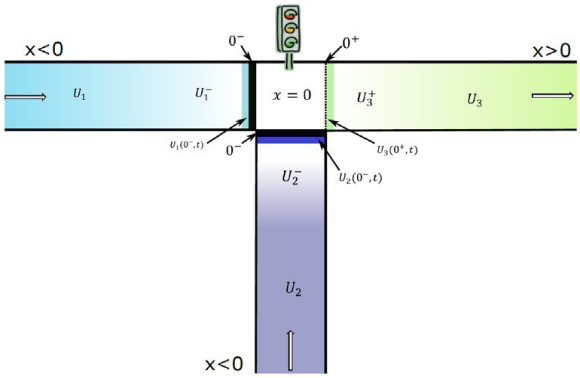

FIGURE 3: signalized merging junction