DRISI
Caltrans Division of Research, Innovation and System Information

Research Results

UTC - FAST Act - PSR 017: Implications of Information Structure in Control of Urban Traffic Networks

Research to study performance of traffic networks under various information structures.

Transportation Safety and Mobility

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Project Title:
Testing of Combined Variable Speed Advisory (VSA) and Coordinated Ramp Metering (CRM) for Freeway Traffic Control

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WHAT WAS THE NEED?

Rapid advancements in technology have facilitated a tremendous increase in the number of control/decision and sensor points in urban traffic networks, ranging from an individual driver carrying a smart phone to ramp metering, to a city-scale traffic control center.

Due to the large volume of data generation, it is computationally and arguably, even technologically infeasible, to inter-connect all the points to each other for real-time applications. Therefore, there is a need to study performance of traffic networks under various information structures (i.e., sparse interconnection of control/decision and sensor points).

WHAT WAS OUR GOAL?

Our goal was to develop algorithms for distributed control of urban traffic networks and route recommendation mechanisms; and illustrate their impact through simulation case studies.

The findings of this research were submitted to respected transportation and control journals and presented at relevant conferences and workshops.

WHAT DID WE DO?

The research team at the University of Southern California (USC) analyzed optimal control of traffic flow over networks using a combination of variable speed limit, ramp meter, lane-changing, and routing control. They developed the foundations for a framework to design closed-loop control under given information structures. The emphasis was on computational tractability of performance gap with respect to centralized control.

The research team then studied optimal information design to influence route choice decisions of drivers in dynamic environments. Specifically, they adopted the framework of algorithmic persuasion, under which the system planner can exploit information asymmetry about the knowledge of the real-time state of the network to release alternate routes to the drivers to optimize the social objective.

The study of algorithmic persuasion was very recent, and more so, the existing work implicitly evaluated the incentive compliant nature of the recommendations from the system planner only asymptotically. Researchers addressed these shortcomings to develop foundations for algorithmic persuasion in routing. The methodological contributions supplemented with case studies using traffic data from corridors in the Los Angeles area.

WHAT WAS THE OUTCOME?

First, the researchers considered optimal control of traffic flow over networks using a combination of variable speed limit, ramp meter, lane changing, and routing control. While this problem has attracted significant attention, most of the prior work has been limited to centralized or open-loop control. They developed the foundations for a framework to design closed-loop control under given information structures. The emphasis was on computational tractability and characterization of performance gap with respect to centralized control.

Second, the research team studied optimal information design to influence route choice decisions of drivers in dynamic environments. Specifically, they adopted the framework of algorithmic persuasion, under which the system planner can exploit information asymmetry about the knowledge of the real-time state of the network to release noisy information or recommend routes to the drivers in order to optimize social objective.

The study of algorithmic persuasion in the context of routing games was very recent, and more so, the existing work implicitly assumes the drivers to evaluate the incentive compliant nature of the recommendations from the system planner only asymptotically, they do not consider externality from drivers who do not participate in persuasion, and assume static traffic flow models.

In this project, the researchers addressed these shortcomings to develop foundations for algorithmic persuasion in routing games. The methodological contributions supplemented with case studies using traffic data from the Los Angeles area.

WHAT IS THE BENEFIT?

California has several congested urban areas, as well as a vibrant technology culture in the mobility domain. It is imperative to develop the appropriate basic research and case studies to connect the emerging data science and cloud computing technologies with classical control mechanisms such as ramp meter, variable speed limit, and route recommendation mechanisms.

While the case studies were developed in the context of California, the basic research will be universally applicable. The results of this research could help in providing reliable real-time alternate routing to drivers when there is traffic congestion on the California roads.