Applying ITS Technologies to Contend with Highway Congestion

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Problem

Over the past decade, a variety of intelligent transportation systems (ITS) traffic control strategies have been proposed to contend with recurrent congestion at freeway bottlenecks and non-recurrent congestion at work zones. However, due to the dynamic nature of traffic flows and the time-of-day fluctuation of traffic volume, it is difficult for any individual control strategy to be effective, and how to integrate all viable control strategies remains an imperative and challenging issue.

Description

This report presents the research results of two ITS applications: the first is an innovative field implementation of variable speed limit (VSL) control for a recurrently congested highway segment, and the second is a laboratory experiment of a lane-based signal merge (LBSM) control for highway work zones.

PART I - Variable Speed Limit Control for Recurrent Congestion

VSL control is an advanced traffic management strategy that has received increasing interest from the transportation community since the advent of ITS in the 1980s. A complete VSL system typically comprises a set of traffic sensors to collect flow and speed data, several properly located variable message signs (VMSs) to display messages, a reliable control algorithm to compute the optimal speed limit for all control locations, a real-time database, and a communications system to convey information between all principal modules.

As figures on the right show, the entire roadside system consists of four detectors, two VMSs, two VSLs, and two license plate recognition (LPR) trailers. Based on the spatial distribution of traffic flow speeds, this study selected the segment of MD 100 from MD 713 to Coca Cola Dr. as the target control segment. The traffic flow speed within this segment drops substantially, from an average of 50 mph to 25 mph, due to the traffic volumes coming from on-ramps, and then recovers to free flow state.

The field experimental results over a 10-week period clearly indicate that VSL control supplemented with the display of estimated travel times (calculated by the LPR system) can significantly increase both the average speed and throughput for highway segments plagued by recurrent congestion.
PART II - Lane-based Signal Merge Control for Work Zone Operations

Performing work zone activities in freeway segments is one of the principal contributors to non-recurrent congestion, and it may have a significant impact on traffic mobility as well as safety since the capacity reduction due to lane closures often causes drivers to perform mandatory lane-changing and merging maneuvers. To best manage the traffic approaching and traveling through the work zone, transportation professionals have proposed a variety of merge control strategies over the past two decades including conventional merge (CM), early merge (EM), and late merge (LM). However, how to maximize the operational efficiency and safety of a work zone under high traffic volume remains a challenging issue.

LBSM is a new merge control strategy that employs a signal at the proper merging point to assign the right-of-way for traffic in each lane if the approaching volume exceeds 800 vehicles per hour per lane. The basic concept of the LBSM is to use lane-based signals or variable signs to give drivers in different lanes the right of way to proceed through the open lane(s) in a work zone area. As illustrated in the figure on the right, the LBSM that employs either a pretimed or actuated signal system is to function like an intersection signal control.

The proposed LBSM is expected to achieve the following operational benefits: (1) increase traffic mobility by fully utilizing the open lane capacity; and (2) improve traffic safety by using traffic signal to prevent traffic conflicts often incurred to vehicles between the open and closed lanes. LBSM system should only be considered in the presence of congestion on the freeway where traffic demand has exceeded the work zone capacity and queues have already formed. Otherwise, the traffic interruptions induced by activating mainline signals on low density-high speed freeways may raise the risk of rear-end collisions and other safety concerns. In addition, additional stops and delays caused by red signals are the price to pay during uncongested traffic conditions.

The results of extensive simulation evaluation clearly indicate that the design, even preliminary in nature, can significantly increase the throughput and reduce the average vehicle delay, average vehicle stop delay, and the number of vehicle stops for highway work zones under congested traffic conditions.

Report Information

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