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CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION

Research Results

Graphical User Interface Development for Coordinated Ramp Metering (CRM) System

This project will hide all the complications of the CRM algorithms and validate the developed CRM on SR 99 North Bound (NB) and US 50 East Bound (EB) corridors.

Transportation Safety and Mobility

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Project Title:
Graphical User Interface (GUI) Development for Coordinated Ramp Metering (CRM) System

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WHAT WAS THE NEED?

Although freeway ramp metering (RM) has been widely used for California highways for traffic management and control, they are mostly Local Responsive Ramp Metering (LRRM). LRRM determines RM rate only based on the information from its immediate upstream mainline traffic detectors. Therefore, the traffic throughput along the freeway corridor is not optimized.

Our previous project funded by Caltrans Division of Research, Innovation and System Information project focused on field test of Coordinated Ramp Metering (CRM) on the SR99 NB section near Sacramento. The overall corridor traffic efficiency (or average speed) was improved by 7.25% in AM peak hours. After the project was completed, Caltrans District 3 Regional Traffic Management Center (RTMC) traffic engineers made the following request: (a) to continue using the CRM control as the daily operation for the SR99 NB corridor; and (b) to develop a Graphical User Interface (GUI) for the CRM algorithm so that Caltrans freeway traffic engineers can easily apply it to other freeway corridors.

WHAT WAS OUR GOAL?

The goal of the project was to develop a GUI software, e. g. a Linux or Windows-based application that the Caltrans district freeway traffic engineers can easily use to control freeway corridors traffic in California. The developed GUI wanted as user-friendly as possible.

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WHAT DID WE DO?

The project team built user-friendly GUI capable of hiding all the complications of the mathematical algorithms. With this GUI, Caltrans Freeway Ramp Metering traffic engineers can set up the system to control a freeway corridor using the CRM strategy by simply inputting a set of traffic parameters manually or from a file, which include:

- freeway name
- start post mile and end post mile
- total number of lanes of each freeway section
- number of High Occupancy Vehicle (HOV) lanes of each freeway section
- number of onramps in sequence and their locations and lengths
- onramps total number of lanes and number of HOV lane
- number of off-ramps in sequence and their locations and lengths
- traffic (or loop) detector locations
- IP addresses of all the detectors in mainline, onramps and offramps

WHAT WAS THE OUTCOME?

In this project, the project team developed a GUI for the CRM algorithm which was developed and tested in a previous on SR 99 North Bound (NB) corridor near the US50 interchange in a previous Caltrans project. This project developed several modules to enable Caltrans freeway traffic engineers to use the GUI for the CRM control for a give freeway corridor. Those modules include: freeway corridor modeling, traffic detector data mapping, traffic state parameter estimation, control parameter tuning, CRM activation or deactivation for an onramp, output and display traffic state parameters, ramp metering rate and Variable Speed Limit (VSL) at each sign location. and fault detection and warning. After system integration, the developed CRM GUI tool would be used for validation on SR 99 NB and US 50 East Bound corridors. The California Partners for Advanced Transportation Technology (PATH) project team also trained Caltrans District 3 traffic engineers so that they would be able to use the CRM GUI tool independently to other freeway corridors as long as the data is centralized and available in real-time.

The CRM system introduced a series of improvements in ramp meter management including:

1. The CRM system collects data continuously along the entire corridor and use all the valid data to control each of the individual ramp meters from a system approach simultaneously using a simplified version of Optimal Control.
2. The data is used in an algorithm (a simplified Optimal Control strategy, called Model Predictive Control) that employs an optimization method (known as a linear program) that controls ramp metering rate to maximize total Vehicle Miles Traveled, while minimizing total Vehicle Hours Traveled, on the mainline freeway. Mathematically, this is non-zero-sum game approach.
3. The availability of route-wide real time data allows the algorithm to consider traffic conditions created by prior ramp meter control points, and then improve the traffic conditions by providing revised ramp meter timing to all ramp meters under control (at regular time intervals, usually 30s).

WHAT IS THE BENEFIT?

The immediate benefit of CRM with GUI tool capability is that it is a convenient way for Caltrans traffic engineers to apply the CRM traffic control strategy to any freeway corridor.

The CRM algorithm used in the GUI uses a simplified optimal control approach that determines the RM rate at each onramp by considering the overall traffic along the freeway corridor. The traffic improvement benefit should be more significant than the LRRM currently in operation in almost all Caltrans Districts. Therefore, wide use of the CRM for freeway corridor traffic control will lead to direct benefits in freeway throughput improvement and

congestion reduction. This will reduce Total Travel Time which match with the Mobility Improvement of the Caltrans Strategic Goal. Indirect benefits will include but are not limited to energy and emission reduction and safety improvement.

LEARN MORE

TBD- Final report link.