DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Adaptive Coordination Algorithm for Arterial Traffic Signals

Develop a simplified adaptive signal control algorithm for arterials that would work with Caltrans' existing detector configurations, and that Caltrans could incorporate into its own signal control software for a one-time cost..

Transportation Safety and Mobility

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Project Title:
Adaptive Coordination Algorithm for Arterial Traffic Signals

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Task Manager:
John Slonaker
Sr. Transportation Electrical Engineer (specialist)
john.slonaker@dot.ca.gov

WHAT IS THE NEED?

Caltrans Traffic Operations would like to improve progression and reduce delay on signalized arterials on state highways by employing adaptive signal control techniques. However, vendor supplied systems with per site licensing fees tend to be prohibitively expensive, overly complicated for signal technicians to operate both effectively and efficiently, and often require additional detection not included in Caltrans design standards. Research was needed to develop an adaptive signal control algorithm for arterials that Caltrans can incorporate into its own signal control software for a one-time cost. Additionally, the algorithm needed to function with standard detection and be simple and intelligent enough for technicians to operate it effectively without spending too much time on field reviews.

Previous tasks in this project have evaluated commercially available adaptive signal control systems to see if they meet Caltrans' needs. However, the results have shown that statewide implementation of these systems would be too expensive because of per site licensing fees and requisite additional detection. Caltrans needs to develop its own adaptive capability to incorporate into its existing software and field hardware.

WHAT WAS OUR GOAL?

The goal of this project was to develop a simplified adaptive signal control algorithm for arterials that would work with Caltrans' existing detector configurations, and that Caltrans could incorporate into its own signal control software for a one-time cost. This algorithm is intended to eventually be deployed on field master controllers as part of the TSCP (Traffic Signal Control Program) firmware or on a server that manages all signal controllers on a corridor as part of the Caltrans TSMSS (Traffic Signal Management and Surveillance System) control software. The ultimate goal is to reduce travel times on and around state arterials.

WHAT DID WE DO?

University researchers, working closely with Caltrans staff, developed an adaptive arterial signal coordination algorithm that makes real-time adjustments to the splits and offsets of baseline time-of-day (TOD) plans, within specified bounds, in response to current traffic demands. Caltrans staff provided their expectations for the algorithm's functionality, and described the data available from the existing system.
The university research team then designed and tested an algorithm to suit these requirements and accommodate the input data types available. Caltrans signal timing engineers worked with the researchers to ensure that the adaptive algorithm's inputs were feasible and its outputs acceptable.

The algorithm was designed to include tests to validate the data received from each detector. For example, it checks for missing data by looking for state changes from the detectors at least once within a specified interval. The researchers tested the algorithm by incorporating its logic into a simulation software package called VISSIM (Verkehr In Städten – SIMulationsmodell, or "Traffic in cities - simulation model.") This allowed them to compare the algorithm's performance against baseline time-of-day (TOD) plans they generated using a signal coordination optimization software package called Synchro, by Trafficware. A range of traffic and geometric scenarios were tested, including performance under faulty or missing detector data.

The scope of the work did not include coding to deploy the algorithm in the field. Translation of the algorithm into programming code for use on Caltrans' controllers and/or TSMSS (Traffic Signal Management and Surveillance System) server was intended to be completed separately.

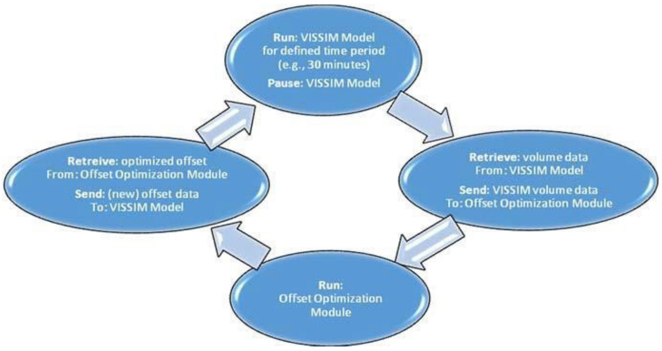
WHAT WAS THE OUTCOME?

The offsets, i.e. timing differences due to distances between signals, generated by the researchers' algorithm had better performance than the offsets generated using the commercially available Synchro software optimization tool. The level of improvement depended on the network geometry and traffic characteristics. In general, the improvements were higher for networks with more complex geometries and traffic patterns. The following tables show the simulation results for three arterials that quantify the improvements in traffic performance when using offsets generated by the researchers' algorithm versus those generated by Synchro.

WHAT IS THE BENEFIT?

This project provided an adaptive algorithm that is now available for Caltrans' unrestricted use and modification without licensure fees. If implemented, it could provide signal performance improvements through refinements to timing parameters as conditions change throughout the day and allow for automatic updating of underlying time-of-day (TOD) plans as volumes change over time. The algorithm could thus reduce Caltrans' labor costs associated with manually updating signal timing plans periodically at locations where it is deployed. This would be valuable considering the large number of intersections under Caltrans' jurisdiction and the limited staff available to manage them. It could ultimately provide the traveling public with reduced transportation costs in the form of improved fuel efficiency and reduced travel times.

IMAGES



TRAFFIC SCENARIO	NUMBER OF STOPS			DELAY (sec/veh)		
	SYNCHRO	ALGORITHM	% DIFF	SYNCHRO	ALGORITHM	% DIFF
1	3.3	3	9.1	153	123	19.6
2	3	2	33.3	126	88	30.2
3	2.2	1.6	27.3	98	81	17.3
4	2.6	2.1	19.2	120	89	25.8
5	2.7	2.6	3.7	128	115	10.2

Image 1: Synchro vs. Algorithm-Montrose Road

TRAVEL DIRECTION	NUMBER OF STOPS			DELAY (sec/veh)		
	SYNCHRO	ALGORITHM	% DIFF	SYNCHRO	ALGORITHM	% DIFF
EB	4	3.8	5.0	145	139	4.1
WB	14.8	13.9	6.1	732	700	4.4

Image 2: Synchro vs. Algorithm-Live Oak Avenue

TRAFFIC SCENARIO	NUMBER OF STOPS			DELAY (sec/veh)		
	SYNCHRO	ALGORITHM	% DIFF	SYNCHRO	ALGORITHM	% DIFF
1	3.1	2.8	9.7	95	95	0.0
2	3.8	3	21.1	110	105	4.5
3	3.1	2.9	6.5	65	65	0.0

Image 3: Synchro vs. Algorithm-San Pablo Avenue