Project Summary

Texas Department of Transportation

0-6029: Fully Adaptive Detection-Control System for Isolated Intersections

Background

Engineers from the Texas Department of Transportation (TxDOT) use all available strategies to improve operations at signalized intersections. Over the past few years numerous systems like D-CS (Detection-Control System), AWEGS (Advance Warning of End of Green System), and PIA (Platoon Identification Accomodation) were developed to improve safety at high-speed intersections. These systems required a pair of advance detectors in each lane. They also required stop bar detectors on all approaches including the major street approaches to improve intersection efficiency. With increases in the cost of installing and maintaining detectors, there is a need to develop strategies that would require fewer detectors and operate satisfactorily even when detectors fail. This project's objective was to develop three modules to improve efficiency not only at traffic signals with D-CS type systems but also at typical fully actuated signalized intersections.

What the Researchers Did

Researchers developed the following three modules to improve the efficiency of fully actuated signalized intersections.

Module 1 - Adaptive Variable Initial Module: This module functions similarly to the variable initial feature in traffic signal controllers. Variable initialization is used when an intersection approach has only setback detectors and no stop bar detectors. This module removes the need for stop bar detectors for systems like D-CS and for intersections with dilemma zone detectors. This module is also useful when stop bar detectors fail. The module determines the minimum initial time required to clear the vehicles detected during the non-green portion of the phase. The minimum initial value is then implemented using the phase-hold function.

Research Performed by:

Texas Transportation Institute (TTI), The Texas A&M University System

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Module 2 - Detector Failure Module: This module monitors the phase utilizations of all phases and builds and maintains a database of phase utilizations for four weeks. This database determines the appropriate phase to be allocated to a particular phase in case of a detector failure. The module monitors the phase utilizations continuously to respond to detector failures. Once a detector failure is identified, the module recommends the appropriate phase time for each phase and implements the phase time using ring force-off function.

Module 3 - Variable Delay Module: This module monitors the activity of the left-turn and right-turn detectors for implementing detector delay. Based on the traffic patterns on these detectors and the phase utilizations of the major movements, the module determines the delay to be applied to the detectors. Delay typically minimizes the unnecessary terminations of the major movements. Use of variable delay can further improve the efficiency of using a static detector delay.

The researchers collected data from two sites in Texas where AWEGS was implemented. The number of actuations on the setback detectors for an approach, as well as the time taken to clear the queue for the same approach, is logged in the AWEGS data files. These data were used to develop and calibrate the models for the adaptive variable initial module. The database of phase utilization for all phases enabled prediction of the phase durations. Phase utilizations of the major street movements assisted in developing the variable delay models.

Researchers from the Texas Transportation Institute (TTI) implemented the modules at: US 84 and Aviation Parkway in Waco (Module 1, Module 2, and Module 3), SH 21 and Business SH 6 in Bryan (Module 2), and SH 105 and FM 3083 in Conroe (Module 1 and Module 2).

What They Found

TTI researchers developed models to predict the maximum initial value based on the number of lanes on the approach. Models were developed for single-lane and two-lane approaches. The variable initial model was verified and calibrated in Waco and implemented at the site in Conroe, which has 3 lanes in each direction. The variable initial module in Conroe showed a very strong correlation to the actual time required to clear a queue as obtained by observing the occupancy of stop bar detectors.

Researchers implemented a model for Module 2 using the rolling average of the phase utilization for the previous four weeks. Input from the project monitoring committee resulted in a more sophisticated prediction model that considered the variances in the average of the phase utilizations. The accuracy of these models depended on the level of activity at the intersections.

Researchers also developed a preliminary module for variable delay and implemented it in Waco. However, this variable delay module was applicable under rare conditions and its benefits were minor, halting its development.

What This Means

The variable initial module developed in this project determines the appropriate maximum initial value (minimum green) when stop-bar detectors are not available. The module can improve intersection efficiency in real time by considering many factors including the utilization of the left-turn phase. The detector failure module is applicable during detector failures at an intersection. Using this module can significantly improve intersection efficiency until the detector failure is rectified. Both these modules require data that are currently available in signal controllers, making their incorporation into the signal controller firmware very feasible.

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