Cooperative Transportation Systems Pooled Fund Study

Year-1 Projects

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Background

For the Year-1 Research Program of the pooled fund study, three infrastructure-oriented Cooperative Transportation Systems focused research projects were completed:

1) Pavement Maintenance Support Applications
2) Signal Phase and Timing (SPaT) Data Applications
3) Connected Vehicle (CV) Traffic Signal Control Algorithms

Pavement Maintenance Support Applications

Project Premise

Maintenance of pavements represents one of the most important (and costly) functions of a transportation agency.

The International Roughness Index (IRI) is a standardized pavement roughness measurement that was developed in the 1980s

Can vehicular probe data available from vehicles be used to measure IRI?

Pavement

Project Objective:

Determining the benefits of using CV probe data:

- To develop estimates of the IRI
- To detect and map potholes
- To understand and document specific risks, constraints and opportunities in a large-scale deployment of the proposed system.

Pavement

Project Focus:

- This project investigated whether vehicular data available from CVs can be used to measure pavement conditions, particularly as compared to current techniques used by DOTs to measure the IRI.
- The results were then analyzed in terms of a potential national deployment to develop a preliminary Concept of Operations, list system requirements, analyze deployment issues, and conduct a comparative cost analysis.

Pavement

Project Findings:

- Using the probe vehicle's onboard sensors, the roughness of sections of road can be assessed.
- Additionally the sensor measurements can be used to identify potholes or bumps on the road.
- Simple algorithms using the measurements from the onboard sensors can be related to the IRI of the road.

Pavement

More Project Findings:

(Assessing pavement quality through probe data is called Probe Data Performance Management (PDPM)).

- PDPM offers the potential for cost-effective pavement assessment using sensors already on today's automobiles.
- A very low level of PDPM vehicles can have some benefit: A fleet of 2.5M vehicles is estimated to be sufficient for nationwide coverage. (There are ~260M licensed passenger vehicles in the U.S.)
- PDPM does not offer a business case to car-makers.

Signal Phase and Timing (SPaT) Data Applications

Project Premise

There exists potential to improve the traveler experience on urban arterials by providing Signal Phase and Timing (SPaT) data to vehicles.

Will the deployment of the infrastructure component of CV by integrating Dedicated Short Range Communications (DSRC) into traffic controllers provide the capability to broadcast SPaT data for use by CV equipped vehicles?

Signal Phasing/Timing

Project Objectives:

- To identify the use cases of SPaT data.
- To develop Concepts of Operations for each of the identified use cases, and
- To conduct high level benefits assessment

Signal Phasing/Timing

Project Focus Applications:

Looked at the potential benefits of using CV data for the following SPaT applications:

- Signal violation warning (CICAS-V)
- Traffic signal adaptation; extending all-red (CICAS-TSA)
- Traffic signal status display in vehicles
- Vulnerable road user warnings near intersections (pedestrians, bikes)
- Signal change warning for trucks

Signal Phasing/Timing

More Project Focus Applications:

- Alerting drivers about imminent emergency vehicle pre-emption
- Transit signal priority
- Arterial truck driving support
- Eco-driving support
- Traffic signal control optimization
- All-User optimization of traffic control

Signal Phasing/Timing

Project Findings:

The applications that appear to have the potential for the most significant benefits (in terms of dollars or lives saved per year) were:

- Signal violation warning (CICAS-V)
- Traffic signal status display in vehicles
- Eco-driving support
- Traffic signal control optimization

Signal Phasing/Timing

More Project Findings:

The applications with a potential for moderate benefits were:

- Traffic signal adaptation; extending all-red (CICAS-TSA)
- Vulnerable road user warnings (pedestrians and bicyclists)
- Transit signal priority
- All-User optimization of traffic control (based on incremental benefit beyond traffic signal control optimization)

Connected Vehicle (CV) Traffic Signal Control Algorithms

Project Premise

Currently the effectiveness of traffic signal control algorithms depends primarily upon the control logic and the quality of the sensing infrastructure.

Traffic signal control algorithms currently cannot take advantage of vehicular information that would be available from a CV architecture.

Are there benefits to be gained with traffic signal control algorithms designed specifically to take advantage of CVs?

Signal Control

Project Objectives:

- To develop and evaluate new traffic signal control algorithms by fully utilizing new CV data sources,
- To develop tools for generating meaningful arterial Measures of Effectiveness (MOEs) from CV data sources, and
- To understand and document specific risks, constraints and opportunities of the developed algorithms in a large-scale deployment.

Signal Control

Project Tasks:

- Task 1: Investigation of the CV Data Sources
- Task 2: Development of New Traffic Signal Control Algorithms under CV
- Task 3: Development of Tools for Generating Arterial MOEs from CV
- Task 4: Evaluation of the Developed Traffic Signal Control Algorithms
- Task 5: Deployment Analysis:

Signal Control

Task 1: Investigation of the CV Data Sources

- This task investigated the potential data sources available in an CV environment, and the potential and limitation of those sources.

Findings

- Two data elements were identified that are beneficial to signalized intersection operations, but are not included in the SAE J2735 DSRC Message Set Dictionary.

Signal Control

Task 2: Development of New Traffic Signal Control Algorithms under CV

- This task looked at traffic control algorithms utilizing CV data as the primary data source.

Findings

- The three algorithms analyzed: Oversaturated conditions, vehicle clustering, and predictive microscopic.
- All require 20% to 50% of vehicles being connected to see improvements.

Task 3: Development of Tools for Generating Arterial MOEs from CV

- This task investigated the effect that CV data would have on the collection of signalized intersection measures-of-effectiveness (MOEs), and proposed new performance metrics.

Findings

- The new metrics included person delay, sudden decelerations, changes in lateral acceleration, network connectivity, aggregate regulation compliance, driver behavior modeling, and weather/light conditions.

Signal Control

Task 4: Evaluation of the Developed Traffic Signal Control Algorithms

- This task evaluated the traffic signal control algorithms developed in Task 2 on a virtual CV test bed, at a range of levels of vehicle connectivity.

Findings

- The algorithms showed a significant improvement over coordinated-actuated signal control, with between 6% and 28% reductions in delay.
- All three algorithms began to experience benefits at 25% market penetration.

Signal Control

Task 5: Deployment Analysis

- This task investigated the potential implications of a large-scale real-world implementation of CV Sat signal systems and included a cost-benefit analysis of CV signal control versus a system using traditional (loop or video) detection.

Findings

- Shows a positive benefit-cost
- More reliable under some conditions then video detection
- Requires up to 50% of vehicles being connected

Cooperative Transportation Systems Pooled Fund Study

Final Project Reports Are Available On-line at:

http://cts.virginia.edu/CTSPFS_1.html

Or search: “Connected Vehicle Pooled Fund”

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