DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Automated Assessment of Safety-Critical Dynamics in Multi-Modal Transportation Systems

This research involves a quantitative assessment of safety-critical multi-modal traffic dynamics at signalized intersections.

Design

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Project Title:
Automated Assessment of Safety-Critical Dynamics in Multi-Modal Transportation Systems

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Task Manager:
Bradley Mizuno,
Transportation Engineer (Electrical)
bradley.mizuno@dot.ca.gov

WHAT WAS THE NEED?

Recent mobility trends in the context of California, as well as the United States, reveal that travel is becoming increasingly multi-modal in nature. The results of the 2010-12 California Household Travel Survey indicate that while driving is still the most dominant mode of choice (75%), its mode share has decreased by 10% since 2000. In comparison, walking (17%), transit (4.5%) and biking (1.5%) have doubled their increasingly significant mode share. Similarly, the results of the 2009 National Household Travel Survey indicate an average American made 17 more walkng trips in 2009 than in 2001, covering nine additional miles.

Given this emergence of multi-modal travel, it is of immense concern that the corresponding improvements made to traffic safety have not been commensurate across all modes. While traffic fatalities have reduced for cars and light trucks by about 40% between 2006 and 2011, the change in the number of pedestrians and bike fatalities has been much less drastic and non-monotonic.

While there has been considerable research done to systematically quantify the safety performance of transportation facilities based on crash history, there is little work on routinely measuring the safety critical behavior of road-users as surrogate measures of traffic safety. In addition to monitoring the crash frequencies, transportation agencies should also be able to evaluate the performance of their facilities on safety-critical behavior, such as yielding. This is especially crucial in multi-modal environments where the dynamics are not well captured by existing performance measures. As the literature indicates, a major challenge associated with studying safety-critical multi-modal behavior lies in simultaneously evaluating the presence

DRISI provides solutions and knowledge that improves California's transportation system and movements of all the different participants over long periods of time, which is essential to develop and validate theories with statistical significance. In addition, as the emphasis on heavier instrumentation of intersections through video cameras and other in-pavement sensors increases, there is an opportunity to create economies of scale to generate comprehensive performance evaluations of multi-modal safety and mobility at these locations through the collected data.

WHAT WAS OUR GOAL?

The study proposes to utilize existing technologies to quantify safety-critical dynamics in multi-modal environments. This will be done by the development of a comprehensive report card of safety-critical multi-modal dynamics of a signalized intersection, which evaluates the safety performance of a signalized intersection using data collected over long periods of time.

WHAT DID WE DO?

For the purpose of this research, the data was made available for free from a signalized intersection in Danville, CA through Sensys Networks, Inc. There were two types of data sources that were investigated as part of the study: in-pavement sensors and videos.

The first data source corresponds to the data generated by the Safety and Mobility System (SAMS) system installed at this location. The system consisted of:

1. Magnetometers deployed at intersection stop bars and departure lanes
2. Microradars deployed at different sections of a crosswalk
3. Signal conflict monitor card, connected to an access point through an Ethernet interface

The SAMS system was originally designed to collect mobility and safety performance measures for vehicular traffic. Sensys Networks installed multiple microradar detectors along one of the crosswalks at the location that facilitate the development of an occupancy-based detection of pedestrians along different parts of the crosswalk. The installation provided a unique opportunity to observe pedestrian crossing behavior at a very refined scale across different segments of the crosswalk.

The second source of data for the study is video obtained through a camera installed at the intersection that is used by Sensys Networks to calibrate the SAMS system.

As the installation indicates, there is information about the motorized vehicles (from the magnetometers), pedestrians/bicyclists (microradars) and the signal phasing at all times. Consequently, using the state of the individual sensors, performance measures on driver yielding rates and pedestrian crossing rates can be calculated as a function of the state of the signal, time of day, etc. A unique feature of the system is that by comparing the events detected at the magnetometers (present along traffic lanes) and micro radars (present along the crosswalk), events associated with pedestrians can be differentiated from those generated due to cars.

Sensor and video data were obtained for the study location for the following dates in 2015: April 22, April 24, and October 12-16. Data associated with October 15 and 16 was reserved exclusively for testing the algorithms developed as part of this effort.

WHAT WAS THE OUTCOME?

The accuracy of the trajectory-based classification when differentiating between non-motorized and motorized events on the crosswalk is 94.5% and 89.2% within the training and test data. In comparison, the accuracy of a sensor-specific

binary logit classifier on the same datasets shows an accuracy of 99.6% and 96.9%.
The analysis of driver yielding behavior when turning right during a pedestrian green reveals two types of yielding:

1. Drivers who wait behind the crosswalk while allowing pedestrians to cross
2. Drivers who yield, but aggressively encroach into the intersection.

The driver yielding behavior is typically difficult to capture, and quantify, in traditional observational studies.

WHAT IS THE BENEFIT?

The development of the classification algorithms in conjunction with the signal phase information helps provide valuable insights for both mode-specific as well as multi-modal safety-critical dynamics. For instance, the insights gained from this behavior can have important implications for other signalized and non-signalized intersections where aggressive yielding behavior may be more common, but not as well documented. Similarly, even in instances where visual verification was not available, the trajectory-based classifier was able to identify events which can be intuitively visualized using the data visualization tool.

The study also demonstrates the feasibility of using a sensor-based classification framework to automatically monitor safety-critical interactions at intersections.

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