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NETWORK SCREENING IN A CONNECTED VEHICLE ENVIRONMENT

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ABSTRACT

Transportation agencies are responsible for analyzing crash data to identify hot spots - locations that experience abnormally large numbers of crashes, pointing to potential geometric and or control problems. Current network screening practice involves using information from police reports to determine hot spot locations. There are numerous issues with current practice. First, police reports are often inaccurate with regards to exact location and the cause of the incident. Second, from a statistical perspective, this method requires a large number of crashes to occur before the problem can be recognized, which often takes years.

A connected vehicle environment offers the potential to improve this process. In a connected vehicle environment, transportation agencies will have access to more vehicular probe data than ever before. As a result, it may be possible to detect a near miss. Near misses are events during which evasive maneuvers occur and a crash is narrowly avoided. These are not reported to the police so current network screening practice will not have information regarding near misses. Current hot spot location identifier techniques will be applied to near miss event locations

Using the CVI-UTC Virginia connected vehicle testbed, data will be collected and near misses will be identified using threshold values determined from a combination of a literature review, analysis of existing data, and contact with professionals in industry. Thresholds will be determined for any data element that may indicate a near miss occurred. This includes longitudinal acceleration, lateral acceleration, yaw rate, and speed in addition to a few variables that indicate the driver's intentions or condition of the vehicle such as use of turn signal or size of vehicle.

Following data collection at the UTC Virginia connected vehicle testbed, locations that had near misses frequently occur, will be compared to hot spots indicated by police reports for verification of the proposed method.

INTRODUCTION

The Connected Vehicles program has the potential to significantly change surface transportation. If successful, the program will result in a system with significantly improved integration between travelers, their vehicles (if applicable), and the infrastructure itself. The idea behind the highway mode of the connected vehicles program is to allow vehicles to send and receive messages via dedicated short-ranged communication (DSRC). This allows vehicles to communicate with other vehicles (V2V) and with infrastructure (V2I). Each vehicle is equipped with an on-board unit (OBU), which consists of the communication devices plus a connection to the vehicle's on-board computing/communications sysetms. Thus, the OBU can also gather and transmit the vehicle's movement, being able to read location, speed, acceleration, yaw, etc. in addition to the status of certain vehicle features, such as windshield wipers, anti-lock brakes, headlights, etc.

The Basic Safety Message (BSM) defined by the J2735 standard message set for DSRC is broadcasted every 0.1 seconds from a vehicle's OBU, transmitting information on the vehicle's position, speed, accelerations, heading, etc. Additionally, if an event occurs, such as anti-lock brake activation, the vehicle will transmit an additional message.

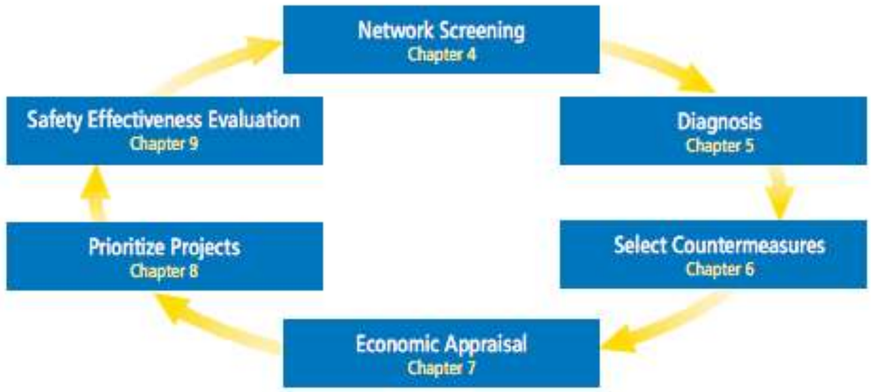
Thus far, numerous connected vehicle testbeds have been established as both proofs of concept and for research use. Much of the research has been focused on individual vehicle safety applications, using messages to alert drivers of vehicles or other objects in their vicinity that may not be visible to the driver. While these are important applications of connected vehicles, other ancillary applications have received relatively little attention in the early stages of the program. For example, connected vehicles provide the feasibility of creating applications that can allow transportation agencies to provide new services, improve existing services, or reduce the costs of providing services in numerous areas, such as traffic management.

This technology, as previously stated, is currently being tested in numerous locations. The future of this technology's use will rely on federal policy that is associated with requiring OBUs to be equipped on vehicles as standard safety equipment. As a result, there is uncertainty in regards to when or even if this technology becomes adopted as standard practice. Useful applications of connected vehicles will significantly improve the chances that connected vehicles become standard practice. The purpose of this research is to investigate an infrastructure safety monitoring application for use by transportation agencies to identify unsafe locations in the transportation network.

Current Network Screening Practices

The *Highway Safety Manual* describes a process called the Roadway Safety Management Process (Figure 2), outlining a recommended process for a DOT to locate and fix hot spots, or areas with unusually high crash frequencies. This process is currently standard practice in government agencies.

Fig



Network screening, step 1 of the roadway safety management process, involves using crash data to identify and rank locations where improvements to geometry or other roadway characteristics will reduce the number of incidents. The current method for collecting crash data is from police reports, which is both slow and inaccurate. Additionally, this means that the DOT needs to wait until numerous crashes occur instead of being able to prevent them preemptively. The longer it takes for crashes to accumulate, the longer drivers are at risk in that location.

Processing police crash reports is a long process prone to numerous mistakes. To begin with, not all collisions get reported, especially ones that are not severe. This will mean that data sets from these reports will have a higher representation of severe crashes. Secondly, the reporting officer is supposed to record both street information, milepost, and GPS coordinates (when available). Street information can vary in level of detail and accuracy. That report then is sent to an agency that copies the form into a computer database. In some states, multiple middle agencies are involves. This process can take 6 months to a year for the data to be copied over and may contain errors that an analyst is unlikely to be aware of.

Network Screening in a Connected Vehicle Environment

By establishing a connected vehicle environment, it is now possible to test alternative methods of network screening. The use of police reports is currently the only option available for DOTs to use. Since crash data has a regression-to-the-mean bias, accurate hot spot identification techniques generally require at least 3 years' worth of data, meaning the process of identifying hot spots is extremely slow. A connected vehicle environment offers a DOT an alternative method for the collection of crash data. The data given to a DOT in a connected vehicle environment would be real time, and will likely allow for the detection of near misses, or collisions that were avoided by extreme driver action and some element of randomness. Near misses are not reported, however if those can be detected by a DOT (in addition to minor collisions that are not reported), and considered as crashes, it would make accidents more frequent and allow for hot spot identification to occur more quickly without the regression-to-the-mean bias being as significant. This premise will be tested using the UTC Northern Virginia Connected Vehicle testbed.

Project Testbed

The project team is working on a new connected vehicle testbed in northern Virginia, created by the Connected Vehicle/Infrastructure University Transportation Center (CVI-UTC) in Virginia. It is located in Fairfax County along I-66, Route 50, and Route 29. OBUs will be installed in a fleet of vehicles and other vehicles will use smartphones to communicate. Figure 1 shows the RSE locations along the testbed. The freeway traveling north/south is the Capital Beltway, and the 3 routes traveling east west are, from top to bottom, I-66, Route 29, and Route 50.

Detecting Near Misses

Aside from establishing a new method for network screening and illustrating the benefits a connected vehicle environment would provide to a DOT, a primary goal of this project is to determine first, the feasibility of detecting a near miss event in a connected vehicle environment and second, if a near miss event is more frequent in areas with frequent collisions.

Figure 1 - RSE Locations in the Connected Vehicle Testbed, *www.connectedvehicleinfrastructure-utc.org*

The first goal, detecting near misses in a connected vehicle environment, will be done by examining BSMs for instances where established thresholds are exceeded. Data elements that are required to determine if an evasive maneuver occurred include the following, all of which are included in the J2735 standard message set:

1. Acceleration
2. Brake Applied Pressure
3. Brake Boost Applied
4. Coefficient of Friction
5. Driving Wheel Angle
6. Latitude
7. Longitude
8. Obstacle Direction
9. Obstacle Distance
10. Speed
11. Stability Control Status
12. Steering Wheel Angle
13. Steering Wheel Rate of Change
14. Traction Control State
15. Yaw Rate

Establishing thresholds is a tradeoff between sensitivity and severity. In other words, if the threshold is too high, only the most severe near misses will be detected, and if the thresholds are too low, there will be a large number of false positives. False positives will result in meaningless data and false negatives mean that a location may be deemed as safe even if it is not.

Naturalistic driving data will be used prior to the study to establish these thresholds. In the 100- Car Naturalistic Driving Study (NDS), conducted by Virginia Tech Transportation Institute (VTTI), participant's vehicles were equipped with multiple video cameras and data collection devices. Trips with near miss events will be identified, confirmed, and then used in this study to establish thresholds. Those thresholds will be tested with a control group to determine the frequency of false positives. This data will be supplemented with a literature review of pre-crash scenarios.

Once thresholds are established, it must be determined if near misses occur more frequently at hot spots or if near misses tend to occur more frequently when a certain type of collision is imminent. If it is the case where frequent near misses coincide with hot spot locations, DOTs can use that information to locate hot spots faster and more accurately in a connected vehicle environment.

METHODOLOGY

The first phase of the project will be started while the UTC Northern Virginia testbed is under construction. This involves a literature review, defining thresholds for near misses events using NDS data, and using crash data from VDOT to locate hot spots in the testbed region. These three tasks are preparation for the beginning of data collection.

The NDS dataset will include two sets of data. The first set will consist of trips in which a near miss had occurred, and then been identified and confirmed at VTTI. The second data set will consist of trips without a major event occurring. The first set will be used to establish thresholds, which will then be applied to the second set to detect false positives.

The crash data from VDOT will be used to locate hot spots using empirical-bayes analysis. The crash data is compiled using police reports of accidents. It will consist of three years' worth of crashes that occurred in the Northern Virginia testbed region. The results of this analysis will be used as a baseline for comparison to the results from analyzing the data collected in the testbed.

Once the construction of the testbed is complete, data collection will begin. All BSMs, emitted every 0.1 seconds, will be saved to RSE. Periodically, the data will be extracted and used for analysis. It should be noted that in this study design, the research team does not have real time access to the data; however, it can be accessed whenever needed once the data is stored. The thresholds determined in the first phase of the project will be applied to detect near misses that occurred in the testbed. Locations with frequent near misses will be compared to known hot spots in the testbed to look for correlation.

The final result will be a prototype system for network screening using a connected vehicle environment. Ideally, this system will show that near misses can be accurately detected in a connected vehicle environment and occur more frequently in hot spots indicated by empirical-bayes analysis. If that is not the case, the DOT will still have real time access to crash data that is more accurate and inclusive than police reports.

CONCLUSION

As mentioned before, a DOT stands to benefit greatly by using a connected vehicle environment for network screening purposes. In the event that near misses and crashes are correlated, detecting near misses can allow for a DOT to become aware of a hot spot more quickly than they would by waiting for a crash to occur and then get reported. Even in the event that near misses cannot be accurately defined or if they are not correlated with hot spot locations, collisions can be detected. This means the DOT has real-time crash reports of all severity.

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