Infrastructure Safety Assessment Using Connected Vehicle Data

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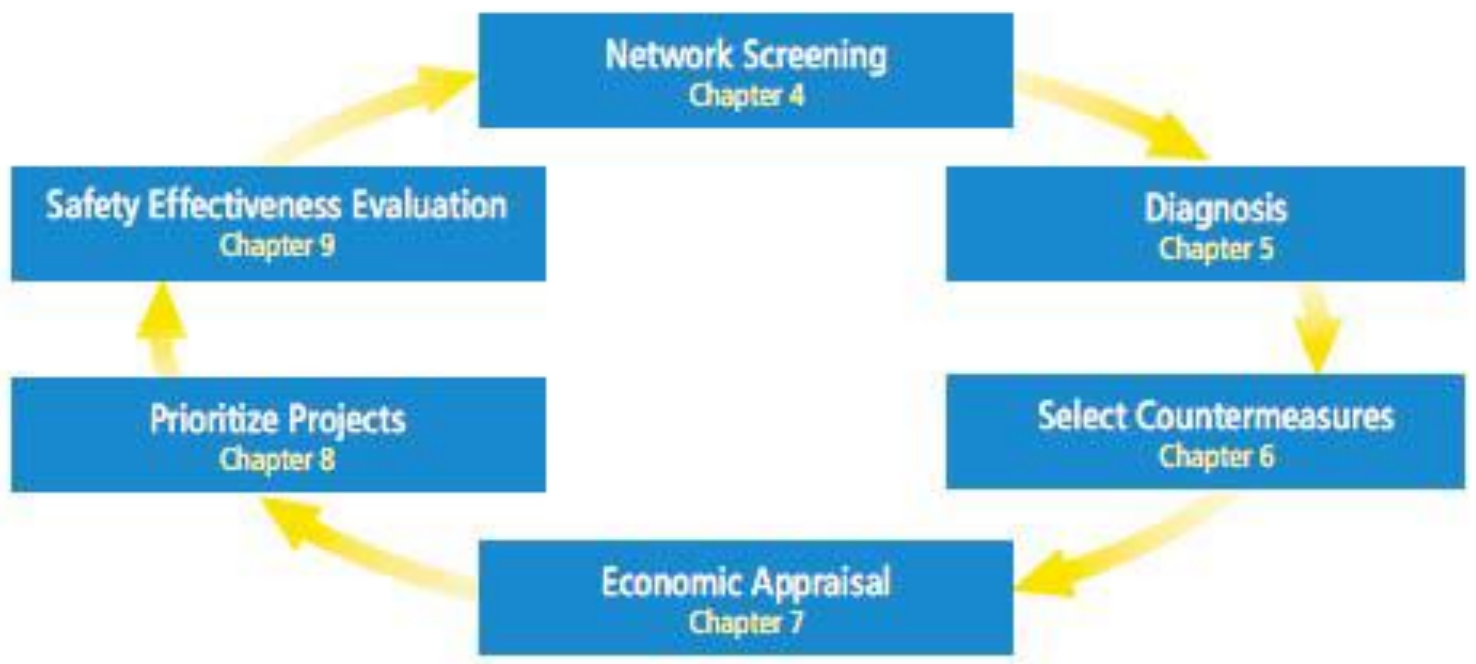
Introduction

Transportation agencies devote significant resources to analyzing crash data collected by responding police agencies to identify "hot spots" – locations which experience larger than normal numbers of crashes. In many cases, upon identification of a hot spot, field investigation will point to a feature of the infrastructure that is contributing to the crashes. This feature may then be addressed specifically to improve safety. This method, detailed in the *Highway Safety Manual's* Roadway Safety Management Process (image below), has been used for many years, and has proven to be effective. However, this method also has significant shortcomings. One of the key shortcomings is that the agency must wait for a large number of crashes to accumulate before a hot spot may be identified. In other words, this is a very reactive method that requires a number of crashes to occur before corrective action may be taken.



Roadway Safety Management Process, *Highway Safety Manual*

Fortunately, there is a reason that crashes are most often referred to as "accidents." They are infrequent, even at most hot spot locations. Thus, for a statistically significant accumulation of crashes to occur requires a rather long period of time. Furthermore, accurate capture of the location of crashes has long been a challenge in the transportation community. Police reports have been notoriously inaccurate in terms of crash location – although this is improving somewhat with the use of GPS. Thus, even when a hot spot is identified, the exact location of the problem is often difficult to pinpoint.

Thus, there is a need to develop a more proactive way to accurately identify "hot spots" – locations that require modifications to the transportation infrastructure to improve safety. The premise behind this project is that for every actual crash, there also exist numerous "near misses" where drivers' take last second, extreme evasive action (such as swerving or rapid deceleration) to avoid a crash. These near misses may be as significant as actual crashes in terms of indicating potential safety problems. The challenge lies in identifying and compiling these near misses (since they have never been formally reported by individuals or through the police). However, with vehicles in a connected vehicle environment, basic vehicular operation data will be available from the vehicle data bus. If significant evasive maneuvers may be extracted from this data, along with the corresponding GPS location, this near miss data may be analyzed by a transportation agency in a manner similar to current police crash reports to identify hot spots. Using connected vehicles, instead of police reports, offer the potential for a much quicker and more accurate network screening step, which in turn speeds up the entire Roadway Safety Management Process.

Research Objective

The objective of this project is to investigate the feasibility of using connected vehicle data to create a system to identify infrastructure safety problems based on vehicular data indicating a high frequency of evasive driving maneuvers indicative of near-misses.

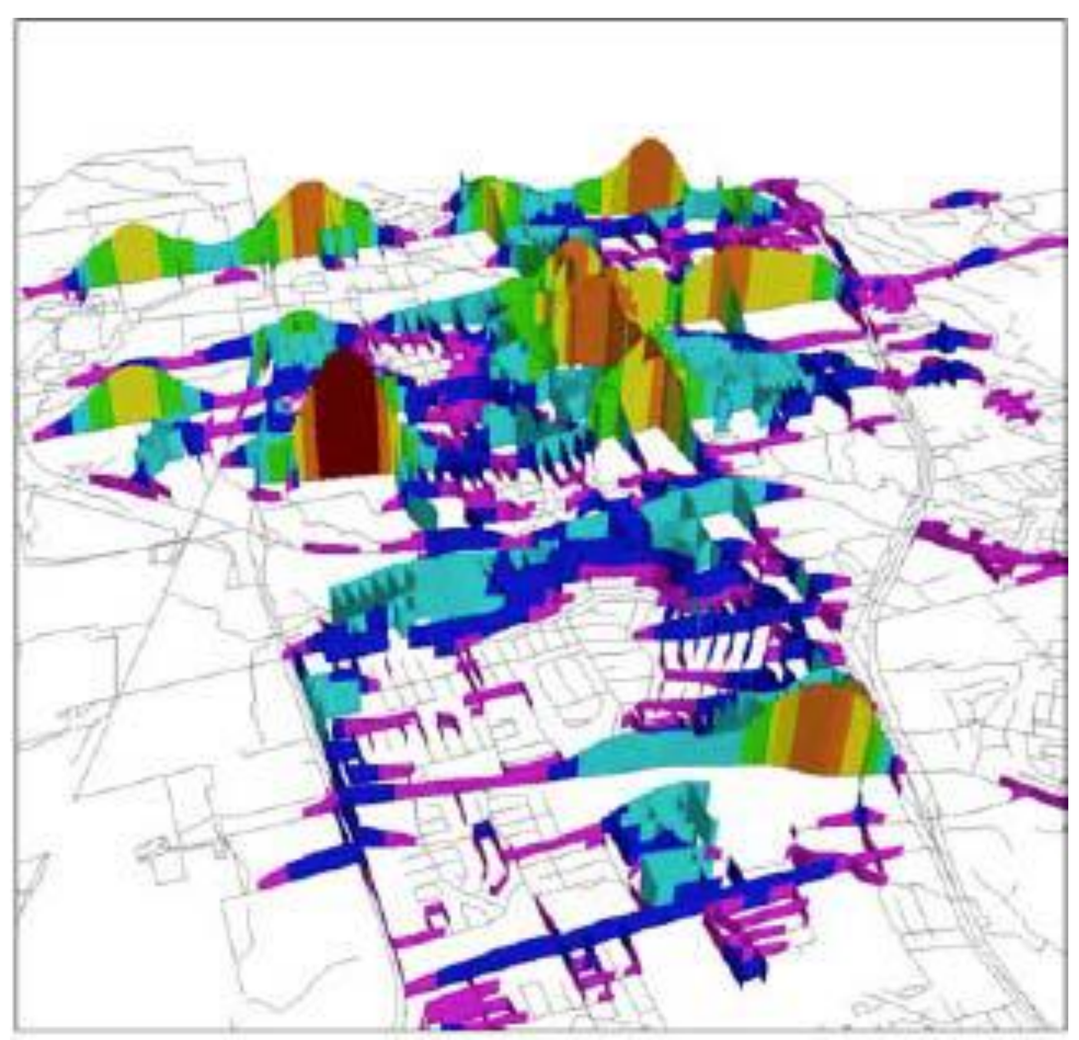
Specific objectives of this study can be summarized as follows:

1. To identify thresholds for vehicle maneuvers (i.e. lateral control and accelerations) that may indicate an evasive maneuver.
2. To delve into statistical tests to combine frequency of maneuvers with location data to identify hot spots.
3. To demonstrate and test this approach using the UTC Northern Virginia testbed.
4. To validate this approach by comparing results to traditional crash data analysis results.

The final success of this project will be determined by the ability to identify hot spots more quickly and accurately than using traditional methods. Considering that near misses are much more frequent than collisions, there should be evidence of a hot spot more quickly because of the ability to observe a near miss, combined with the accurate location of the vehicles involved using connected vehicles. Final results of this project will include the development of technique for network screening using connected vehicle technology.

Methodology

1. Analyze vehicular data available from connected vehicles to identify measures that may be used to identify evasive maneuvers.
2. Develop threshold values to use in extracting evasive maneuvers from vehicular data.
3. Use network kernel density algorithms to identify hot spots from vehicular data.
4. Apply results of tasks 1-3 to demonstrate and test the system on the UTC Northern Virginia testbed.
5. Compare hot spots identified in Task 4 with traditional crash data analysis to determine level of correlation.



Network Kernel Density Estimation Hot Spot Results, *Kuo et. al.*

Major Tasks Accomplished Under Project

Task 1: Analyzing literature and collecting background information. This includes, but is not limited to, an in depth look at the connected vehicle technology currently available in the UTC Virginia testbeds, a detailed look at frequent evasive maneuvers taken during a roadway incident, as well as analyzing available vehicular data.

Task 2: Determine threshold values that define a near miss incident or extreme evasive maneuvers using the performance measures selected in task 1. A combination of network kernel density (KDE) analysis as well as Getis-Ord (GI*) analysis will be used to determine the probability of any location being a hot spot. Results will be compared to existing crash data for validation.

Task 3: Develop and prototype a safety screening application to operate using data collected by the standard Virginia Tech Transportation Institute data acquisition system on the UTC Northern Virginia testbed. This will allow for the demonstration and testing of this concept. The research team will periodically acquire the vehicular data, apply the thresholds identified in Task 2, and automatically determine if there is a certain area that frequently receives data that exceeds the thresholds determined for chosen performance measures. Near miss and evasive maneuvering data will be compiled and evaluated using a KDE and GI* techniques in order to identify hot spot locations along the UTC Northern Virginia testbed.

Task 4: Possible hot spot locations identified using the prototype system from Task 3 will be compared to traditional crash data (obtained from the Virginia Department of Transportation) to look for correlation. If traditional data indicates hot spots at the same point as the connected vehicle data collected indicates them, that there is most likely a correlation. There should be at least the same number, or more hot spots indicated as traditional data indicates since the idea of using connected vehicle data is to find at risk areas more quickly than waiting for incidents to occur and be reported. Once hot spots are determined, the location's physical features will be carefully examined to determine if the hot spot is indicated due to random occurrence or some flaw (e.g. sight distance violation) with the design of the infrastructure.

Task 5: A plan for widespread integration of this process into connected vehicle roll out will be developed. Findings could be outlined extensively in the *Highway Safety Manual's* Roadway Safety Management Program, primarily in the network screening and safety effectiveness evaluation steps. State DOT's and private traffic data collection companies could also use these concepts once connected vehicles become standard practice. Additionally, there are plans for future testing and analysis depending on the results of this assessment. Success of this project will be determined by the ability to identify hot spots more quickly and accurately than traditional ways as well as progression of connected vehicle technology.

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

Evasive Maneuvers Variables Examined in this Study

CVI UTC · Morgan State University · Virginia Tech Transportation Institute · University of Virginia