STRIDE | Southeastern Transportation Research, Innovation, Development and Education Center

Technology Transfer Final Report

STRIDE Project F4

Automatic Safety Diagnosis in Connected Vehicle Environment

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1. Project Overview

Highway accidents cause serious social and economic problems and, therefore, preventing crashes is a primary task for transportation systems. Crashes have many causation factors, among which the most important one is the driver's driving status. This project built a near-crash warning system -- the automatic safety diagnosis system for the connected vehicle environment (ASDSCE) -- to diagnose abnormal driving status and generate near-crash warnings.

The ASDSCE consists of a dedicated cloud-based subsystem an in-vehicle subsystem equipped in all the connected vehicles (CVs) under its surveillance, and the datapath between them. The ASDSCE has two computational models: a driving anomaly detection (DAD) model and a conflict identification model (CIM). In the cloud, the DAD collects and extracts the non-private information from the periodical historical basic safety messages (BSMs), with which the DAD determines the thresholds that can differentiate the abnormal driving behavior from the normal driving behavior of each driver-vehicle unit (DVU). In the in-vehicle subsystems of each CV, using the thresholds and the real time BSMs the DAD further identifies abnormal driving behaviors of the DVUs and flags the DVUs once identified abnormal. Also, in the in-vehicle subsystems in each CV, the CIM detects the conflicts using the real time BSMs. The thresholds and flags are transmitted in the datapath, which is bi-directional in the CV environment. A near-crash warning will be generated once a conflict was detected between two DVUs when at least one of these two DVUs has been flagged as abnormal by the DAD.

2. Research Goals

The purpose of this project was to construct a computational near-crash warning system to identify near-crash events using only the basic safety messages (BSMs) generated by the connected vehicles (CVs).

Due to the tremendous volume and complexity, it is not realistic to store all the BSMs generated in the CV environment into the data centers. Therefore, the research goals of this project were to find out what information needs to be extracted from the BSMs for safety, and determine how to extract it, how to identify abnormal driving behaviors, how to define conflict and near-crash in our system and how to implement these processes.

3. Findings

Through systematic analysis, this project concluded that the information needing to be extracted from the BSMs for safety analysis were the threshold values differentiating the normal and abnormal driving behaviors of each DVU. The means and standard deviations of each selected key performance indicator of each speed bin were the major contents of the threshold panel.

In our system, a conflict was defined as a traffic situation involving a DVU pair which satisfies the following two conditions: (1) at least one driver is under abnormal driving status; (2) the actual distance between the drivers is less or equal to the critical distance.

The ASDSCE was implemented by the Python programming language using the BSM data from the CV pilot studies and it passed the validation process using the crash data from the SHARPII naturalistic driving study.

4. Performance Metrics

Metric	# Completed
OUTPUTS	
Product(s): Number of new or improved tools, technologies, products, methods, practices, and processes created or improved	1
Technical Report: Number of client-based technical reports published	STRIDE Final Report
OUTCOMES	
Body of Knowledge: Number of trainings for transportation professionals	1 (scheduled)
Professionals Trained: Number of professionals participating in trainings	TBD
IMPACTS	
Stakeholders: Number of stakeholders you met with to encourage adoption or implementation of product(s)	1
Adoption/Implementation: Number of incidences outputs of research have been implemented or adopted	0

5. Product

Computational near-crash warning system using only the basic safety messages (BSMs) generated by the connected vehicles (CVs) The system determines the thresholds of normal behavior of each DVU using the periodical historical BSMs, and checks the real time BSMs against the thresholds for anomalies. With the real time BSMs, the system also detects the conflicts between two DVUs. A near-crash warning will be warranted once a conflict was detected between two DVUs while any DVU of the conflicting pair had been determined abnormal. The system can mitigate congestion by reducing crashes through giving near-crash warnings to the drivers using only the BSMs, which is a data source ignored by existing collision warning tools. The system can be used by the department of transportation and automotive makers.

6. Who benefits/will benefit from your product(s)?

- Departments of Transportation
- automotive industry

7. Body of Knowledge & Professionals Trained

A STRIDE webinar is scheduled for October 19, 2022.

8. Stakeholder Engagement

MEETING DETAILS		NARRATIVE DESCRIPTION
STRIDE Rep.	Dr. Shuang Z. Tu, Dr. Robert W. Whalin, Dr. Kejun Wen, Ms. Guojing Hu, Ms. Di Wu	We did a presentation as an overall introduction for our project based on our proposal.
Date of Activity	08/10/2020	
Type of Activity	demonstration	
Location	On-line Zoom meeting	
Stakeholder(s)	Cindy Smith P.E., Research Director, MDOT Marta Charri P.E. Engineer, MDOT	

9. Adoption/Implementation

Departments of Transportation, automotive makers and autonomous vehicle and connected vehicle related research agencies are anticipated to adopt/implement this product.

Beyond this project, this product can be used to enhance commercial in-vehicle traffic safety warning devices.

10. Broader Impacts

This product can improve traffic safety systematically by giving near-crash warnings utilizing only the BSMs in the CV environment, a data source that does not rely on the vehicle's own sensors, such as camera, LIDAR and radar etc. This product can be used as an additional collision warning tool on top of the existing ones. In the case of malfunctioning of the vehicle's own sensors, this product can keep functioning while the others were shut down. The short-term impact would be decreasing the number of traffic accidents, saving lives and property damage. The long-term impact of this product would be improving safety of transportation automation. A continuing research project is ongoing to implement parallel computing to this product.