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

Technology Transfer Final Report

STRIDE Project J3

Identifying and Mitigating Congestion Onset

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October 2022

THE STRIDE CENTER

The STRIDE Center is the 2016 USDOT Region 4 (Southeast) University Transportation Center (UTC) housed at the University of Florida Transportation Institute (UFTI). Our mission is to develop novel strategies for Reducing Congestion. The Center has nine partners, representing seven states in the Southeastern U.S. The UFTI and its partners in the STRIDE Center are recognized leaders at state, regional, national, and international levels. The STRIDE Center is focused on assembling and integrating research projects throughout the region in a way that maximizes contributions to solving current and future transportation problems as well as strengthening expertise and developing new technologies. For more information see https://stride.ce.ufl.edu/.

DISCLAIMER

ACKNOWLEDGEMENT OF SPONSORSHIP AND STAKEHOLDERS

This work was sponsored by a contract from the Southeastern Transportation Research, Innovation, Development and Education Center (STRIDE), a Regional University Transportation Center sponsored by a grant from the U.S. Department of Transportation's University Transportation Centers Program.

1. Project Overview

This project aimed to help transport agencies use "big data" to help mitigate congestion and manage system performance, for both freeways and arterials. Two investigatory objectives were pursued. First, we created and trained algorithms to spot the onset of incidents and recurring congestion, so that system managers could be more responsive. Our hypothesis was that early responses would help reduce the impacts (make the queues shorter, disappear quicker, and create less delay). We 1) fused data such as real time traditional detector data, CV data, and other online information, to produce a significant and consistent data-stream of high volume and high velocity heterogeneous data; and 2) trained algorithms to spot the onset of these events, distinguish between them. Second, we created a performance monitoring algorithm that uses policy-based targets (e.g., speeds of 45 mph or better during congested conditions) and "big data" technology to give agencies a tool they can use to improve the efficacy of their congestion mitigation. We used condition-based policy travel rates to simplify the inference process with an eye toward helping to ensure that performance management focuses on deficiencies whose improvement produces the greatest value. In all these efforts, we produced analysis tools that practitioners can use.

2. Research Goals

The goal was to create tools that can improve the ability of agencies to be 1) faster and more effective in responding to incidents and recurring congestion and 2) more consistent in the quality of service their systems provide. The detection algorithms would be designed to spot the onset of demand-induced congestion (DIC) and incident-induced congestion (IIC). They would enable agencies to respond sooner and take helpful actions, like changing route guidance advisories on freeways and signal timing on arterials. In the case of the performance monitoring algorithm, the aim was to help agencies provide the right resources to the right places at the right time, including changes to operation plans and tactics, to minimize the congestion impacts of recurring congestion and incidents. By predicting actions on performance targets, user expectations can be better managed; agencies can take actions that fix the congestion problems on the portions of the network where the demonstrated need is greatest. The goal of the study was to understand how smartphone navigation apps impact users' trip routing. Objectives were to evaluate (1) trip re-routing potential of route guidance apps, (2) how drivers utilize the information provided, and (3) the impact of traffic re-routing on roadway facility usage, congestion, and prevailing speeds.

3. Findings

The findings from the project were that trends in travel rates and speeds, from both individual vehicles and system detectors, could be used reliably to identify the onset of DIC and the occurrence of IIC. This is beneficial because it means that operating agencies, in real-time can automate the processes of identifying when DIC is about to occur and that IIC has occurred. In the former case, it allows them to begin taking DIC mitigating actions sooner, regardless of when the DIC occurs, so that disruption and delays are reduced. In the latter, it allows them to dispatch appropriate resources more quickly (emergency vehicles, help trucks, etc.) to minimize the impact of the disruption, both for the individuals involved as well as other travelers.

4. Performance Metrics

Metric	# Completed
OUTPUTS	
Product(s): Number of new or improved tools, technologies, products, methods, practices, and processes created or improved	3
Technical Report: Number of client-based technical reports published	1 - STRIDE Final Report
OUTCOMES	
Body of Knowledge: Number of trainings for transportation professionals	1 - STRIDE Webinar
Professionals Trained: Number of professionals participating in trainings	80
IMPACTS	
Stakeholders: Number of stakeholders you met with to encourage adoption or implementation of product(s)	9 (Agencies and municipalities)
Adoption/Implementation: Number of incidences outputs of research have been implemented or adopted	0

5. Products

Onset of Congestion Detector

Based on Bluetooth observations from I-5 in Sacramento, the 5th percentile travel rate (min/mi) is tracked for a subject freeway segment. When the 5th percentile travel rate exceeds a threshold value (0.9 min/mi), a flag is set indicating of demand-induced congestion (DIC) has occurred. When the difference between the 5th and 95th percentile travel rate exceeds a second threshold (0.4 sec/mi), a second flag is set indicating incident-induced congestion (IIC) has occurred, with or without DIC. The method produces no false negatives. (It never determines that DIC has occurred when it has not.) For DICs, the daytime percent of correct positives is 83–86%. For IICs, the percent of correct positives is lower because it is challenging to differentiate between DICs and DICs combined with IICs. The percentage of IIC events that could be more clearly classified is 23%–34%.

Speed-based Traffic State Transition Detector

Based on speed data from Atlanta, GA, this product is an algorithm that clusters system detector speeds into categories based on operating condition and then looks at transitions from one cluster to another to spot both DICs and IICs. The traffic state is characterized by a set of input feature vectors that reflect the lane dynamics and spatio-temporal conditions, and was labeled as belonging to one of the two classes, pre-congestion, and non-pre-congestion. This problem formulation was tested using a set of generative and discriminative Machine Learning (ML) classifiers. The performance of these classifiers was evaluated using balanced accuracy, recall, and precision scores. Initial results demonstrated superior accuracy performance from tree-based classifiers.

Travel Rate-based System State Transition Detector

This algorithm, based on data from Tampa, uses clustering of probe travel rates to do detection of DIC and IIC in a similar manner. The analysis revealed that the traffic states could be successfully classified into six "operating condition" clusters based on speed, standard deviation of speed between vehicles, standard deviation between points, as well as deceleration values. The machine learning-based algorithm achieves good accuracy and precision in predicting breakdowns.

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

Drivers benefit from reduced delays and better system performance. Vehicle occupants may also benefit from improved incident response. Society benefits from fewer resources consumed in transportation.

7. Body of Knowledge & Professionals Trained

1) STRIDE Webinar - Drs. George List, Billy Williams, Michael Hunter, and Mohammed Hadi presented " Detecting and Characterizing Demand and Incident-Induced Congestion" on April 13, 2022. (62 attendees, 59 views on YouTube). Participants in the webinar represented universities, state DOTs, consulting companies. Eleven participants completed an evaluation survey after the webinar. 100% of respondents said the quality of the webinar was either "above average" or "excellent." Similarly, 100% responded that the usefulness of the webinar to them or their organization was either "above average" or "excellent." Recording: https://youtu.be/DKeN3YzPgQE
2) Ishtiak Ahmed, Ahmad Abdallah, George List, and Billy Williams, Detecting and Characterizing Demand and Incident-Induced Congestion, 7th Annual UTC Conference for the Southeastern Region, March 24–25, 2022.
3) Ahmed, I., A. Abdallah, G. List, and B. Williams, "Detecting and Characterizing Demand and Incident-Induced Congestion," *101st Annual Meeting of the Transportation Research Board*, January 9-13, 2022, Washington, DC.
4) Ishtiak Ahmed, Ahmad Abdallah, George List, and Billy Williams, Detecting and Characterizing Demand and Incident-Induced Congestion, *NCDOT Research Summit*, October 6, 2021.

8. Stakeholder Engagement

MEETING DETAILS		NARRATIVE DESCRIPTION
STRIDE persons at meeting	George List, Ishtiak Ahmed, Ahmad Abdalla	Presentation about findings from work to date, especially the algorithms for detecting DIC and IIC. Presentation was well received. Kelly could see the value in the work done and its practical application. She also provided suggestions about people to contact, at INRIX, the CATT Lab, DriveWyze, and WayCare, to see if they might be interested in incorporating our algorithms into their work / products.
Date of Activity	7/12/2021	
Type of Activity	demonstration	
Location	Raleigh, NC	
Stakeholder(s)	Kelly Wells, State Traveler Information Engineer, NCDOT	

STRIDE persons at meeting	George List, Ishtiak Ahmed, and Ahmad Abdalla	Presentation about findings from work to date, especially the algorithms for detecting DIC and IIC. Presentation was well received. Jerry, Tom, and David all saw the value in what we had done. They indicated a willingness to see if they could provide us with data we could use to do similar work for arterials.
Date of Activity	7/30/21	
Type of Activity	demonstration	
Location	Zoom	
Stakeholder(s)	Jerry Jensen, Tom Riley, David Spencer (Town of Cary, NC)	
STRIDE persons at meeting	George List, Ishtiak Ahmed, and Ahmad Abdalla	Presentation about findings from work to date, especially the algorithms for detecting DIC and IIC. Presentation was well received. Terri saw the value in what we had done. She indicated a willingness to connect us with people at Inrix who are working on similar ideas.
Date of Activity	7/30/21	
Type of Activity	demonstration	
Location	Zoom	
Stakeholder(s)	Terri Johnson (Inrix)	
STRIDE persons at meeting	George List, Mohammed Hadi, Angshuman Guin, and other members of the project team	Presentation about findings from work to date, especially the algorithms for detecting DIC and IIC. Presentation was well received. Jim and Tom saw the value in what we had done. We also discussed obtaining arterial data. Jim and Tom expressed a willingness to provide what data they have and to connect us with additional people at NYSDOT Region 4 who might have probe data we could use.
Date of Activity	7/30/21	
Type of Activity	demonstration	
Location	Zoom	
Stakeholder(s)	Jim Pond and Tom Pollack, Monroe County, NY	
STRIDE persons at meeting	George List, Mohammed Hadi, Michael Hunter, Angshuamn Guin, and many other team members	Presentation about findings from work to date, especially the algorithms for detecting DIC and IIC. Presentation was well received. Michael saw the value in what we had done. He indicated a willingness to consider ways to capitalize on what we had done. We also discussed obtaining arterial data. Michael said he would help us see If we can obtain data from some of his supporters, especially municipalities in Massachusetts, who have been receiving probe trajectory data for a while.
Date of Activity	10/1/21	
Type of Activity	demonstration	
Location	Zoom	

Stakeholder(s)	Michael Pack, CATT Lab, UMD	
STRIDE persons at meeting	George List, Ishtiak Ahmed, and Ahmad Abdalla	Presentation about findings from work to date, especially the algorithms for detecting DIC and IIC. Presentation was well received. Then, we explored ways in which Wejo data might be useful to do similar analyses for arterials
Date of Activity	12/13/21	
Type of Activity	demonstration	
Location	Zoom	
Stakeholder(s)	Bethany Haslam, Wejo	

9. Adoption/Implementation

For all three products, there have not been direct adoptions, but the individuals with whom we interacted had takeaway ideas for actions to take based on what was presented. We will continue to seek adopters of the methods, especially in the context of the continuing efforts in Phase 2.

10. Broader Impacts

Transportation Management Agencies can use the information provided by these algorithms to enhance their strategies for active travel demand management and operations to reduce the impacts of congestion and incidents.

Drivers benefit from reduced delays and better system performance. Vehicle occupants may also benefit from improved incident response. Society benefits from fewer resources consumed in transportation.

Reducing delay, through quicker and more focused responses to DIC and IIC events, can have a positive effect on climate change by reducing carbon emissions and heat from operating engines.