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

Technology Transfer Final Report

STRIDE Project A

Impact of Smartphone Applications on Trip Routing and Congestion Management

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1. Project Overview

Part I: Trip Re-routing Potential of Route Guidance Apps (Georgia Institute of Technology Study)

Smartphone navigation applications (apps) such as Google Maps and Waze provide drivers with options to make informed decisions about their route. It is important to understand how these apps affect drivers' behavior as governments invest in variable message signs (VMS) and other Active Transportation and Demand Management (ATDM) strategies. In addition, several communities have attributed disruptions to typical traffic patterns and increased local cut-through traffic to the use of navigation apps.

Part II: Diversion Prediction (Florida International University Study)

When there is congestion due to incidents, drivers seek up-to-date information on traffic conditions and alternative routes. Under these conditions, it is important to estimate driver diversion behaviors to support traffic management plans. For example, under what conditions are drivers likely to take a different route, what is the proportion of the diverted drivers (diversion rate), and which routes are drivers likely to take (diversion route). These behaviors are often predicted using preference surveys. Better estimates can be achieved by the use of traffic data combined with advanced analytics.

Part III: Gating Control Traffic Management Using Decentralized Traveler Information Data (Jackson State University Study)

Emergency evacuation, in response to both natural and man-made disasters, aims to move a large disaster-affected population through a transportation network towards safer areas both quickly and efficiently. Evacuations generally increase traffic congestion and would, therefore, benefit from effective traffic management strategies that seek to reduce congestion.

The Jackson State University led study used decentralized traveler information data to locate potential congestions to be applied with the gating control traffic management strategies to reduce traffic congestions in emergency events. Travel time reliability measures were applied to account for delays and identify significant traffic congestions for potential gate locations in evacuation zones. Performance of the gating control traffic management strategies were evaluated using a case study in Memphis, TN with DTALite program, a simulation based DTA tool.

2. Research Goals

Part I: Trip Re-routing Potential of Route Guidance Apps (Georgia Institute of Technology Study)

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.

Researchers conducted an interview-administered questionnaire (N=237) about preferences and behaviors related to using navigation apps and collected drivers' location data (N=27) that provided

empirical evidence of smartphone routing app usage. The location data consisted of four months of Google Location History (GLH) data, collected before and after the shutdown of a bridge on I-85 in Atlanta, GA as well as one year after the incident for a control period.

Part II: Diversion Prediction (Florida International University Study)

The goal of this study was to develop a more accurate diversion rate prediction method. Using the new method, researchers calculated diversion rates using 1) freeway mainline detector data (volume, speed, and occupancy) combined with incident data (such as lane blockage, location, duration, etc.) along a limited access facility in Florida and 2) on-line survey and face-to-face (in-person) survey responses. The diversion rates from these datasets were then compared.

Part III: Gating Control Traffic Management Using Decentralized Traveler Information Data (Jackson State University Study)

The goal of this study was to address how to use decentralized traveler information to determine potential congestion locations with highly unreliable travel times and identify weak points in urban network to be deployed with gating traffic control strategies to achieve the minimum travel cost in emergency evacuation. The research will contribute to using probe data in design of a traffic control or management strategy and reducing traffic congestion in emergency evacuation.

3. Findings

Part I: Trip Re-routing Potential of Route Guidance Apps (Georgia Institute of Technology Study)

- Users do not use navigation apps uniformly. App users have distinct travel patterns and app usage preferences which may lead to the unequal distribution of road and navigation app usage.
- First time trips (78%) and infrequent trips (74%) are the two most common types of trips for which drivers use apps for directions.
- A 3 to 5-minute time savings was required for users to accept a routing change.
- 46% of respondents used navigation apps for regular commute trips.
- 46% of smartphone app users follow the suggested route for at least 80% to 99% of trips and another 25% of users follow the suggested route for 100% of trips.
- The data collection process resulted in a small sample size of GLH data. Future research could include larger GLH datasets.

Part II: Diversion Prediction (Florida International University Study)

Using the new prediction method, the estimated diversion rate based on mainline detector data ranged from 4% to 22%, depending on the severity (mainly reflecting duration), lane blockage (up to three out of five lanes), and the time of incident occurrence. The estimated diversion rate based on the survey results was up to 40% which is significantly higher than what field observations suggest in this location.

The actual diversion rate is a function of many local conditions such as the availability of alternative routes, travelers' behaviors in the region, and the degree of congestion in the network. The new

method can be used to develop site-specific models for each freeway facility in order to address local variabilities.

The study found evidence that the diversion rate is constrained by the capacity of the signals at the off-ramps, indicating the need for special signal control plans during incidents.

Part III: Gating Control Traffic Management Using Decentralized Traveler Information Data (Jackson State University Study)

The traffic simulations in the case study for the evacuation network in Memphis, TN configured with the gating control strategies using the decentralized traveler information data showed the effectiveness of the gating control traffic management strategies in managing evacuation traffic operations. Specific findings are described below.

1. The gating control traffic management strategies deployed using the decentralized traveler information data, could well reduce congestion for emergency events under extreme weather. The travel time reliability data analysis based on the probe data could catch the dynamic nature of potential congestions and achieve improved performance of average travel time and traffic conflicts in a realistic large-scale evacuation network.
2. According to the average buffer time index results, there was one segment checked during AM peak hours and four segments checked during PM peak hours. Compared to AM peak hours, there was more low travel reliability during PM peak hours. The segments on which the index values were larger than 0.55 during PM peak hours were segment 6 on TN-277 Southbound and segment 10 on Democrat Road Eastbound in Zone I, segment 17 on Getwell Road Southbound in Zone II, and segment 29 on TN-204 Northbound in Zone III. They were identified as the potential traffic congestion locations.
3. Simulation results of the gating traffic management strategies with the realistic large scale evacuation network in fourteen scenarios, showed that all the gating scenarios could achieve better evacuation performance with reduced average travel time than the non-gating strategy could. The smallest average travel time for scenario was from 57.8 minutes with 72.9% improvement at the lowest demand of 286,000 vehicles to 151.2 minutes with 48.0% improvement at the highest demand of 640,000 vehicles. The simulation results also showed that the number of possible traffic conflicts using a gating strategy was always lower than that using the non-gating strategy. The best scenario improved traffic conflicting with 59.9% improvement at 376,000 evacuating vehicles and 63.1% at 64,000 vehicles. The simulation results confirmed that a gating control strategy could improve the evacuation performance by reducing the average travel time and total possible traffic conflicts in evacuation traffic operations in the network.

4. Performance Metrics

Metric	# Completed
OUTPUTS	
Product(s): Number of new or improved tools, technologies, products, methods, practices, and processes created or improved	2
Technical Report: Number of client-based technical reports published	STRIDE Final Report

OUTCOMES	
Body of Knowledge: Number of trainings for transportation professionals	1 (STRIDE Webinar)
Professionals Trained: Number of professionals participating in trainings	88 (32 attendees; 56 YouTube views)
IMPACTS	
Stakeholders: Number of stakeholders you met with to encourage adoption or implementation of product(s)	1 (Georgia Department of Transportation)
Adoption/Implementation: Number of incidences outputs of research have been implemented or adopted	0

5. Products

Part I: Trip Re-routing Potential of Route Guidance Apps (Georgia Institute of Technology Study)

Framework for Collecting Google Location History (GLH) Data

Google Location History (GLH) data is stored in individuals' Google accounts (if they opt in). GLH can provide large sets of historical data in a non-intrusive fashion at a fraction of the cost as compared to instrumenting individual vehicles with dedicated GPS devices.

Researchers developed a web-based interface to receive GLH data from participants. The interface allows the investigator to obtain informed consent from the participants, provides an easy way for the participants to retrieve the necessary data from their Google accounts restricted to the period required by the survey, and a way to securely upload the data to the survey database.

The use of this tool requires participation from volunteers like any other study that involves collection of vehicle trace data. There are potential selection bias issues in obtaining data in this fashion, since the data is available primarily from users of Android smartphones. However, such issues can be resolved by obtaining a large sample of users and using subsequent screening of the data to balance the sample for demographic and other biases.

The software can be accessed on GitHub. (*navigation apps* repository by GTI-GaTech at https://github.com/gti-gatech/navigation_apps)

Part II: Diversion Prediction (Florida International University Study)

Method to Predict Driver Diversion Rates

A new method was developed that predicts the diversion rate based on the incident severity, number of blocked lanes, time of the incident occurrence, and incident locations. The method uses a combination of clustering, cumulative volume analysis, and predictive data analytics.

The clustering analyses was used to categorize the days based on the variations of traffic patterns. Then, the study used a cumulative volume analysis approach to estimate the diversion for each incident, considering the variations in the traffic patterns. Finally, three supervised learning

techniques were used and compared to predict the diversion rates due to the incident. These techniques are linear regression (LR), multilayer perceptron (MLP), and support vector machine (SVM). The MLP model produced the best results.

A limitation is that the method estimates the overall diversion rate and not the diversion at each off-ramp. Most transportation agencies in the United States do not install sensors on the off-ramps. It is recommended that agencies start installing sensors at the off-ramps to allow more detailed examination of the diversion.

Part III: Gating Control Traffic Management Using Decentralized Traveler Information Data (Jackson State University Study)

No product

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

Part I: Trip Re-routing Potential of Route Guidance Apps (Georgia Institute of Technology Study)

Researchers and practitioners who need detailed trip location data to study travel behavior and trip routing.

Part II: Diversion Prediction (Florida International University Study)

- Traffic management agencies
- Drivers

7. Body of Knowledge & Professionals Trained

Part I: Trip Re-routing Potential of Route Guidance Apps (Georgia Institute of Technology Study)

1) STRIDE Webinar - Dr. Angshuman Guin, Georgia Institute of Technology & Mohammed Hadi, Florida International University, presented "Impact of Smartphone Applications on Trip Routing and Congestion Management" on January 29, 2020. (32 attendees; 56 YouTube views) Participants in the webinar represented universities, state DOTs, consulting companies, Seven 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.”

8. Stakeholder Engagement

MEETING DETAILS		NARRATIVE DESCRIPTION
STRIDE rep.	Angshuman Guin	The results of the project were presented at a professional conference, the ITS Georgia Annual meeting on October 7, 2019 in Athens, Georgia. The presentation was very well accepted by the Georgia Department of Transportation Representatives and the consultant community and piqued considerable interest in the results. (http://www.itsga.org/event/2019-annual-meeting-and-exposition/)
Date of Activity	October 7, 2019	
Type of Activity	other - please describe	
Location	Athens, GA	
Stakeholder(s)	GDOT, consultants	

9. Adoption/Implementation

No adoption yet.

10. Broader Impacts

Part I: Trip Re-routing Potential of Route Guidance Apps (Georgia Institute of Technology Study)

This study is one of the first attempts to objectively quantify how drivers respond to navigation apps and rerouting information. Transportation Management Agencies can use this information to determine strategies for active travel demand management and operations to reduce congestion.

Part II: Diversion Prediction (Florida International University Study)

The new method will allow the agencies to predict diversion to alternative routes and then use this information to develop special management plans (such as special signal timing plans) and to activate these plans in real-time operations. This is expected to reduce the impacts on the alternative routes and improve the performance of the diversion process.

Part III: Gating Control Traffic Management Using Decentralized Traveler Information Data (Jackson State University Study)

This study identifies a strategy to help assess network vulnerability, particularly in situations of evacuation during extreme weather and flooding. This study approaches the problem with an effort in time reliability analysis framework, that can help remind the local authorities not only to identify which weak links could lead to recurring congestion to the network, but also to understand how a gating control strategy associated with appropriate traffic management would possibly be deployed at these weak points and improve evacuation performance. Improved long-term and short-term planning can help communities achieve greater resiliency, particularly during emergency situations.