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

Technology Transfer Final Report

STRIDE Project K3

Traffic Congestion Identification and Prediction based on Image Processing and Deep Learning Methods

Robert W. Whalin, Ph.D., P.E.

Jackson State University

December 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

Traffic congestion is a global problem affecting all levels of society. The main reason is that there are too many vehicles on the road network, but with a limited capacity. Drivers cannot always avoid heavy traffic, but, with accurate traffic predictions, they can make safer and smarter route choices. In addition, if the evolution of traffic state over time can be accurately described and predicted, it will also be helpful for the government to develop smarter and sustainable mobility systems to reduce congestion. Therefore, the aim of this project is to present an effective short-term traffic state prediction method.

In this research, a sensor on I-285, one of the most congested and busiest roads in Atlanta, was selected for study. The historical data of the sensor was collected to forecast its future evolution.

In addition to a single sensor, traffic state prediction on the whole road network is also a concern. Thus, 501 sensors among the city of Atlanta were selected for study. Usually, traffic states of the 501 sensors are not isolated, they influence each other. When predicting the network-wide traffic state, it is questionable whether to and how to consider the influence between the sensors. This project applied the graph convolutional technique to mine the spatial relationship of traffic speed on multiple sensors, and then fed the output into the deep learning models to extract the temporal features embedded in the traffic speed.

2. Research Goals

The goal is to develop methodologies that can predict the future traffic conditions based on historical data.

3. Findings

The hybrid model proposed in this project has obvious advantages in efficiency and accuracy when predicting the traffic flow of a single location.

When modeling the road network, its spatial structure needs to be treated with caution. Considering the spatial connection of road network does not always improve the prediction accuracy of road network.

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	2

Professionals Trained: Number of professionals participating in trainings	27
IMPACTS	
Stakeholders: Number of stakeholders you met with to encourage adoption or implementation of product(s)	1 MDOT
Adoption/Implementation: Number of incidences outputs of research have been implemented or adopted	0

5. Product(s)

1) Data processing technique

A data processing technique was created to decompose nonstationary traffic data into stationary components for further study. The technique can be applied and extended to various time-series data, including traffic flow, speed, occupancy, etc.

2) Methodology for short-term traffic flow prediction

A secondary hybrid methodology was developed to forecast the short-term traffic flow of a single sensor. With this method, the prediction accuracy and efficiency were both improved significantly. This method can be used for congestion prediction at key locations.

Additional details: A hybrid CEEMDAN-WPD-Deep ESN deep learning methodology for short-term traffic flow prediction was developed. The methodology can forecast the future real-time traffic flow based on current and past traffic information. The hybrid methodology combines the data decomposition technology with a deep learning architecture to capture the nonstationary nature of traffic data and forecast traffic flow accurately and efficiently. With real-time traffic flow predictions, travelers can make smarter choices to avoid congested roads, and also the government can implement traffic control strategies to ease traffic congestion. Navigation system companies and DOTs can benefit from the methodology.

3) Methodology to predict traffic of a road network

A methodology was innovatively applied to the traffic state prediction of a road network. The superiority of this methodology in predicting network state was verified through experiments. The method can be used for congestion prediction on a large road network.

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

- Road users
- Traffic managers
- Regional planners
- Navigation systems
- Researchers

7. Body of Knowledge & Professionals Trained

1) Online presentation: On August 10, 2020, Dr. Robert Whalin and Ms. Guojing Hu at Jackson State University organized a ZOOM meeting with MDOT researchers. The background, methodology and experimental results of the STRIDE K3 project was presented. Approximately 10 professionals attended.
2) STRIDE webinar: On November 3, 2022, Dr. Robert Whalin and Dr. Guojing Hu at Jackson State University presented a STRIDE webinar "Deep Learning on Traffic State Prediction." The audience was engaged and had some follow-up questions. (17 attendees, 48 YouTube views) Recording: https://youtu.be/HeDmHH-Mmxo.

8. Stakeholder Engagement

MEETING DETAILS		NARRATIVE DESCRIPTION
STRIDE rep.	Dr. Robert Whalin and Ms. Guojing Hu	Dr. Robert Whalin and Ms. Guojing Hu presented the background, methodology and experimental results of the K3 project to the MDOT researchers. (10 attendees)
Date of Activity	August 10, 2020	
Type of Activity	demonstration	
Location	Zoom meeting	
Stakeholder(s)	Ms. Cindy Smith and her colleagues from Mississippi Department of Transportation (MDOT)	

9. Adoption/Implementation

The dissemination of the products of this project through publications and webinars can provide guidance for traffic managers and navigation systems to predict the evolution of congestion. The products were submitted to a journal for publication and are currently in the process of revision.

10. Broader Impacts

The impact of these products will enable navigation systems to predict and display future traffic conditions, based on which road users can optimize their travel arrangements and determine suitable routes. These products also help identify where and when severe congestion will occur, allowing traffic managers to look for solutions to ease congestion, such as optimizing signals and warning drivers to change routes or times. In addition, regional planners can use these results to prioritize their general congestion mitigation efforts.