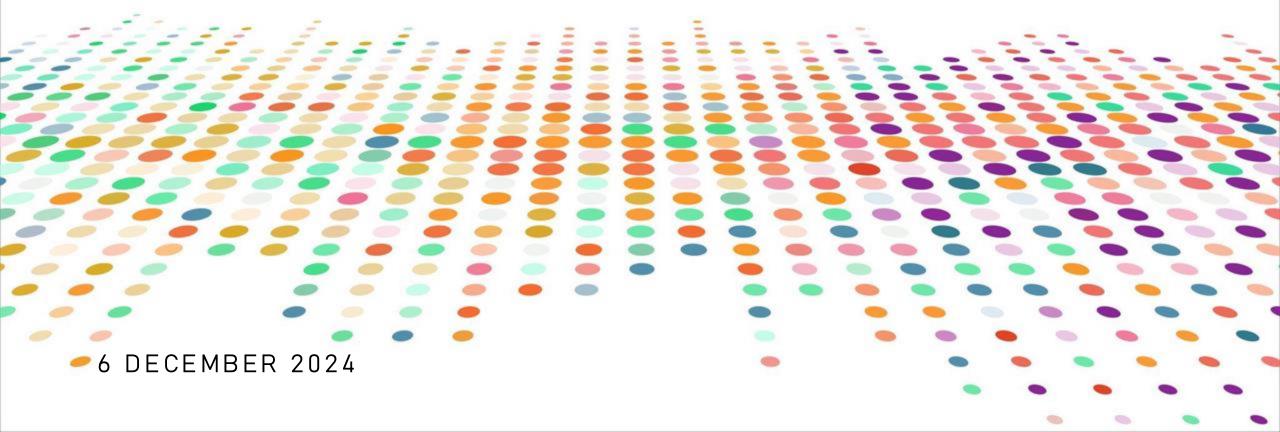
### VDOT Anomaly Detection Capstone



## Stakeholders



Qais Youssef Member



Finn Mokrzycki Member



Bernard Gonzales Member Heman Shakeri Mentor



Chien-Lun Lan VDOT Sponsor

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# Purpose & Background

"This project aims to analyze connected vehicle trajectory data from SmarterRoads, RITIS, and the Virginia Department of Transportation (VDOT) to identify anomalies in roadway networks, focusing on the Staunton, Virginia region. Using machine learning-based techniques, the project will investigate shifts in traffic patterns caused by the installation of new detour signs. By detecting deviations from normal traffic behavior, the project seeks to minimize disruptions and reduce the number of trucks entering city areas due to detours."

### Data

- Data Sources: SmarterRoads.org, INRIX, TMC & XD Road Segments, Probe Speed Dataset, NPMRDS
- Target Variable: Detection of traffic anomalies
- Potential Predictor Variables: Traffic volume, average (mean) and median vehicle speeds, vehicle type, time of day, day of the week, weather conditions, etc.

# Return to Purpose & Background

"This project aims to analyze connected vehicle trajectory data from SmarterRoads, RITIS, and the Virginia Department of Transportation (VDOT) to *identify anomalies in roadway networks, focusing on the Staunton, Virginia region.* Using machine learningbased techniques, the project will *investigate shifts in traffic patterns caused by the installation of new detour signs*. By **detecting deviations from normal traffic behavior**, the project seeks to minimize disruptions and reduce the number of trucks entering *city areas due to detours*."

# Project Plan

identify anomalies in roadway networks, focusing on the Staunton, Virginia region

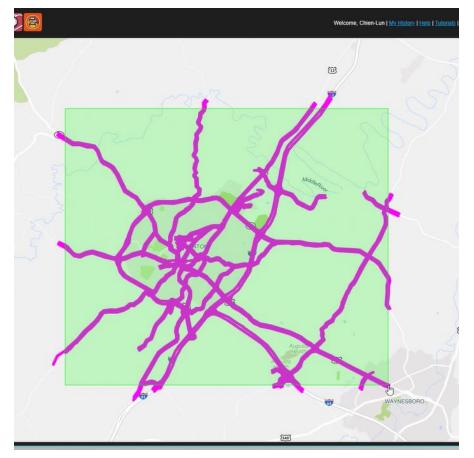
investigate shifts in traffic patterns caused by the installation of new detour signs

detecting deviations from normal traffic behavior

minimize disruptions and reduce the number of trucks entering city areas due to detours

# Project Plan

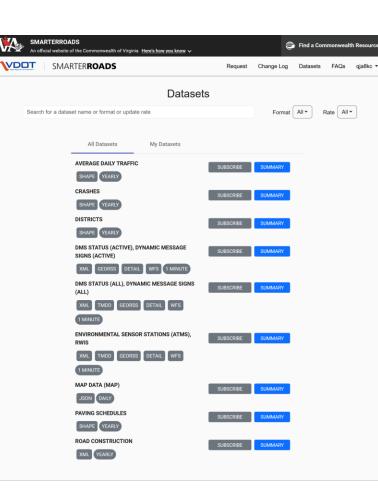
- Data Collection
  - Historic Traffic Volume, Vehicle Count and Speed Stations
  - Detour Sign Locations
  - Anomalies (Crashes, Detours)
- Establish Normal Traffic Behavior
  O Understand Flow Dynamics and Influencers
- Spatiotemporal Modeling for Deviation
  - o Spatiotemporal Graph Neural Networks (ST-GNNs)
  - Validation on Previous Anomaly Data



Map of Staunton, Virginia with roads in bold

# Background Material

- SmarterRoads, INRIX, TMC, XD
- Probe speed dataset
- NPMRDS National Performance Measure Research Dataset
- Virginia Transportation Research Council. (2024). Leveraging connected vehicle trajectory data to improve roadway networks:
- Song, J., Zhang, Y., & Cui, Z. (2021). Traffic anomaly detection: A review of methods and applications. Transportation Research Part C: Emerging Technologies, 129, 103211.
- Liu, L., & Wang, J. (2019). An outlier detection approach based on improved self-organizing feature map clustering algorithm. ResearchGate.
- Djenouri, Y., Belhadi, A., Lin, J., Djenouri, D., & Cano, A. (2019). A Survey on Urban Traffic Anomalies Detection Algorithms. IEEE.



https://smarterroads.org/

#### **IEEE**Access

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#### A Survey on Urban Traffic Anomalies Detection Algorithms

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ABSTRACT This paper reviews the use of outlier detection approaches in urban traffic analysis. We divide existing solutions into two main categorise: (low outlier detection and trajectory outlier detection. The first category groups solutions that detect flow outliers and includes statistical, similarity and pattern mining approaches. The second category contains solutions where the trajectory outliers are derived, including offline processing for trajectory outliers and online processing for sub-trajectory outliers are derived, including offdrawn. Compared to the state-off-heart survey papers, the contribution of this paper lises in providing a deep analysis of all the kinds of representations in urban traffic data, including flow values, segment flow values, trajectories, and sub-trajectories. In this context, we can better understand the intuition, limitations, and penefits of the existing outlier urban traffic detection algorithms. As a result, practitioners can receive some guidance for selecting the most suitable methods for their particular case.

INDEX TERMS Urban traffic analysis, outlier detection, machine learning, data mining.

#### I. INTRODUCTION

Recent advances in high-precision GPS technologies and infrastructure have made our cities smarter. Urban traffic analysis is one of the most attractive applications in a smart (sty [11, 12]. One of the main applications of urban traffic analysis lies in detecting anomalies from the traffic data. A useful way of detecting anomalies in urban traffic data by utilizing outlier detection techniques. An outlier is defined as an observation (or a set of observations) which appears to be inconsistent with the remainder of that set of data [3]. Outlier detection has been intensively studied in recent decades [3]–[8], and an interesting recent survey which reviews existing outlier detection methods can be found

This paper presents a comprehensive overview of the

existing urban traffic outlier detection algorithms. We split

existing approaches into two main categories: flow outlier

detection and trajectory outlier detection. The first one aims

at detecting flow outliers, including statistical, similarity

and pattern mining approaches. The second category aims at

detecting trajectory outliers and includes offline processing

for trajectory outliers and online processing for sub-trajectory

outliers. Solutions in each category are described, illustrated, and discussed, and open perspectives and research tends in this area are depicted. Compared to previous review papers, this paper provides a deep analysis of all kinds of urban traffic applications, including flow values, segment flow values, trajectories, and sub-trajectories. This allows us to clearly understand the merits and limitations of each urban traffic outlier detection algorithm. Consequently, matter solutions could be derived or intelligent transportation engineering.

A. PREVIOUS REVIEW PAPERS

This section summarizes survey papers from the literature that are relevant to this one, clarifies the differences, and makes a position for the contribution of this paper. This survey paper is composed of two main topics: cuttler detection algorithms and urban traffic data mining. In the following section, we review some existing surveys of these topics. Schubert *et al.* [10] introduced the locality notion in identifying outliers. By defining the context function outputs the set of reference objects that are relevant to judging the outliers, and the model function is the sequence

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A Survey on Urban Traffic Anomalies Detection Algorithms

# Potential Concerns

### • Data Access

- $_{\rm O}\,$  Staunton controls its roads, not the VDOT
- Licensing to VDOT Sources
- Possible Rescopes
  - o Limit scope to detour route data, no city data
  - o Model for historic anomaly detection rather than real-time