# Freight Volume Modeling on Major Highway Links

Cyrus Shahabi
Genevieve Giuliano
Luciano Nocera

University of Southern California
shahabi@usc.edu

## Project Objective

The objective of this research is to investigate the feasibility of modeling freight volume information on major highways from existing freight data sources. We would like to study the feasibility of freight traffic modeling from precise and localized but sparse freight data and build machine learning (ML) models that can predict freight volume on highway segments, from which metrics of interest to Caltrans, such as the origin-destination matrix (OD matrix) can be inferred. Most sensors on roadways today can be used to provide input to these algorithms and can provide truck observations, e.g., weight in motion stations (WIMS) and UCI Truck Activity Monitoring System (TAMS). CCTV cameras are also widely available on highways; however, the video feed requires processing to extract the truck observations. Therefore, to leverage existing Caltrans CCTV cameras we also set out to study whether these sensors can be used to detect trucks when processed by state-of-the-art computer vision algorithms.

## Problem Statement

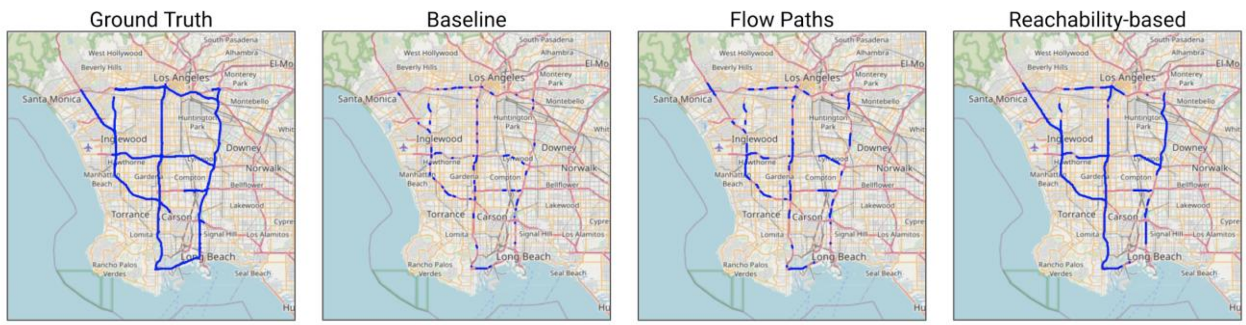
One of the most challenging problems in urban transportation planning is the lack of fine grain data on freight movements. Cities and regions do not know how many trucks operate in the region and have only limited information on freight flows. A particularly important information problem is the absence of a consistent and current source for freight volume and origin-destination data. Without such information, it is difficult to manage or plan for freight in metropolitan areas. This research is aimed at developing a method for generating freight (truck) volume and origin-destination estimations at the traffic analysis zone level from streamed data so that estimations can be constantly updated. Specifically, we seek to learn if it is possible to accurately estimate the time-dependent flow of trucks in a road network and the OD matrix (number of trucks traveling from each origin to each destination) and if feasible what is the most accurate way to do so. The outcomes of this research can provide a valuable tool for transportation planning: a low cost, always current best estimate of freight flows on the highway and arterial systems. This information can be used in various ways, e.g., to examine impacts of e-commerce or changes in spatial patterns of economic activities.

## Research Methodology

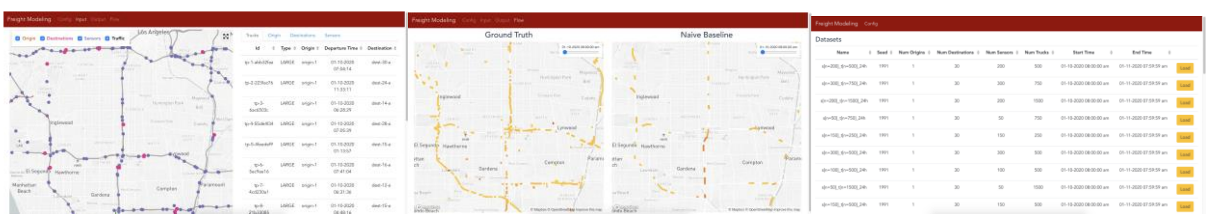
To validate the feasibility and automation of freight volume estimation on links from accurate but sparse data sources (e.g., WIMS, CCTV), we focus on a restricted control area in the Los Angeles metropolitan area where freight volume is most relevant. We considered an area covering approximately 12 square miles around the Ports of Los Angeles and Long Beach for which Caltrans and UCI can provide sensor data. Due to the COVID pandemic collecting data has proven challenging, therefore we modified our research strategy to be able to proceed with limited data by (1) generating synthetic datasets on the area of interest that can be used to train and verify different freight volume estimation models, and (2) leverage existing Caltrans CCTV video footage from public Caltrans feeds to investigate whether cameras can be used to provide truck observations (i.e., timestamp, truck type and truck type confidence). One advantage of this approach is that we will be in a better position to understand what data to collect and how to use the data to validate our work in future studies.

## Results

Our truck simulation software allows us to generate consistent datasets of truck traffic over a highway system during an arbitrary period. Parameters include the number and type of trucks, their departure and destination, the number of sensors and the truck observations at the sensor locations. The simulation software produces truck trajectories and truck observations at the sensor's location that are consistent with traffic conditions that we obtain from historical traffic data collected by our ADMS system. This allows us to generate truck traffic patterns under different traffic conditions and different fleet mixes. Using these simulated datasets, we developed algorithms to estimate truck flow on highway links for different models, including a new reachability-based approach that reconciles truck observations by verifying that the locations observed can be reached when traveled under the existing traffic conditions. We have also created an extension that allows us to compute the OD-matrix. The figure below shows inferred truck volume reconstructed from synthetic data for different approaches.




To display the synthetic data and the results of the predictive models we built a comprehensive dashboard. The dashboard displays the simulation parameters (truck number, type, departure times, origins, destinations, period and sensor locations) the simulated data (truck paths, and truck observations) and predictions (truck flow at the link level, model performance metrics, OD matrix), using maps, tables, and graphs. This analytical dashboard (screenshots below) is a new product that we hope can be useful to Caltrans to utilize our research results and as a planning tool.




Finally, we have collected Caltrans CCTV videos from freely available online feeds and developed computer vision models to identify and classify trucks observed in the videos. For this we defined truck categories that are of interest to Caltrans and that achieve optimal classification performance. For example, we label trucks front and back and consider different labels for pick-up trucks and delivery vans. The following pictures show examples of classification results obtained on single frames extracted from Caltrans CCTV footage.