METRANS Transportation Center USC | CSULB Research Project

Connected Emission Control Technologies for Freight Vehicles

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Problem Statement

Heavy-duty diesel trucks are significant contributors of nitrogen oxides and particulate matter emissions. As a result, areas with a lot of truck traffic often experience elevated levels of diesel-related air pollution. There has been increasing awareness of this environmental justice issue, which has led to the designation of disadvantaged communities in California. At the same time, the emerging connected vehicle (CV) technology, which enables communication between vehicles and infrastructure as well as among vehicles, has led to innovative applications that promise to improve safety, mobility, and sustainability of future transportation systems. To date, there has been much less attention on utilizing CV technology to reduce criteria air pollutant emissions from vehicles, particularly from freight vehicles. New CV applications can be developed to influence the travel routes of freight vehicles in a way that reduces the impact of air pollutant emissions from these vehicles on local residents, especially those living near roadways.

Project Objective

This project explores how CV technology can be used to reduce the impacts of air pollutant emissions from freight vehicles. Specifically, the objective of this project is to develop new vehicle routing algorithms for determining travel routes for heavy-duty diesel trucks (HDDTs) that would reduce the exposure of local residents to air pollutant emissions from these trucks.

Research Methodology

The core of the methodology is to first estimate the total amount of human exposure to pollutant emissions generated by a truck when that truck travels on a particular road segment. Once the estimation is performed for all road segments in a city, the estimated exposure value can be used as the cost in a least cost path algorithm (e.g., Dijkstra's algorithm) to find a travel route that would minimize the total exposure value for the trip. The total exposure value represents how much pollutant generated by the truck is inhaled by local residents. It depends on a number of factors

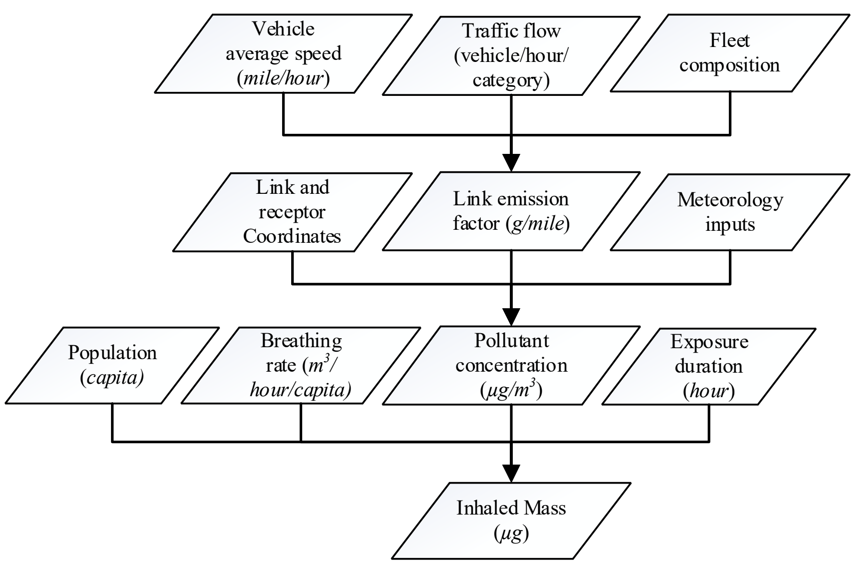


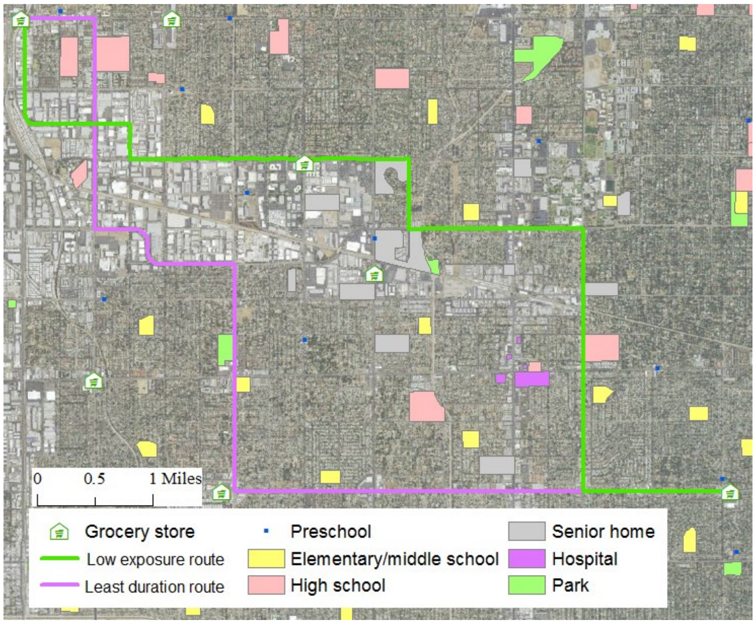
Figure 1. Flowchart of total exposure modeling methodology

such as how much pollutant is emitted from the truck, how far the pollutant is blown away from the road and in which direction, and how many people live/work/play near that road. The estimation of this value involves a modeling chain that goes from traffic activity to emissions production, to air pollutant dispersion, and finally to human exposure (see Figure 1).

To evaluate the potential benefits of this air pollution mitigation strategy, simulation-based experiments were carried out using the Reseda-Northridge area of Southern California as a case study. The area has a road network with a variety of road types (freeways, arterials, collectors, etc.). It also has densely-populated communities with a large fraction of children and seniors who are more sensitive to air pollution. Additionally, several parks, stores, daycare facilities, primary schools, senior centers, and hospitals in this area are located near the roadways. In the evaluation, we simulated 400 different trips traveling from one side of the area to the other sides. For each trip, we determined the fastest route, and also applied the developed algorithm to find the low exposure route. Then, we calculated the differences in travel time, total exposure to fine particulate matter (PM2.5), and total exposure to reactive organic gases (ROG) between the two routes.

Results

The results for an example truck trip are shown in Figure 2. When comparing the low exposure route (green) to the fastest route (pink), the travel time would increase by 3% (~40 seconds) while the total mass of PM2.5 and ROG inhaled by residents in the area would be reduced by 87% and 76%, respectively. This suggests that with a small increase in travel time, the truck taking the low exposure route for this trip instead of the fastest route could lead to a significant reduction in the amount of air pollutant inhaled by the residents.



Route	Travel Time (minutes)	Total PM2.5 Inhaled (υg)	Total ROG Inhaled (υg)
Fastest route (pink)	20.3	588.2	1,238.5
Low exposure route (green)	21.0	74.7	297.3
% change	*3.3*	*-87.3*	*-76.0*

Figure 2. Comparison of low exposure route vs. fastest route

Overall, it was found that as compared to the fastest route, the low exposure route could result in more than 30% reduction in total air pollutant exposure for about 40% of the 400 simulated trips while keeping the increase in trip travel time to no more than 10%. When coupled with clean vehicle technology such as newer diesel engines with lower emissions, a larger reduction in total air pollution exposure can be achieved. This low exposure routing concept is particularly valuable for mitigating the air quality impact of high-emitting vehicles (e.g., HDDTs) in disadvantaged communities as well as near sensitive facilities such as schools and hospitals.