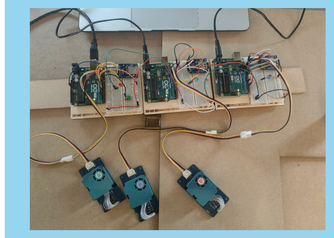
The Impact of Ventilation Systems on Air Quality in Underground Parking Structures

Pascal Yin
Flintridge Sacred Heart Academy
440 St Katherine Drive, La Canada, CA 91011

Project Statement

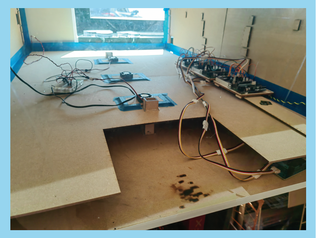
Flexible intake and exhaust systems are commonly used to control air circulation (specifically PM2.5) in parking structures. In a flexible system, each exhaust fan is connected to a sensor to evaluate the local air quality. When air quality reaches a trigger value, the local fan will run. This project will investigate the effectiveness of localized sensors and localized exhaust in keeping air clean in all areas of a one-level garage.

Sensors



An Arduino Uno and Grove - Laser PM2.5 Sensor (HM3301) comprise the air quality detection device. The system is able to detect real-time air quality from three independent sensors and record data onto SD cards. Data from each sensor is synchronized.

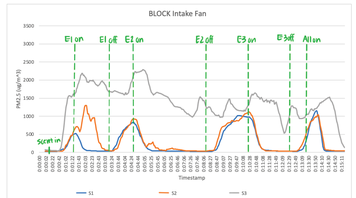
Model

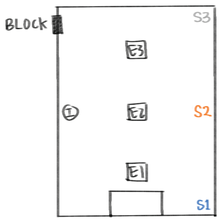


The garage model, made from medium-density fiberboard and acrylic plastic, replicates the layout of a small underground parking facility. It consists of three levels, featuring columns and a flexible sliding layer design. Each level is equipped with three ceiling exhaust fans and two diagonal intake fans to facilitate effective airflow management.

Polluted air distributes unevenly in enclosed spaces and accumulates in the corners

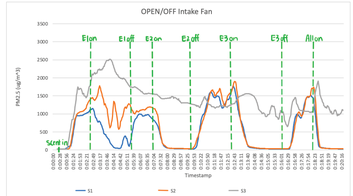
Intake Vent Closed - Fan Off

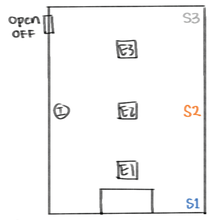




Dead zone near S3 (grey line)

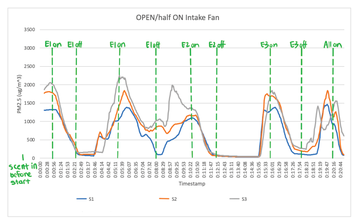
Intake Vent Open - Fan Off





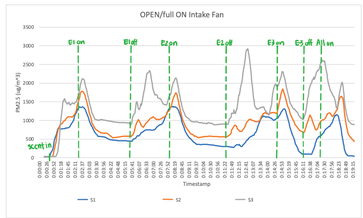
Still, dead zone near S3 (grey line)

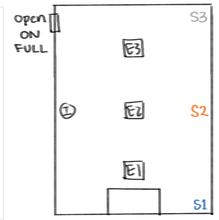
Intake Vent Open - Fan On 50%



All zones get cleared

Intake Vent Open - Fan On 100%





Dead zone at all detecting zone S1, S2, and S3

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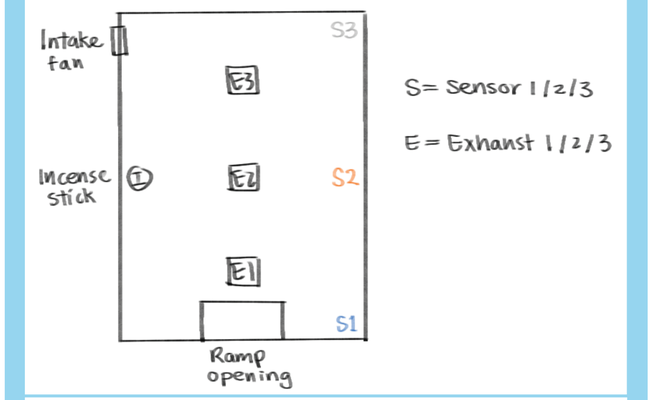
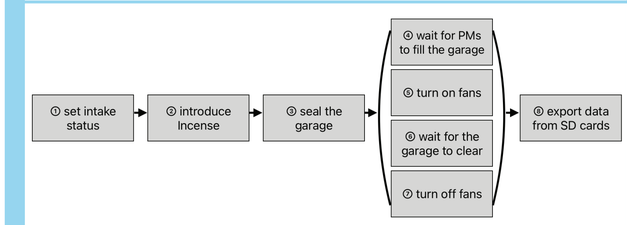
Flow rate for intake and exhaust must match - too much intake or not enough exhaust is ineffective
Corners and edges are most difficult

Methods





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