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# Optimization of low-cost sensor network sensor placement using simulation

MECH 493 Project Description

## Background

Air quality in cities varies both spatially and temporally. A limited number of existing fixed-site air quality monitoring stations fail to capture this variability. A dense network of low-cost air quality sensors can be used to create pollution maps, identify hotspots, drive public policy decision-making, and improve health outcomes attributable to air pollution. However, it is not possible to install and operate sensors in every neighborhood due to limited resources. It is also known that there is a risk of redundant information if sensors are not optimally placed. As part of this project, the student will build an optimization model to determine the minimum number of sensors required to support air quality related decision-making while maximizing coverage area. Different use case scenarios will be tested including air pollution source identification/characterization and exposure estimation. Throughout this process, we will consult Metro Vancouver and focus on best value additions for their existing air quality monitoring network.

## The Project

We aim to minimize the number of sensors required while maximizing coverage area. This problem is commonly referred to as “Node Deployment Scheme” or “Location/Allocation Problem” in Operations Research. Models such as multi-objective optimization, Mixed Integer Linear Programming (MILP), Entropy-based semi-supervised learning (ESSL), and a combination of combined Gaussian Processes (GP) and + Krause’s Optimal Experimental Design (OED) algorithm will be explored.

Most of the above models are based on the sensing error of the deployed nodes and the estimation error of pollution concentration at locations where no sensor is deployed. It is also known that these models are highly sensitive to input parameters and that different models work better for different air pollutants. However, none of the previous studies, to our knowledge, have included factors such as meteorology, the high variability of low-cost sensor data, traffic data sets and planned public policy interventions (which may increase weighting as a good candidate location for sensor deployment). Ultimately, the goal is to create an interactive dashboard or GUI where users can input locations of interest based on these factors and the algorithms will suggest good candidate locations for low-cost sensor deployment.

Students applying for this position should be interested in environmental sustainability, comfortable working with large and complex data sets, and be interested in developing their coding and data analysis skills. Communicating science in a policy context is also an important interest, as we anticipate presenting our findings to the Air Quality and Climate Group at Metro Vancouver, the regulatory authority in the region. Depending on progress, the student may also have the opportunity to publish their results in a peer-reviewed academic journal.

## Facilities and Resources

The student will have space in the iREACH offices to conduct this work if needed, but since this is a computationally-driven project they can work in the location of their choosing. Software will be either Python, MATLAB or R which is either open-source (Python, R) or widely available to all UBC students (MATLAB). The student will meet weekly with Prof. Zimmerman and will also have the opportunity to interact with graduate students within her group on a regular basis.