AQsensor – Air Quality sensing for estimation and control traffic emission

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Outlines

• Introduction
• Project ideas
• Research approach and activities
• Further perspectives
Introduction

• Air pollution is one of the leading causes of mortality worldwide
  • Short-term exposure -> acute respiratory infection etc.
  • Long-term exposure -> lung cancer, heart disease etc.

• Air quality health index (AQHI) is a new tool to report public exposure to air pollutants
  • Obligatory to let the public know the AQ and health risks in EU
  • AQHI is going to be reported from 2021 in Stockholm

• Road traffic emission is dominant source in urban
  • Monitor and estimate traffic air pollutants
  • Design traffic management measures
Project Idea

• Traffic Emission
  • Complicated to estimate (vehicle model, type, engine, exhaust treatment etc.)
  • Impossible to measure directly

• Air Pollution Measurement
  • Precision stations (expensive complicated measurement equipment, big and intrusive)
  • Electrical Chemical Sensor (ECS) has been fast developed as one type of cheap sensors that can be used for Air Pollution Measurement (small, power-efficient, easily form an IoT network with wireless communication)
  • ECS can help intensify the measurement in space and can be potential used for traffic environment studies
Pre-Study

• Sensors installation
  • KTH Campus (hardware and software)
  • E4 - dispersion (2016)
  • E18 – comparison (2017-2018)
Pre-study

- ECS can capture the air pollutant profile but cannot precisely capture the amplitude in many cases
- Each individual ECS will have to be calibrated according to precision equipment
- We applied DL tools to calibrate the ECS sensors, and the suggested process requires some calibration effort (every six months)
Objectives and approaches

- To improve air pollution estimation for road-side emissions using Air Quality data as feedback information;
- To integrate traffic flow model and AQ model as well as AQ measurement in the analysis of traffic-induced emissions at road-sides;
- To apply the integrated model for mitigating traffic emissions by traffic management and control measures.
Methodology: Macroscopic Traffic Flow Model

Consider a homogeneous traffic flow in a road element; according to the conservation law,

\[
\frac{dn(t)}{dt} = Q_a(x, t) - Q_a(x + \Delta x, t) \approx \frac{\partial \rho_a(x, t)}{\partial t} \Delta x
\]

\[
\frac{\partial \rho_a}{\partial t} + \frac{\partial (\rho_a V)}{\partial x} = 0 \quad \text{or} \quad \frac{\partial \rho_a}{\partial t} + \frac{\partial Q_a}{\partial x} = 0
\]
Methodology: Air Pollution Model

- Emission is dispersed along channels
- Each channel is cuboid within which line-source emission from road segment will transport and disperse
- Air pollution dispersion will be described by conservation law in each channel:

\[
\frac{ds_i^p(x_i, t)}{dt} = \phi_i^p(x_i, t) - \psi_i^p(x_i, t) - d_i^p(x_i, t)
\]

inflow outflow dispersion
Case Study on E4S
Further Perspective

- To deliver
  - Integrated computational model for traffic-induced air pollution estimation at roadside (with case of E4S)
  - Design principle for optimal speed limit control that considers air pollution as one objective

- Further perspectives
  - Parallelize the computational code for more efficiency (in collaboration with KTH PDC)
  - Data-driven approach can be used or combined to support traffic and air pollution estimation process (collaboration with SLB)
  - Promote the method for real application in collaboration with public organization