Crowdsourced Air Pollution Monitoring in Saigon (Vietnam) with Low Cost Mobile Sensors

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Air pollution level is very (dangerously) high in Saigon, Vietnam

- AQI (air quality index) can be > 200 on some days
- Typically above 100

Health implications:

- Healthy people may experience slight irritations and sensitive individuals will be slightly affected to a larger extent.
- Children, seniors and individuals with respiratory or heart diseases should reduce sustained and high-intensity outdoor exercises.
Air pollution in Saigon, Vietnam

One single air pollution monitoring station (on the roof of the US embassy)

- Only shows aggregated information (AQI, PM2.5)

Another station is in the National University of HCMC

- Doesn’t work for at least 6 months per year due to maintenance

Price of 1 single monitoring station: £50-100k
Air pollution in Saigon, Vietnam

Question: can we build a cheaper air pollution monitoring system?

Idea 1: low cost sensor based system
- Reliability issues (cheap sensors)
- Sustainability issues
- Requires at least 10k sensors (not very cheap in total)

Idea 2: mobile sensors -> mount them on motorbikes
- 45 million motorbikes in Vietnam (1 motorbike/2 persons)
- New issue: inaccurate readings
Project Plan

Phase 1 – Hardware design:
• Objective: mountable sensor device – cheap, physically durable

Phase 2 – Sensory reading adjustment:
• Objective: Machine learning based data correction

Phase 3 – User participation optimisation:
• Objective: Crowdsourcing based incentive design
Phase 1 – Hardware Design

Objective: mountable sensor device – cheap, physically durable

Tasks:

• Buy/design sensor device
• Design sensor box
• Functionality test
• Data collection system
Phase 1 – Sensor device

Funding: GCRF Institutional Grants (~£10k) in 2017

- Alphasense OPC-N2
- Raspberry Pi 3
- Power adapter (220 VAC - 5VDC)
- Module LTE-4G to Wifi
Phase 1 – Sensor Box
Phase 1 – Scientific Competition

DAAD Falling Walls Labs Scientific Competition

• National 3rd Prize

• Attracted a lot of local news media coverage
Phase 1 – Further Funding

Binh Duong City Council (~10km to North-East of Saigon):

• Grand Challenge: First smart city in Vietnam

• Asked for a demo in June 2018
  • The cost of demo itself was funded by CIoT (~£1.5k)

• Provided 2 billion VND funding (~£80k):
  • Build hundreds of similar sensors to cover Binh Duong City
  • 2 years project
Phase 2 - Sensory Reading Adjustment

Objective: Machine learning based data correction

Tasks:

• ML model to learn sensor reading profile
• ML model to adjust inaccurate readings
• Sensor placement optimisation
Phase 2- Learning Sensory Reading Profile

Data type: time series (dust level)

LSTM: popular deep neural net model (RNN)

Future work: identify outlier readings
Phase 2- Data Reading Adjustment

Heterogeneous sensor network: many cheap sensor + few reliable ones

- Reliable sensors: Alphasense
- Cheap sensors from China

Theoretical models:

- Matteo Venanzi (2013), Alexandros Zenonos (2017) – PhD theses @ Soton
- Ronald Gualan Saavedra (2017) – MSc thesis @ Soton
- Underlying idea: Gaussian Process based accuracy prediction
Phase 2- Sensor Placement Optimisation

Future work:

• Objective: where to put the reliable sensors to minimise the reading error across the network

• Improves performance of the Gaussian Process model

• Submodular maximisation problem -> approximation algs needed

• Potential PhD student from 2019/20
Phase 3- User Participation Optimisation

Objective: Maximise number of participants to cover Saigon’s area

• Idea: use crowdsourcing to recruit participants

• Challenges:
  
  • how to incentivise them to join the system?
  
  • Different cultural patterns -> different incentives

• Ongoing work

  • Tentative plan: apply crowdsourcing app from Soton (Gerding + Stein) to our problem (future work)

  • Promising findings: identified enthusiastic and active communities (expats, students)
Many thanks for your attention!