Drive-by sensing systems for Air Pollution Monitoring

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Background

Air pollution has emerged as a global concern due to the rapid increase in urbanization and industrialization, causing severe health issues such as respiratory disorders and cardiovascular diseases and can increase the mortality risk. The conventional monitoring approach involves deploying multiple fixed air quality monitoring stations throughout the urban area. However, due to high equipment and maintenance costs, the monitoring stations are typically deployed in limited quantities, and consequently, spatial interpolation models are employed to approximate air quality values at unsampled locations.

Recently, drive-by sensing systems have emerged as a promising approach for air quality monitoring, utilising taxis, buses, trams, and other vehicles as mobile sensing platforms. Compared to fixed stations, mobile sensors can serve vast geographical areas and provide high-resolution data using a relatively low number of low-cost devices. For example, Breathe London project used two Google Street cars equipped with air pollution sensors to collect unprecedented amount of data over about a year [2]. At the same time, drive-by sensing has introduced a range of novel research challenges in terms of spatio-temporal coverage, sensor deployment and calibration. In particular, the low-cost sensors require periodic calibration to ensure the accuracy and integrity of the sensed data. However, the research on the calibration of bus-mounted sensors is currently limited. The open questions include the optimal locations of reference stations given the actual bus routes and schedules, trade-offs between calibration and coverage [3], and exploiting the overlapping nature of bus routes for cross-checking individual bus readings and mutual sensor calibration.

Programme

The aim of this PhD is to investigate air pollution monitoring using vehicles such as busses, taxis, and UAVs as mobile sensing platforms. The programme is a rich blend of theory, data analysis and experimentation and has the following milestones:

i. report of prior art (6 months)
ii. analysis of candidate solutions and progression point 1 report (8 months)
iii. results from performance modelling and progression point 2 report (19 months)
iv. experimentation and data analysis using suitable datasets (30 months) and thesis submission (36 months)

Impact potential

The researcher is encouraged to publish in leading academic journals. Examples relevant to this programme of study are IEEE Transactions on Vehicular Technology, IEEE Transactions on Intelligent Transportation Systems, IEEE Sensors Journal and Elsevier Communications.

References

[1] H. Zarrar and V. Dyo, "Drive-by Air Pollution Sensing Systems: Challenges and Future Directions," in IEEE Sensors Journal, vol. 23, no. 19, pp. 23692-23703, 1 Oct.1, 2023, doi: 10.1109/JSEN.2023.3305779.

[2] Padilla LE, Ma GQ, Peters D, Dupuy-Todd M, Forsyth E, Stidworthy A, Mills J, Bell S, Hayward I, Coppin G, Moore K. New methods to derive street-scale spatial patterns of air pollution from mobile monitoring. Atmospheric Environment. 2022 Feb 1;270:118851.

[3] Ali, J. and Dyo, V. (2017). Coverage and Mobile Sensor Placement for Vehicles on Predetermined Routes: A Greedy Heuristic Approach. In Proceedings of the 14th International Joint Conference on e-Business and Telecommunications (ICETE 2017) - WINSYS; ISBN 978-989-758-261-5; ISSN 2184-3236, SciTePress, pages 83-88. DOI: 10.5220/0006469800830088