



OpenSense

OPEN SENSOR NETWORKS FOR AIR QUALITY MONITORING



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What it's about...

Providing accurate, real-time information about air quality to users interested in health and environmental issues by using low-cost, mobile sensors.

Context and project goals

Mobile communications and inexpensive embedded sensors open new opportunities in terms of environmental monitoring, such as air quality. However, the impact of doing such measurements on a massive scale, with uncontrolled mobility and end user involvement is not well understood nowadays. This poses novel challenges in terms of system architecture, distributed algorithms and data analysis that are addressed in this project.

How the project differentiates from similar competition in the field

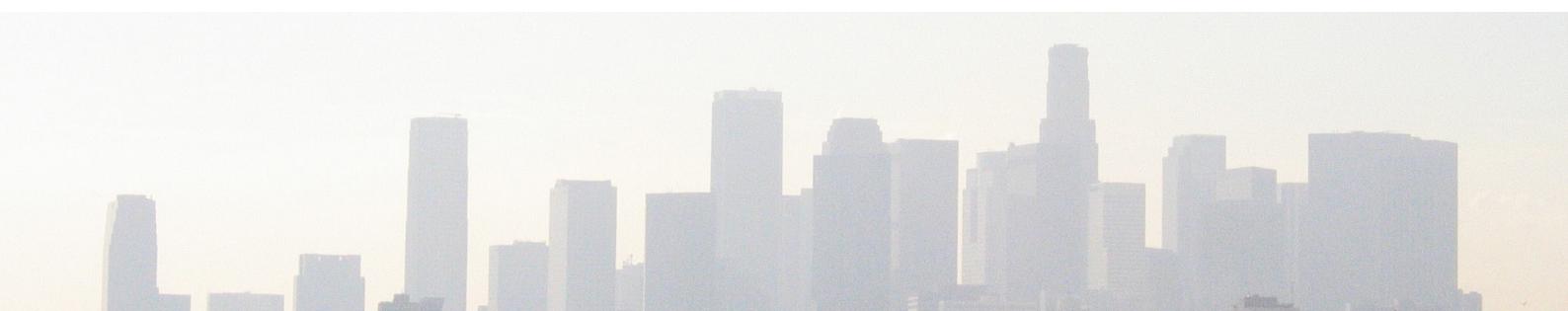
- OpenSense is quite unique in terms of producing dense measurements in the domain of air pollution monitoring using mobile measurement stations and aiming at long-term measurements.
- OpenSense deals with a difficult measurement problem (as compared to other participatory sensing projects that use readily available data, e.g. from smartphones such as sound, accelerometer and GPS data).
- OpenSense is unique in adopting an end-to-end systems perspective assembling IT expertise concerning all system layers, whereas comparable projects usually focus on specific sub-problems.

Quick summary of the project status and key results

The full sensor deployment was completed for the city of Zürich, with ten sensor boxes on top of trams monitoring a wide range of pollutants on an area of 100 km². The deployment in Lausanne, has also generated useful data with only a few nodes and different prototype versions. The finalized deployment (12 nodes in total, including ten on buses and one on an electrical car) is currently been deployed in Lausanne. Nodes in both deployments share similarities in sensing modalities, but show complementary design choices in terms of computation, localization, and flow pre-processing.

Techniques have been developed for ensuring quality and trust in the huge amount of data generated by the mobile sensors. Different modeling methods were explored and improved to be able to produce high quality and fine-grained pollution maps, such as region-based Gaussian models or land use regression models.

Sensor placement and scheduling was also optimized for reducing duplicates and correlated measurements, thus improving resource usage of the sensing nodes. But the vicinity of sensors can also be leveraged for calibration and, based on the new concept of Rendezvous Graph, a calibration and faulty sensor detection scheme was developed.



Success stories

- The OpenSense Zurich deployment was presented at the IoT Zurich Walkshop. A City WalkShop is a short engaging activity to involve people in the physical world of a city, to observe and to document where the digital world is sensing our presence and our environment while we are part of it (<http://zurich.walkshop.org>).
- The OpenSense video presentation won the second best prize at the Nano-Tera annual meeting 2013 in Bern.
- Samsung Research (Palo Alto) granted to the group of K. Aberer a 1 year award to continue research on activity recognition originated in the OpenSense project.
- Citroën Switzerland and the Transportation Center at EPFL donated a C-zero electrical vehicle to the group of A. Martinoli to extend the mobility of the sensor network in Lausanne and explore opportunities of private vehicle involvement in the follow-up project OpenSense II.

Presence in the media:

The mobile application used for the user study in Zürich generated some interest from the press:

- 24Heures (12.03.2013)
- Le Temps (12.03.2013)
- Netzwoche (05.2013)

Main publications

Karl Aberer, Saket Sathe, Dipanjan Chakraborty, Alcherio Martinoli, Guillermo Barrenetxea, Boi Faltings, Lothar Thiele, OpenSense: Open Community Driven Sensing of Environment, ACM SIGSPATIAL International Workshop on GeoStreaming (IWGS) 2010 (along with GIS 2010)

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S. Sathe, H. Jeung and K. Aberer, Creating Probabilistic Databases from Imprecise Time-Series Data, Proceedings of the IEEE International Conference on Data Engineering (ICDE), 2011.

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S. Sathe, T. G. Papaioannou, H. Y. Jeung and K. Aberer, A Survey of Techniques for Model-based Sensor Data Acquisition and Management, MANAGING AND MINING SENSOR DATA (C. Aggarwal ed.), Springer, 2012 (book chapter).

Sebastian Cartier, Saket Sathe, Dipanjan Chakraborty and Karl Aberer, ConDense: Managing data in community-driven mobile geosensor networks, 9th Annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), Seoul, Korea (June 2012).

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M. Riahi, T. G. Papaioannou, I. Trummer and K. Aberer, Utility-driven Data Acquisition in Participatory Sensing, 16th International Conference on Extending Database Technology (EDBT), Genoa, Italy (2013)

S. Sathe and K. Aberer, A FFINITY: Efficiently Querying Statistical Measures on Time-Series Data, ICDE, Brisbane, Australia (2013)

Bratislav Predic, Zhixian Yan, Julien Eberle, Dragan Stojanovic, Karl Aberer, ExposureSense: Integrating Daily Activities with Air Quality using Mobile Participatory Sensing, Pervasive Computing and Communications Workshops (PERCOM Workshops), IEEE International Conference on, pp.303,305, March 2013

Tian Guo, Thanasis G. Papaioannou and Karl Aberer, Model-view Sensor Data Management in the Cloud, Proceedings of IEEE International Conference on Big Data (2013)

