CHALLENGES AND APPROACHES FOR LOW-COST PARTICULATE MATTER SENSING IN SMART CITIES

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Particulate Matter (PM) sensing is important, as medical science has revealed severe health effects and society develops an increasing awareness. Around the world, the permitted PM mass concentration is regulated. Standard gravimetric measurement provides accurate 24-h-means (μg/m^3), but stations are large, static and expensive. Enabling real-time capable, distributed dust sensing entails several challenges, chief among them *Instrumentation*, *Coverage*, *Intelligence*, *Calibration* and *Incentivation*. Additionally, while a technique may be suitable for a controlled sensor network, it may not work for other approaches, such as *Participatory Sensing (PS)*, which by involving citizens in the data collection can enable sensing at a much larger scale.

Alternative PM **Instrumentation** has become available, most of which uses laser scattering to enable mobile real-time measurements. Example projects using such devices are the tram-based *OpenSense* in Zurich, Switzerland, and the *Aeroflex* bicycles in Antwerp, Belgium. However, for large-scale scenarios, such devices are still too bulky and expensive. Low-cost commercial off-the-shelf (COTS) particle sensors are suitable for large distributed applications, provided they are frequently calibrated and their data is processed intelligently. Such **Intelligence** is strongly related to the aspects of **Coverage** and **Calibration**. While not as large an issue in controlled scenarios, PS campaigns or vehicular networks require suitable algorithms to ensure data quality. *CabSense* in Shenzen, China e.g. employs a sparse signal reconstruction algorithm, which allows the creation of pollution maps from few noisy samples. We also propose cross-calibration to calibrate COTS sensors - both with or without reference equipment - for the use in volatile sensing scenarios. Finally, **Incentivation** is an important aspect in scenarios involving participation. Within the first day of the recently started *PiMi* project in Beijing, China, over 500 people applied for a *PiMi* box (cheap, networked indoor air quality monitor). This shows both a large social attention and intrinsic motivation. To maintain high motivation, we propose adding extrinsic incentives using Gamification elements.

We expect that a system addressing the presented challenges in a combined, holistic approach would be most suitable for low-cost, distributed PM sensing: Motivated citizens traversing the smart city they live in operate cheap mobile instrumentation, the data of which is intelligently combined to ensure high data quality and coverage.

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