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Mapping urban air quality in real-time: Applications of crowdsourced microsensor data

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Recent advances in sensor technology have enabled the construction of small and low-cost platforms for measuring various parameters related to air quality. These platforms are ideally suited to be used within a crowdsourcing or citizen science framework. Due to their small size and lower cost, such devices can be deployed throughout the urban environment at much higher density than what is feasible with traditional air quality monitoring stations equipped with reference instruments. A large network of such low-cost sensors is thus capable of providing significantly more detail regarding the spatial distribution of air pollutants in the environment. However, despite the increased deployment density, such sensor networks continue to require additional information for producing spatially exhaustive maps of air quality throughout the urban environment.

We present here our recent work on mapping real-time urban air quality by combining crowdsourced observations from the recent generation of low-cost air quality sensors with time-invariant data from local-scale dispersion model. The approach is based on geostatistical data fusion, which allows for combining observations with model data in a mathematically objective way and therefore provides a means of adding value to both the observations and the model. The observations are improved by filling spatio-temporal gaps in the data and the model is improved by constraining it with observations. The model further provides detailed spatial patterns in areas where no observations are available. As such, data fusion of observations from high-density low-cost sensor networks together with air quality models can contribute to significantly improving urban-scale air quality mapping. We have implemented the methodology to run in near-real time in several locations throughout Europe and focus here primarily on results obtained for mapping nitrogen dioxide (NO_2) in the city of Oslo, Norway.

The results indicate that using a crowdsourced network of low-cost microsensors in conjunction with model information is able to provide realistic high-resolution maps of urban air quality. Comparisons with observations made at air quality monitoring stations equipped with reference instruments show that the resulting maps are able to replicate the average true NO_2 measurements with a root mean squared error of 14.3 $\mu g/m^3$ and an R^2 value of 0.89. In addition, we show that the resulting maps are able to replicate the typical bi-modal diurnal cycle related to traffic emissions.

Detailed urban air quality maps such as those derived from data fusion techniques can then further be used for providing personalized information about air quality to the citizens. We present examples of how this kind of real-time data allows end users to find the currently least polluted route through a city or to track their individual personal exposure to air pollutants while moving through the urban environment.