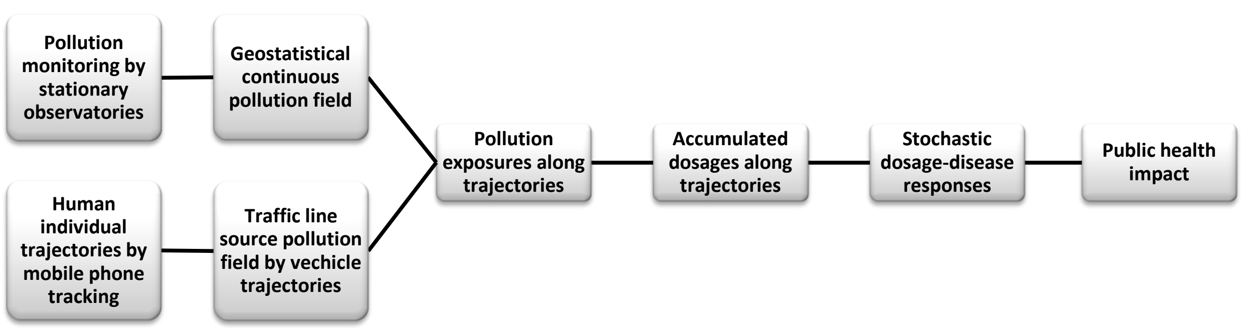
A validation study: estimation of personal air pollution exposure based on aggregating individual citizen mobile phone trajectories in roadway networks

Traffic is the largest source of air pollution in European cities. Cities all around the world grow faster than roadway capacity with increasing congestion and air pollution. How do traffic and roadway emissions affect health for populations living, working, or going to school near roads and the traveling citizens on the road? What are the best policies/regulations to obtain better air quality on short and long term?

To answer such questions one may measure real-time exposure of each citizen by large scale implementation of wireless citizen's observatories (Oslo-Haifa case study in this project), or alternatively and rely on monitored pollution data and use GPS devices to monitor the whole population. However, neither of these approaches is economically feasible for population scale urban studies, e.g. involving 1–10 million citizens. Instead we propose to use low cost existing mobile phone data to obtain population scale individual trajectories to estimate traffic pollution source-exposure-dose-response for the urban populations and thereby enable effective participation of nearly all citizens. The aim of this study is to validate the concept of using mobile phone trajectory based air pollution exposure-dose for urban populations. Our primary choice is Oslo, but other cities may be considered, depending of feasibility.

The use of mobile phone data for public mobility research emerged from network physics (Barabasi and Albert, 1999, 2002, Song et al., 2010). Health InfoScape from MIT Senseable Cities and GE aims to create new ways of understanding human health in the United States. By analyzing data from over 7.2 million anonymized electronic medical records, taken from across the country, they seek to uncover statistical relationships between space, geography and health. In the future one may couple anonymized individual exposure-dose trajectories and responses in electronic medical records.

The architecture of this study is illustrated below:



In the following we will establish a causal chain that differs from the traditional near roadway air pollution research (USA, EPA, http://www.epa.gov/AMD/HumanHealth/nearRoadway.html). We attempt to calculate the real-time traffic pollution from the trajectories of individual vehicles of different pollution type. If feasible, vehicle identification is done as follows: 1) identify public transportation by routes and stopping pattern; 2) identify trucks by long range driving pattern, and 3) identify commuters by their repetitive driving patterns between suburb and city. Unidentified vehicle types may stochastically draw a vehicle type from a known vehicle distribution of city/country.

OSPM (Operational Street Pollution Model) (Berkowicz 2000) or a fast analytic Gaussian plume line source solution (Emad *et al.*, 2010) will be used to estimate the traffic air quality level. Both models require input data on traffic for the individual street in question, street configuration data, emission factors, urban background concentration data and meteorological data. An air emission factor is assigned for each vehicle and pollutant type, including emission factor for idle engine to calculate traffic jam emission. The average vehicle speed in a road segment is needed for calculating emission rate, and it is readily calculated from trajectory data, ($\Delta x, \Delta y, \Delta t$), and terrain, Δz. Based on this, we think a real-time pollution field can be estimated by trajectory data.

To support collection of human individual trajectories, a system will be developed for tracking people by their mobile phone. Accurate mobile phone algorithms have been developed (Thiragarajan, 2011) and companies providing mobile phone based vehicle trajectory services will be contacted: ITIS Holdings, Cellint, Airsage and Intelligent Mechatronic Systems Inc (IMS) powered by Urban Informatics Corporation (UIC) (UIC provides a real-time demo showing the traffic situation in Toronto). Mobile phone service providers, such as Telenor in Norway, will also be contacted.

Exposure is readily collected along citizen’s trajectories on the roadway network. Stationary locations such as home, kindergarten, school and work can be identified and accounted for separately. The disease response can be stochastically estimated by the estimated dose. One expected outcome of more detailed information is that the roadway network pollution source field is likely to be more heterogeneous in space and time than believed today. Particulary exposed groups of individuals with a common exposure trajectories may be identified. If the pollution field is more heterogeneous, these groups may have several times higher exposure than average. New knowledge on the individual based causal chain will eventually lead to new models to calcualte impact of air pollution on public health.

Privacy issues are important, so we may need to distinguish between large anonymized population scale data and citizens that receive personalized pollution exposure trajectories (Gianotti and Pedreschi, 2010). Aggregating all individual responses we will establishe a system to predict the impact of traffic air pollution on public health. Based on this system we may simulate effects of mitigating actions to reduce air pollution. We believe that individual trajectory based systems have a huge global potential due to: low cost, effortless individual participation, scalability to the global population of mobile phone users, new network-based public health research and environmental knowledge based business opportnities. It may open a new paradigm of understanding and optimizing urban dynamics and new perspectives in public health research.

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Traffic engineering companies providing mobile phone vehicle trajectory data:

- ITIS Holdings
- Cellint
- Airsage
- Intelligent Mechatronic Systems Inc
- Urban Informatics Corporation