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A computational framework for personal multi-exposure assessment using space-time activity and socio-economic data

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The construction of simulation models for personal exposure analysis requires the integration of field-based data representing spatially distributed values (e.g. air pollution, noise, temperatures), agent-based data (e.g. daily activities, residential and work locations) and socio-economic data (e.g. age, social economic status, mode of commute) to fully cover the space-time activity patterns of cohort participants. In addition, evaluating the associated uncertainty is necessary as potentially not all required input variables are known.

We developed a modelling framework implemented in Python providing modules for 1) the specification of agents' activity diaries including the durations of activities and their spatial contexts, i.e. the location of a person during that activity, commute trips between residential and work location are thereby routed using OpenStreetMap data; 2) incorporating multiple environmental factors potentially on different temporal and spatial scales; 3) personal exposure assessment by calculating, for each time step and environmental factor, average exposure values within the spatial contexts. The modules can be combined in a Python script for exposure assessment of all agents in a cohort, including Monte Carlo simulations.

We show results from a modelling study conducted for the province of Utrecht, the Netherlands. The study area covers about 500000 residential address locations covering urban and rural areas. We used cadastral and census data to define characteristic diurnal activity profiles describing different characteristics such as social economic status and commute type (e.g. car, bicycle, on foot). We calculated individual exposures to NO_2, $PM_{2.5}$ and noise in Monte Carlo mode and demonstrate the spatial variability of exposures per activity profile and the associated uncertainty. The personal exposures for commuter profiles show more contrast across addresses compared to the homemaker profiles.

Our activity-based mobility simulation provides a representative description of space-time activities of individuals. The calculated personal exposures can be used for further epidemiological

analysis to investigate the relationship between air pollution exposure and chronic diseases such as diabetes or cardiovascular disease.