GPS-based time-activity classification for personal exposure to air pollutant concentrations

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     - accumulated health outcomes in longitudinal studies

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     - potential autocorrelation in space and time

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2. assess uncertainty in the exposure estimates due to estimated time-activity patterns.

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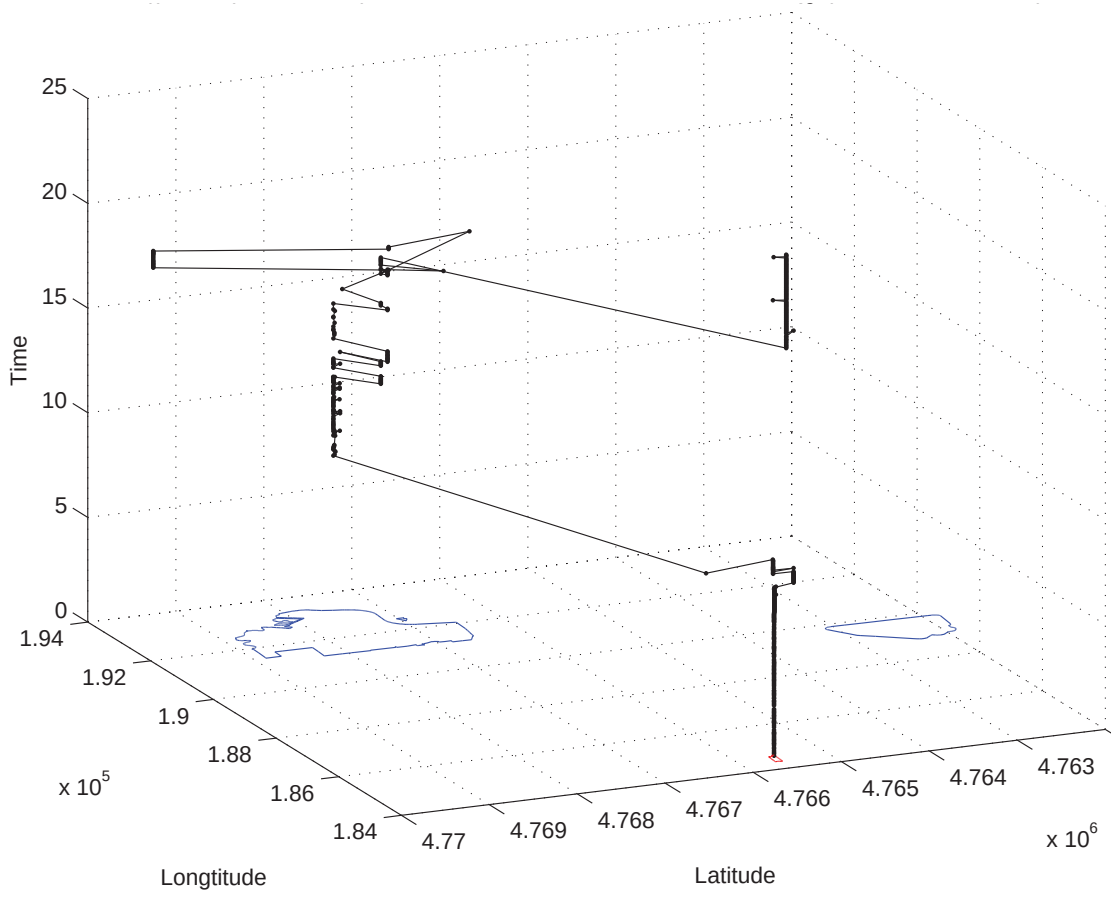
Input Data

- Travel diary

ID	Date	StartTime	EndTime	Location	Address	City	State
A009	1/27/12	0:01:00	11:15:00	Home	406 Linwood Avenue	Buffalo	New York
A009	1/27/12	11:35:00	23:59:59	Home	406 Linwood Avenue	Buffalo	New York
A009	1/29/12	0:01:00	9:55:00	friend	130 Emerson Drive	Amherst	New York
A009	1/29/12	9:55:00	10:09:00	in-vehicle			
A009	1/29/12	10:10:00	10:25:00	Home	406 Linwood Avenue	Buffalo	New York
A009	1/29/12	10:35:00	11:25:0				

- Baseline questionnaire: age, gender, occupation, …
- Time-location information from a smartphone app.



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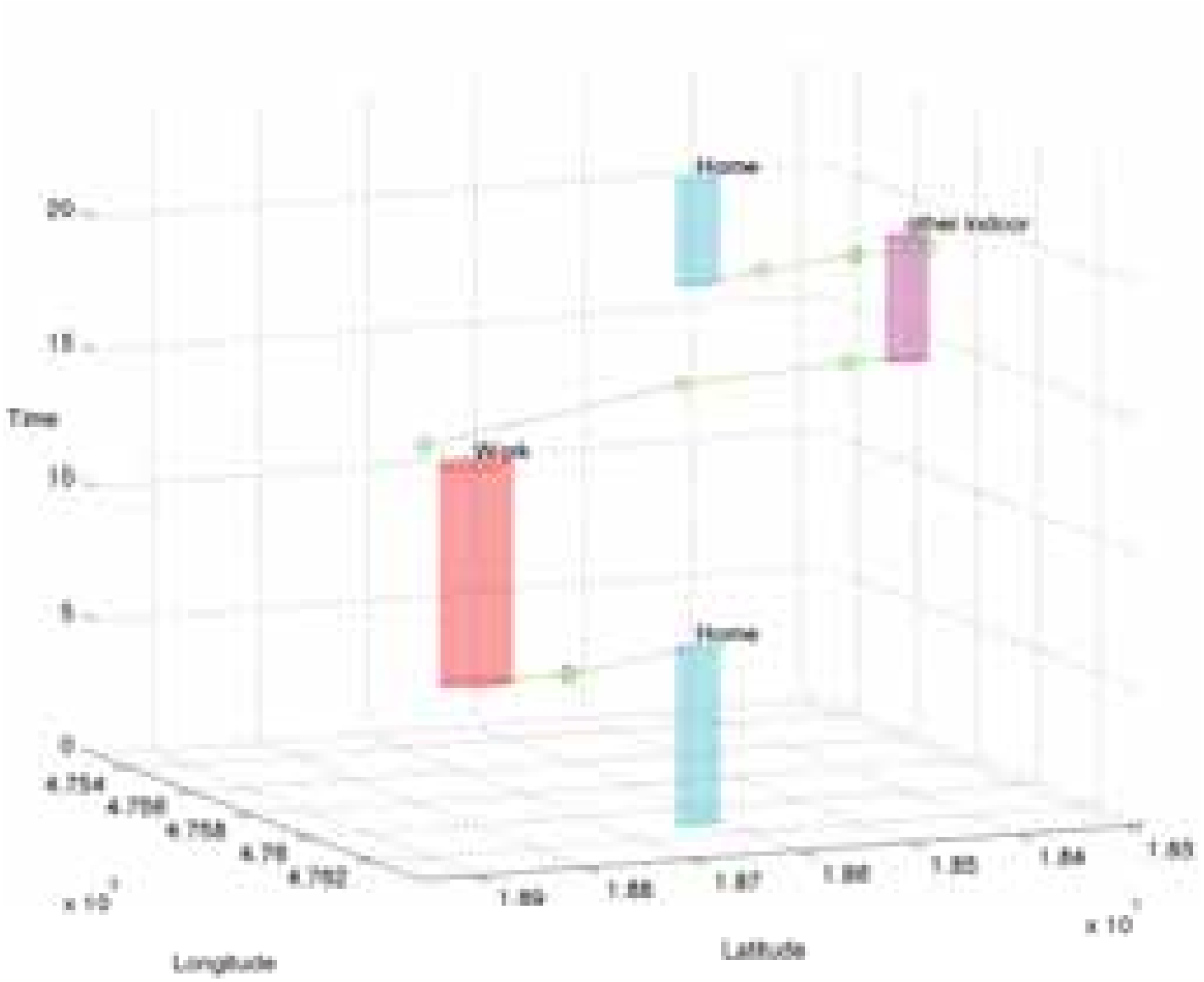
   - extend the search after dark by overlaying with GPS points with home clusters.

Rule-based classification algorithm, cont.

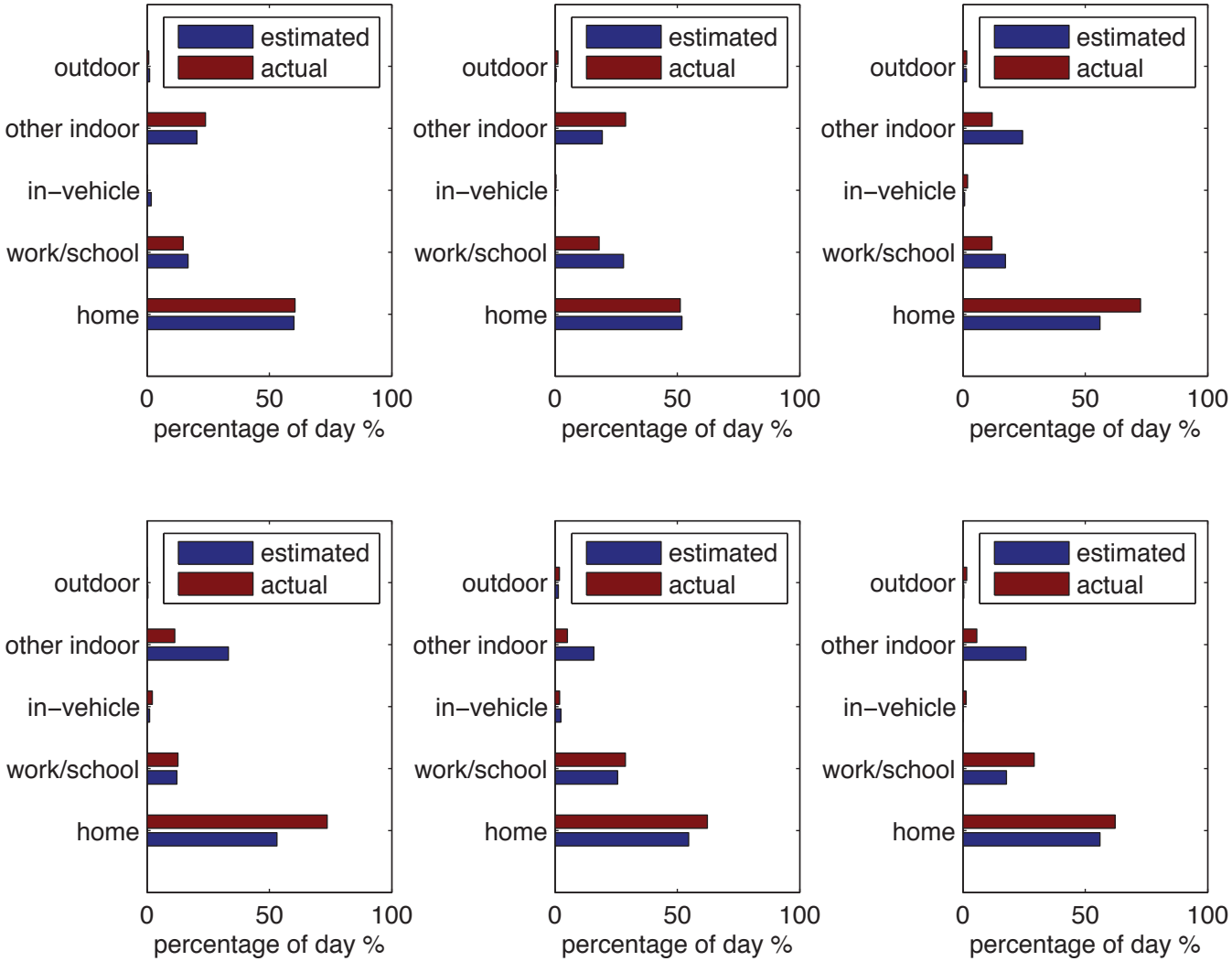
3. work place: there are students who live near or on campus.
   - any point is located within 1 km from the work place address.
   - any point located within the boundary of work places, such as school boundaries.
4. outdoor: any point belong to the known boundary of outdoor space, such as parks, playground, and vacant lands (delineated from GIS parcel map).
5. in-vehicle: based on the travel distance between two consecutive GPS recordings and the speed.
   - any pair of consecutive points with speed 15 mph and their travel distance per minute is $\geq$ 0.8 km.
   - any point in-transit between two different MEs when the speed is $>$ 10 mph.
6. other indoor: a spatiotemporal cluster of GPS points that do not belong to home, work place, nor in-transit.

Estimated time-activity patterns



Performance evaluation

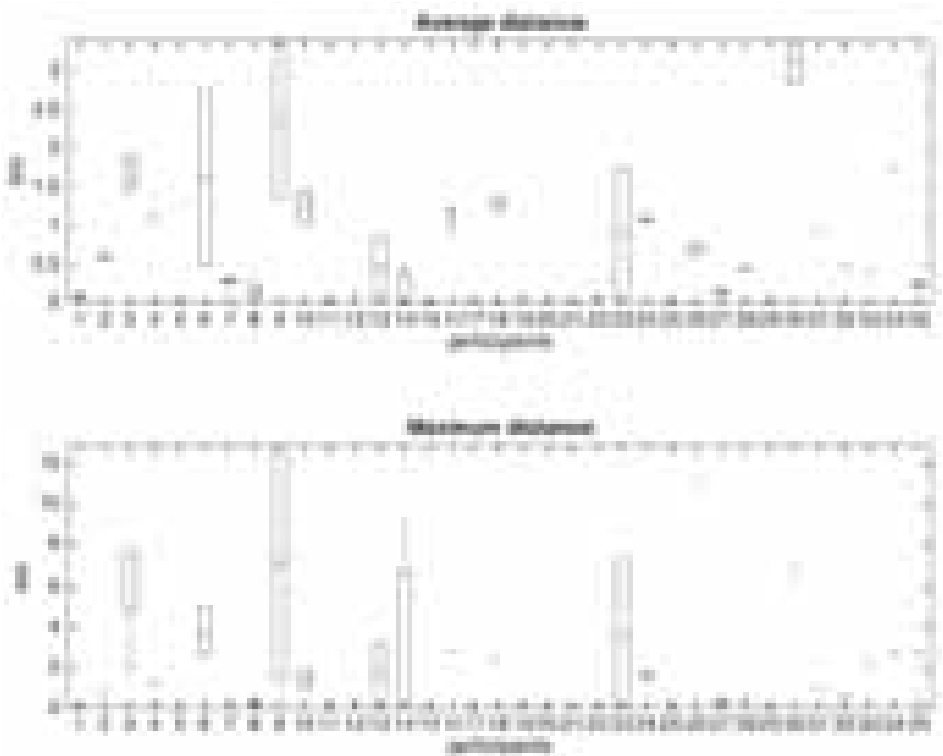
- comparison of GPS-based classification outputs (into five categories) with travel diaries
- on three randomly assigned days in weekend and weekday



Spatial discrepancy between GPS points and diary at darkness

Travel dairies vs. GPS spatial errors at darkness (12:00 to 6:00 am)

- a total of 35 participants with matching GPS records (a total of 70 days)
- 51% of participants have two days of records (1 to 4 days)
- 90 % of participants reported one time-activity record
- spatial errors: difference between GPS recordings and some known places (home, other indoor, work place) from travel diary/questionnaire.
  - average mean distance 0.67 km (up to 3.4 km)
  - average maximum distance 1.9 km (up to 13 km).



Uncertainty propagation in personal exposure assessment

large spatial discrepancy between DTA and GPS points

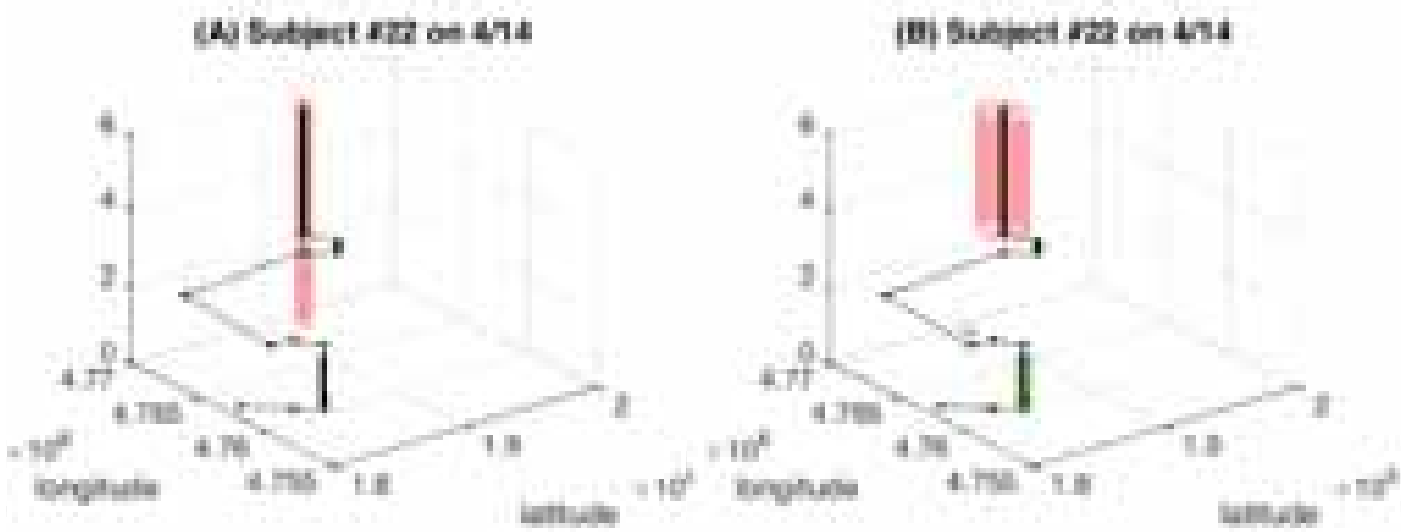
misclassification in time-activity patterns

misclassification in personal exposure estimates

- the quality of time-activities estimated from GPS-based classification method depends on the accuracy of GPS data.
- inaccurate GPS points are likely to yield misclassified time-activity patterns.
- misclassified time-activities yield misclassification of personal exposure.

Illustration of uncertainty propagation

Misclassified time-acivities (MEs)



(A) GPS points with travel diary (home ME)

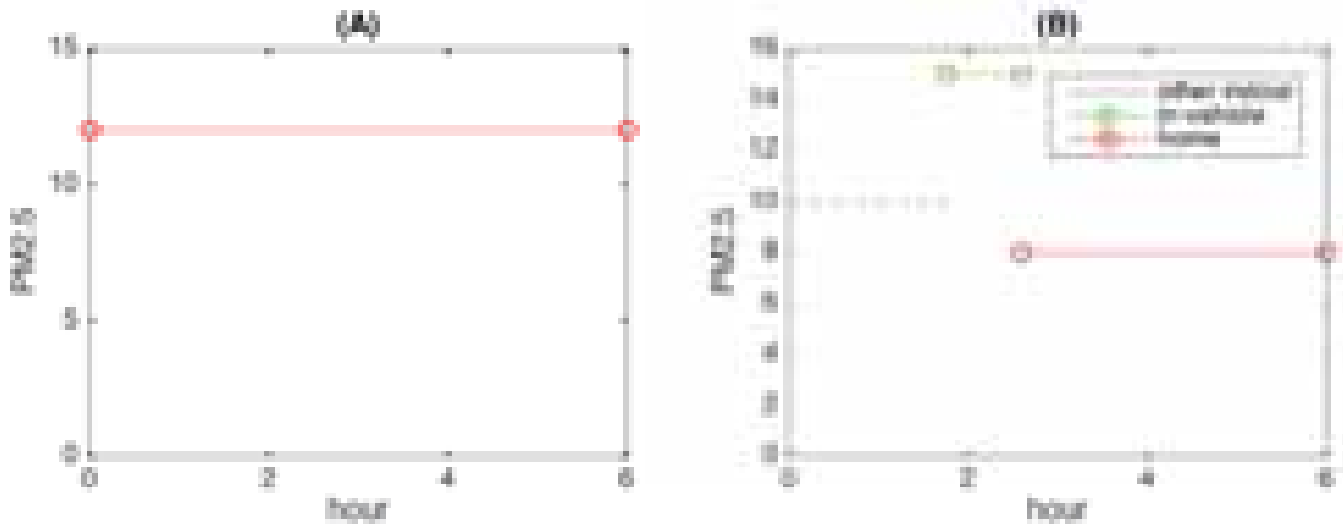
(B) GPS points with time-activities estimated from classification method

*red : home ME

*green: other indoor

Illustration of uncertainty propagation (II)

Misclassification of personal exposure



(A) home-based exposure estimate

(B) GPS-based time-activity classification based exposure estimate

Conclusions

1. we developed a GPS-based time-activity classification method, which potentially replace labor-intensive manual matching procedure.

2. we validate the proposed time-activity classification method with travel diaries.

3. we found substantial spatial discrepancy between travel diary and GPS recordings at dark, which can be somewhat alleviated by the proposed classification method but potentiallyly leads to misclassification in estimated time-activity patterns and exposure estimates.

Future work

1. to add multiple environmental sensors to enhance the capability to classify individuals' time-activity patterns and improve the accuracy.
   - waypoint data sampling by participants' manual input (Breen 14)
   - temperature data (Nethery:14), and humid, wind, ultraviolet, light, dust information to classify GPS samples into various types of MEs.
2. to evaluate the proposed model with a larger number of participants whose background information is diverse and representative.
3. to improve the time-activity pattern data used for population-level exposure assessments.
   - can be applied to large sets of GPS data collected from smartphones
   - to increase sample size and update older diary data to reflect the changes in population and result in time-activity patterns of large population with less errors.
4. to enhance the quality of travel diaries and questionnaire.

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