Towards an activity-based model for pedestrian facilities

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April 25, 2013
Motivation

Data (short)

A Bayesian estimation to detect destinations

Model (long)
Why do we care about pedestrians?

- Urban growth ➔ pressure on infrastructure
  - In particular in transport hubs
- Demand modeling for pedestrian facilities needs
  - data collections and
  - developments of modeling approaches
- Testbed on campus with WiFi from access point
What we plan to do
What we are doing
Available data

- Pedestrian network
  - destinations
  - path

- WiFi traces from access points

- Capacity
  - of classes,
  - of restaurants,
  - of platforms,
Available data: Pedestrian network

- Source: map.epfl.ch
- 56’655 edges
- 4 different levels of path
  - Major (« highway »)
  - Inter-building
  - Intra-building
  - Access to offices
- Weighted shortest path
- All offices, restaurants, classrooms and other points of interest are coded
Available data: WiFi traces

- Triangulation data from the 789 access points on campus
- Low precision (187m)
- 200 students from 6 different classes + 300 employees
  - Randomly chosen
  - Anonymous
    (but class is known)
Available data: Capacity

- Class schedules with
  - Number of students
  - Name of the classroom
- Number of employees per office
  - Name of the office
  - Sum of percent of work (e.g., 3 full times = 300%)
- Number of seats in restaurants
  - Localization
  - Opening hours
- Number of seats in library
Bayesian estimation of destinations

- Activity probability

\[ P(\text{dest.} | \text{signals}) \propto P(\text{signals} | \text{dest.}) \cdot P(\text{dest.}) \]

Measurement likelihood \quad Prior knowledge

Activity probability
Bayesian estimation of destinations

- Candidate generation
  - Space
  - Time
Bayesian estimation of destinations: Results

- Flat prior

<table>
<thead>
<tr>
<th>Model</th>
<th>Truth</th>
<th>Δx (in m.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival time</td>
<td>Departure time</td>
<td>Floor</td>
</tr>
<tr>
<td>8:35-8:35</td>
<td>10:38-10:38</td>
<td>1</td>
</tr>
<tr>
<td>10:40-10:40</td>
<td>11:51-11:51</td>
<td>3</td>
</tr>
<tr>
<td>12:09-12:10</td>
<td>12:47-12:53</td>
<td>1</td>
</tr>
<tr>
<td>12:52-12:58</td>
<td>13:03-13:44</td>
<td>3</td>
</tr>
<tr>
<td>13:06-13:47</td>
<td>13:53-14:02</td>
<td>2</td>
</tr>
<tr>
<td>13:55-14:04</td>
<td>19:45-19:45</td>
<td>3</td>
</tr>
<tr>
<td>19:47-19:47</td>
<td>19:52-19:52</td>
<td>0</td>
</tr>
</tbody>
</table>

- Perfect prior 1:3

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</table>
Bayesian estimation of destinations: Results

- **Campus prior**

<table>
<thead>
<tr>
<th>Model</th>
<th>Arrival time</th>
<th>Departure time</th>
<th>Floor</th>
<th>Location</th>
<th>Time spent</th>
<th>Floor</th>
<th>Location</th>
<th>Δx (in m.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8:35-8:35</td>
<td>10:38-10:38</td>
<td>1</td>
<td>Classroom</td>
<td>8.32am-10.30am</td>
<td>1</td>
<td>Classroom</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>10:40-10:40</td>
<td>11:51-11:51</td>
<td>3</td>
<td>Classroom</td>
<td>Until 11.47am</td>
<td>3</td>
<td>Author’s office</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>11:54-11:54</td>
<td>12:47-12:53</td>
<td>1</td>
<td>Restaurant</td>
<td>From 11.55 am</td>
<td>1</td>
<td>Restaurant</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>12:51-12:58</td>
<td>13:03-13:44</td>
<td>3</td>
<td>Office</td>
<td>Around 1pm</td>
<td>3</td>
<td>Author’s office</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>13:06-13:47</td>
<td>13:53-14:02</td>
<td>2</td>
<td>Cafeteria</td>
<td>Around 2pm</td>
<td>2</td>
<td>Cafeteria</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>13:55-14:04</td>
<td>19:40-19:44</td>
<td>3</td>
<td>Classroom</td>
<td>Until around 7.45pm</td>
<td>3</td>
<td>Author’s office</td>
<td>37</td>
</tr>
</tbody>
</table>

- **Class prior**

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<td>0</td>
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<td></td>
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<td>11:51-11:51</td>
<td>3</td>
<td>Office</td>
<td>Until 11.47am</td>
<td>3</td>
<td>Author’s office</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>11:54-11:54</td>
<td>12:47-12:53</td>
<td>1</td>
<td>Restaurant</td>
<td>From 11.55 am</td>
<td>1</td>
<td>Restaurant</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>12:51-12:58</td>
<td>13:03-13:44</td>
<td>3</td>
<td>Office</td>
<td>Around 1pm</td>
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<td>Author’s office</td>
<td>7</td>
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<td>Office</td>
<td>Until around 7.45pm</td>
<td>3</td>
<td>Author’s office</td>
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</tr>
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</table>
Activity-based model for pedestrians?

- **Goal**: adapt the concept to pedestrian facilities
- **Hägerstrand**
  - Capability constraints: *lunch*
  - Coupling constraints: *timetables*
- Pedestrians have **planned** and **unplanned** activities
- Sensitivity to changes in:
  - Pedestrian network
  - Possible destinations
  - Schedules

Carlstein, T. (1978)
Differences urban / pedestrian facilities

- Focus on pedestrian facilities
  - Space: Train stations, music festivals, supermarkets, airports, stadiums, campuses, city centers
  - Time: Covering the journey in the facility

- **No home** → no tour

- Mode is already known

- No monetary cost (but distance)
Model structure

- One modeling approach: sequential destination choice
  (hybrid simulation: Ettema, Borgers and Timmermans 1993; Ettema et al. 1995)

Choice set: 1,2
Model structure

- One modeling approach: sequential destination choice
- Existence of schedules in pedestrian facilities, activity scheduling decision (Bowman 1998)

Choice set: \( \{1,2\}, \{2,1\} \)
Model structure

Primary activity (scheduled)

- Primary activity pattern
  - Pattern probabilities
  - Expected start and end times

Start and end times

- Activity time probabilities
- Expected destinations

Destinations for primary activities

- Primary destinations probabilities
- Expected secondary activity pattern

Secondary activity pattern

- Activity time probabilities
- Expected destinations

Start and end times

- Activity time probabilities
- Expected destinations

Destinations for secondary activities

Secondary activity (unscheduled)
Model structure: example (campus)

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</tbody>
</table>

- **Primary pattern (scheduled):**

<table>
<thead>
<tr>
<th>Primary activity</th>
<th>Free time</th>
<th>Primary activity</th>
<th>Free time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>Restaurant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:33-10:38</td>
<td></td>
<td>11:54-12:47/12:53</td>
<td></td>
</tr>
<tr>
<td>CE 1 105</td>
<td>Ornithorynque</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Model structure: example (campus)

#### Secondary pattern (unscheduled):

<table>
<thead>
<tr>
<th>Primary activity</th>
<th>Sec. activ.</th>
<th>Primary activity</th>
<th>Secondary activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>Office</td>
<td>Restaurant</td>
<td>Office / Cafeteria / Office</td>
</tr>
<tr>
<td>CE 1 105</td>
<td>GC B3 445</td>
<td>Ornithorynque</td>
<td>GC B3 445 / Satellite / GC B3 445</td>
</tr>
</tbody>
</table>
Model structure: example (station)

- **Primary pattern (scheduled)**

<table>
<thead>
<tr>
<th>Primary activity</th>
<th>Free time</th>
<th>Primary activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ticket machine</td>
<td>7:30-7:34</td>
<td>Train</td>
</tr>
<tr>
<td></td>
<td>7:40-7:50</td>
<td></td>
</tr>
<tr>
<td>North east machine</td>
<td></td>
<td>Platform 8</td>
</tr>
</tbody>
</table>

- **Secondary pattern (unscheduled)**

<table>
<thead>
<tr>
<th>Primary activity</th>
<th>Secondary activity</th>
<th>Primary activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ticket machine</td>
<td>Buying a croissant and a newspaper</td>
<td>Train</td>
</tr>
<tr>
<td></td>
<td>7:36-7:40</td>
<td>7:40-7:50</td>
</tr>
<tr>
<td>North east machine</td>
<td>Newspaper kiosk</td>
<td>Platform 8</td>
</tr>
</tbody>
</table>
Primary activity pattern: choice set

- Free time (21)
- myClassroom, freeTime (2)
- freeTime, myClassroom (2)
- freeTime, myClassroom, freeTime (2)
- myClassroom, freeTime, restaurant, freeTime (1)
- freeTime, myClassroom, freeTime, myClassroom, freeTime, myClassroom (1)
- freeTime, restaurant, restaurant, freeTime, myClassroom, myClassroom (1)
- ...

TRANSP-OR

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
Primary activity pattern: attributes

- **Socioeconomic:**
  - class

- **Alternative-specific:**
  - nb of courses in total,
  - nb of courses followed,
  - going to restaurant for lunch or not
What’s next

- Application with data for 10 days
  - Test panel effect
  - Test different attributes:
    - distance
    - rain
    - cost of meals
    - evaluation of restaurants
    - evaluation of courses
    - ...
  - Latent class model with measurement equation
- Destination category (observed) ≠ activity (unobs.)
  - Destination category is an indicator of a latent activity
Conclusion

- Transport hubs face an increasing demand
  - Detect, model and forecast at a large scale and from innovative and available data
- Schedules are common:
  - Campuses (classes)
  - Stations (trains)
  - Music festivals (concerts)
- Stations are small cities (SBB/CFF: “Rail cities”) with various activities