Activity pattern modeling: A path choice approach

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1. Motivation: Pedestrian demand management strategies
2. A path choice approach to activity modeling
3. Case study: EPFL campus
4. Conclusion
Pedestrian demand management strategies

- Pedestrian facilities
  - Transportation hubs (train stations, airports, ...)
  - Mass gathering (music festivals, ...)
  - Shops
  - ...

- Challenges
  - Designing efficient buildings
  - Locating points of interest
  - Modifying schedules
  - ...

⇒ Pedestrian demand management strategies
Activity modeling: Sensitivity to policies

(Lenntorp; 1978)
Observations: Activity-episode sequences

Activity types

Restaurant
Office
Classroom
Other

8:24
8:33-34
11:37-58
13:09-11
16:20-33
18:33
Modeling assumption

- **Sequential choice:**
  1. activity type, sequence, time of day and duration
  2. destination choice conditional on the previous choice

- **Motivations:**
  - Behavior: “I’m hungry at lunch time”, then “Which restaurant?”
  - Dimensional: destinations $\times$ time $\times$ position in the sequence is not tractable

Here we focus on ①.

Examples of ②: Ton (2014); Kalakou and Moura (2014).
Activity network

\[ S \quad \cdots \quad e \]

Activity types

\[ \mathcal{A}_1 \]
\[ \mathcal{A}_2 \]
\[ \vdots \]
\[ \mathcal{A}_k \]

Activity network

\[ 1 \quad 2 \quad \cdots \quad T \quad \text{Time} \]
Activity network
Activity network
Choice set generation in route choice

- Universal choice set:
  - Too big, not usable
  - Decision maker doesn’t consider all routes
- Consideration choice set:
  - Not available
  - Too small
- Sampling of alternatives from the universal choice set: Metropolis-Hastings algorithm (Flötteröd and Bierlaire; 2013).
Choice set generation: Metropolis-Hastings algorithm

(Flötteröd and Bierlaire; 2013)
Choice set generation in the activity network

With Metropolis-Hastings algorithm, possibility to define non-link additive cost

Target weight defined as

\[ \delta(\Gamma) = -\mu_v \cdot \sum_{v \in \Gamma} \delta_v(v) - \delta_\Gamma(\Gamma) \]

with

- link cost: frequency of observations
- path cost: length of observed paths
Activity network: frequency of observations
Activity path choice model for WiFi traces: sampling of alternatives

- Frejinger et al. (2009): a sampling correction must be added

\[
\ln q(C_n|\Gamma) = \ln \frac{k_{\Gamma n}}{q(\Gamma)}
\]

with \(k_{\Gamma n}\) the number of occurrences and \(q(\Gamma)\) the sampling probability

- Sampling probability require full enumeration

\[
q(\Gamma) = \frac{b(\Gamma)}{\sum_{\Gamma' \in U} b(\Gamma')}
\]

but cancels out in logit
Activity path choice model for WiFi traces: additive utility function

\[ V_\Gamma = \sum_{\tau} V(A_{k,\tau}) \]

Inspired by Ettema et al. (2007):

\[ V(A_{k,\tau}) = \eta_k \ln(t_k) + \sum_{k,\tau} \beta_{k,\tau} l_{k,\tau} \]

with

- \( \eta_k \) the satiation parameter for activity type \( k \)
- \( \sum_{k,\tau} \beta_{k,\tau} l_{k,\tau} \) the time-of-day utility
Case study: EPFL campus

- EPFL campus approximately hosts 13'000 people per day
- Similar to transport hubs: some users follow schedules
- Different activities on campus: working, eating, ...
- Recent development of the campus: 1 billion investment in real estate
- WiFi traces processed as in Danalet et al. (2014) with $L = 1$
Length of activity paths
Length of activity paths: filtering

Removed short activity paths and less than 5.4 measurements / hour.
Time of day

![Graph showing Time of day distribution with a peak around 10-11 AM and a drop in the evening.]

- **Mobility survey**
- Nb of observations
Estimation of the model

- The model:

\[ V_{\Gamma n} = \eta_k \ln(t_k) + \sum_k \beta_k I_k + \ln \frac{k_{\Gamma n}}{b(\Gamma)} \]

- Summary statistics:
  - Number of alternatives: 1201
  - Number of observations = 2219
  - Number of estimated parameters = 10

\[
\begin{align*}
\mathcal{L}(\beta_0) &= -17952.561 \\
\mathcal{L}(\hat{\beta}) &= -1484.635 \\
-2[\mathcal{L}(\beta_0) - \mathcal{L}(\hat{\beta})] &= 32935.852 \\
\rho^2 &= 0.917 \\
\overline{\rho}^2 &= 0.917
\end{align*}
\]
## Estimation results for the model

<table>
<thead>
<tr>
<th>Parameter number</th>
<th>Description</th>
<th>Coeff. estimate</th>
<th>Robust Asympt. std. error</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$\beta_{Lab}$</td>
<td>-0.337</td>
<td>0.0949</td>
<td>-3.55</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>$\beta_{Library}$</td>
<td>-2.74</td>
<td>0.0795</td>
<td>-34.45</td>
<td>0.00</td>
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<tr>
<td>3</td>
<td>$\beta_{Other}$</td>
<td>-2.78</td>
<td>0.0483</td>
<td>-57.62</td>
<td>0.00</td>
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<tr>
<td>4</td>
<td>$\beta_{Restaurant}$</td>
<td>-0.725</td>
<td>0.0612</td>
<td>-11.85</td>
<td>0.00</td>
</tr>
<tr>
<td>5</td>
<td>$\beta_{Shop}$</td>
<td>-0.473</td>
<td>0.103</td>
<td>-4.59</td>
<td>0.00</td>
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<tr>
<td>6</td>
<td>$\eta_{Lab}$</td>
<td>2.55</td>
<td>0.895</td>
<td>2.85</td>
<td>0.00</td>
</tr>
<tr>
<td>7</td>
<td>$\eta_{Office}$</td>
<td>-0.787</td>
<td>0.600</td>
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<tr>
<td>8</td>
<td>$\eta_{Other}$</td>
<td>9.66</td>
<td>1.27</td>
<td>7.63</td>
<td>0.00</td>
</tr>
<tr>
<td>9</td>
<td>$\eta_{Restaurant}$</td>
<td>5.56</td>
<td>0.789</td>
<td>7.05</td>
<td>0.00</td>
</tr>
<tr>
<td>10</td>
<td>$\eta_{Shop, Library, Classroom}$</td>
<td>-3.26</td>
<td>0.782</td>
<td>-4.16</td>
<td>0.00</td>
</tr>
</tbody>
</table>
• Not home-based, nor tour-based model.
• Can adapt to different contexts and activity types.
• Manage large dimensionality of the problem through importance sampling techniques.
• First results show that the approach is feasible in a realistic context.
Future works

- Improve the specification
  - In particular, add in the utility function variables that are related to the path itself (patterns).
- Evaluate the quality of the generated choice set and its impact on the choice model.
- Correct for the correlation structure
- Manage measurement error
Thank you!

Questions?
**URL:** http://dx.doi.org/10.1016/j.trc.2014.03.015

**URL:** http://dx.doi.org/10.1016/j.tra.2007.03.001

**URL:** http://dx.doi.org/10.1016/j.trb.2012.11.002
References II

URL: http://dx.doi.org/10.1016/j.trb.2009.03.001

URL: http://www.strc.ch/conferences/2014/Kalakou_Moura.pdf

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References III