Workshop in Discrete Choice Models

Activity path size for correlation between activity paths

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Outline

Motivation: Activity-based model for pedestrian facilities

A path choice approach to activity modeling

Correlation between activity paths

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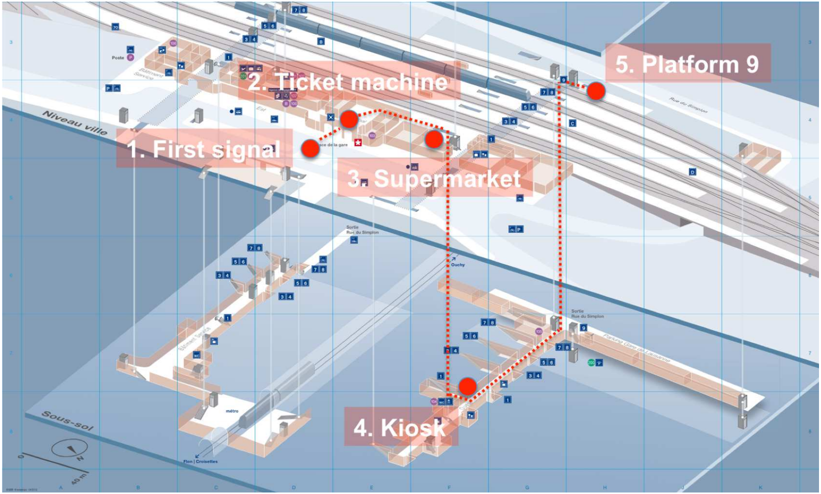
Activities in pedestrian infrastructure

Spatial choices in pedestrian infrastructure



Motivation

- **Activity-based approach**: modeling the activity participation patterns
- **Not tour-based** (no “home” location in pedestrian facilities)
- **No hierarchy** of dimensions or aggregation

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Notation

- Measurement $\hat{m} = (\hat{x}, \hat{t})$ *(e.g., WiFi traces)*

$$(\hat{m}_1, \hat{m}_2, ..., \hat{m}_J) = \hat{m}_{1:J}$$

- Activity episode $a = (x, t^-, t^+)$ *(e.g., BC, 12:10-14:10)*

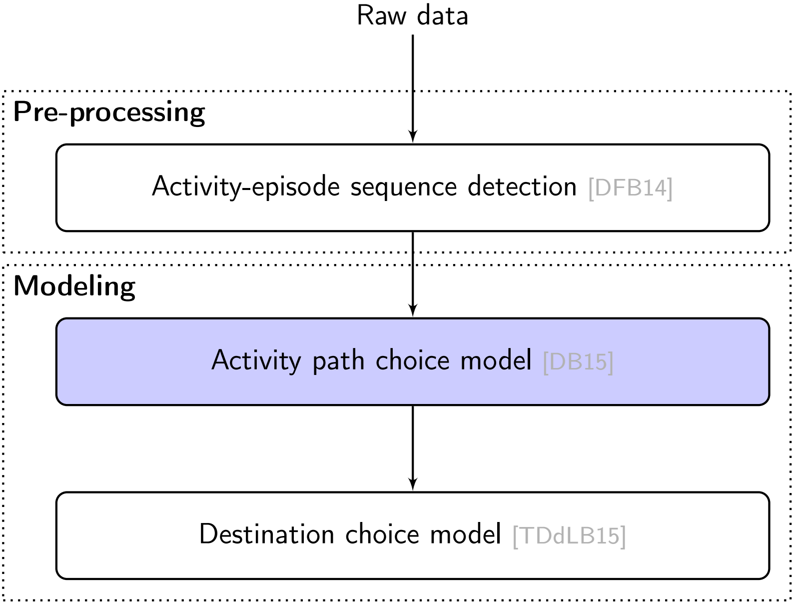
$$(a_1, a_2, ..., a_\Psi) = a_{1:\Psi}$$

- Activity type $\mathcal{A}_k$ *(e.g., eating)*
- Activity $A = (\mathcal{A}_k, t^-, t^+)$ *(e.g., eating, 12:10-14:10)*

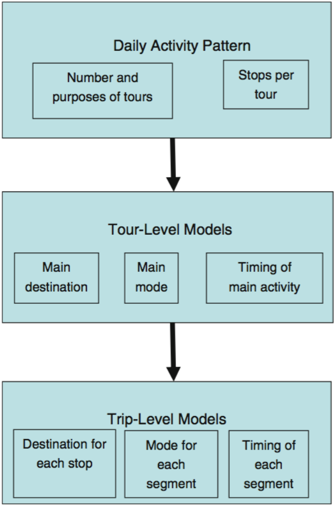
$$(A_1, A_2, ..., A_\Psi) = A_{1:\Psi}$$

Goal

Model the activity-episode sequence $a_{1:\Psi}$
when observing $\hat{m}_{1:J}$ from antennas


Raw data
Pre-processing
Activity-episode sequence detection [DFB14]
Modeling
Activity path choice model [DB15]
Destination choice model [TDdLB15]

Yoram's model



Path choice approach to activity modeling

1. Input
   1.1 Network traces $\hat{m}_{1:J}$
   1.2 Semantically-enriched routing graph
   1.3 Potential attractivity measure
2. Pre-processing
   2.1 Activity-episode sequence $a_{1:\Psi}$ detection [DFB14]

$$P(a_{1:\Psi}|\hat{m}_{1:J}) \propto P(\hat{m}_{1:J}|a_{1:K}) \cdot P(a_{1:\Psi})$$

3. Modeling
   3.1 Activity path choice model [DB15]
   3.2 Destination choice model [TDdLB15]

Modeling assumption

- Sequential choice:
  1. activity type, sequence, time of day and duration

$$P(A_{1:\Psi})$$

  2. destination choice conditional on 1.

$$P(x|A_{1:\Psi})$$

- Motivations:
  - Behavior: precedence of activity choice over destination choice
  - Dimensional: destinations $\times$ time $\times$ order is large

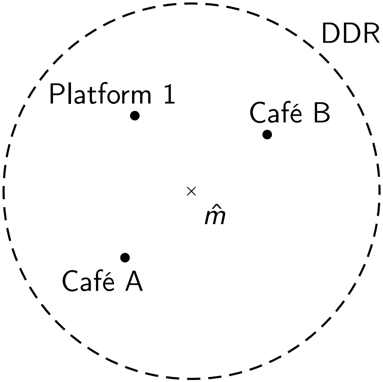
Today, we focus on 1. [DB15].

Full model

Probability of reproducing observations $\hat{m}_{1:J}$ of individual i is

$$
\begin{aligned}
P_i(\hat{m}_{1:J}) &= \sum_{a_{1:\Psi}\in\mathcal{C}} P(\hat{m}_{1:J}|a_{1:\Psi}) \cdot P(a_{1:\Psi}) && (1)\\
&= \sum_{a_{1:\Psi}\in\mathcal{C}} P(\hat{x}_{1:J}|x_{1:\Psi}) \cdot P(A_{1:\Psi}) \cdot P(x|A_{1:\Psi}) && (2)\\
&= \sum_{a_{1:\Psi}\in\mathcal{C}} \prod_{j=1}^{J} P(\hat{x}_j^{\psi}|x_{\psi}) \cdot P(A_{1:\Psi}) \cdot \prod_{\psi=1}^{\Psi} P(x|A_{\psi}) && (3)
\end{aligned}
$$

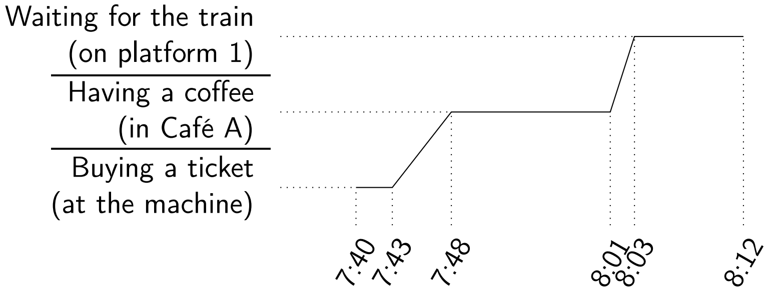
Toy example



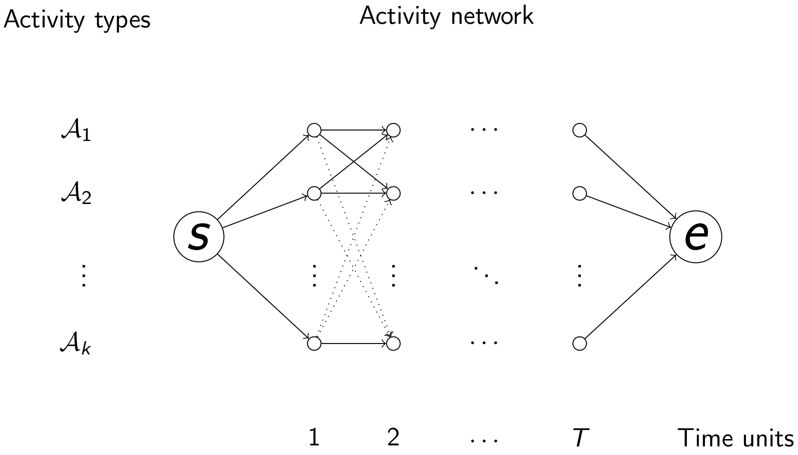
$$P(\hat{m}) = \frac{2}{3}P(\text{Café}) \cdot \Big(P(\text{Café A}|\text{Café}) + P(\text{Café B}|\text{Café})\Big) + \frac{1}{3}P(\text{Platform}) \cdot P(\text{Platform 1}|\text{Platform})$$

Observations: activity patterns in a transport hub

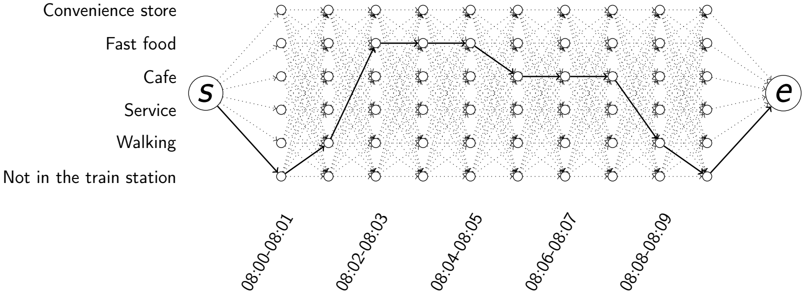
Activity types



Activity path



Activity network

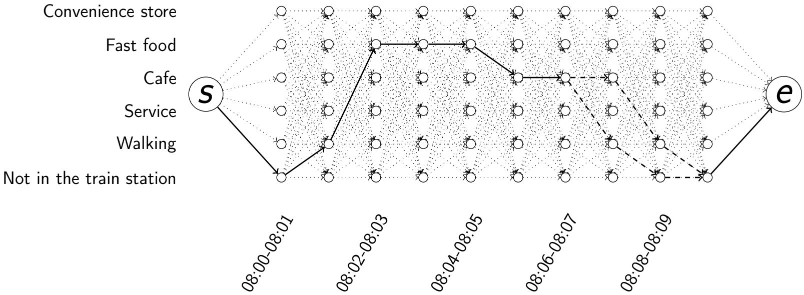


Challenge 1: Choice set generation

- Simple random sampling: observations dominate alternatives
- Importance sampling
  using Metropolis-hastings algorithm [FB13]
  - Observation score [Che13]
  - Strategic sampling [LK12]

Outline

Challenge 2: Correlation between activity paths



- IIA property might not hold
- Activity paths share unobserved attributes
- Due to overlaps?
- Deterministic correction: Activity Path Size?

Route path size

- Aggregation of alternatives [BAL85]
  - Elemental alternatives: activity paths
  - Aggregate alternatives: nodes in the activity network
- Size of aggregate alternative: number of paths using this link
- In activity network: constant, $K^{\tau-1}$, cancels out, no correction.

Activity Path Size

- Similarity measure: shared primary activity [Bow98]
  - Primary activity $\mathcal{A}_p$: relative majority of nodes
  - Size of node: nb of paths using it, with primary activity $\mathcal{A}_p$
- Similarity measure: shared pattern
  - Pattern p: ordered sequence of activity types, without duration
    - Activity path: `Home-Home-Home-Work-Work-Work-Work-Work-Shop-Home-Home`
    - Activity pattern: `Home-Work-Shop-Home`
  - Size of node: number of paths using the node, with pattern p

Primary Activity Path Size

- Node $\mathcal{A}_{k,\tau}$ corresponds to primary activity $\mathcal{A}_p$

$$M_{\mathcal{A}_{k,\tau}} = \left[\frac{x^{T-1}}{(T-1)!}\right] \sum_{j\geq 0} \frac{x^{j-1}}{(j-1)!} \left(1 + x + \frac{x^2}{2!} + \cdots + \frac{x^{j-1}}{(j-1)!}\right)^{K-1}$$

- Node $\mathcal{A}_{k,\tau}$ does not correspond to primary activity $\mathcal{A}_p$

$$M_{\mathcal{A}_{k,\tau}} = \left[\frac{x^{T-1}}{(T-1)!}\right] \sum_{j\geq 0} \frac{x^{j}}{j!} \left(1 + x + \frac{x^2}{2!} + \cdots + \frac{x^{j-1}}{(j-1)!}\right)^{K-2} \left(1 + x + \frac{x^2}{2!} + \cdots + \frac{x^{j-2}}{(j-2)!}\right)$$

Activity Pattern Path Size

$$M_{\mathcal{A}_{k,\tau}} = \sum_{i=1}^{|p_k|} \binom{\tau - 1}{L_i - 1} \binom{T - \tau}{|p| - L_i}$$

- $|p|$: number of elements in pattern p
- $|p_k|$: number of times activity type k appears in pattern p
- L_i: index of the ith occurence of activity type k in pattern p

Conclusion

- Network traces can be used for estimation of activity-based models in pedestrian facilities
- Activity path approach models pattern, time of day, duration and number of episodes simultaneously, using recent developments in route choice modeling
- Similar paths are probably correlated; deterministic correction proposed

Future work

- Estimate a model with Primary Activity Path Size and Activity Pattern Path Size
- Cross nested logit model with sampling of alternatives for route choice models [LB14] adapted to activity path choice

Thank you

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