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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Correlation between activity paths
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 $A_k$ (e.g., eating)

- Activity $A = (A_k, t^-, t^+)$ (e.g., eating, 12:10-14:10)
  
  $$(A_1, A_2, ..., A_\psi) = A_{1:\psi}$$
Model the activity-episode sequence $a_{1:\psi}$ when observing $\hat{m}_{1:t}$ from antennas
Raw data

Pre-processing

Activity-episode sequence detection [DFB14]

Modeling

Activity path choice model [DB15]

Destination choice model [TDdLB15]
Yoram’s model

Daily Activity Pattern
- Number and purposes of tours
- Stops per tour

Tour-Level Models
- Main destination
- Main mode
- Timing of main activity

Trip-Level Models
- Destination for each stop
- Mode for each segment
- Timing of each segment

[SBA11]
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 attractiveness 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

\[ P(A_{1:Ψ}) \]

2. destination choice conditional on 1.

\[ P(x|A_{1:Ψ}) \]

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

Today, we focus on 1. [DB15].
Full model

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

$$P_i(\hat{m}_{1:J}) = \sum_{a_1;\psi \in C} P(\hat{m}_{1:J}|a_1;\psi) \cdot P(a_1;\psi)$$  \hspace{1cm} (1)$$

$$= \sum_{a_1;\psi \in C} P(\hat{x}_{1:J}|x_1;\psi) \cdot P(A_1;\psi) \cdot P(x|A_1;\psi)$$  \hspace{1cm} (2)$$

$$= \sum_{a_1;\psi \in C} \prod_{j=1}^{J} P(\hat{x}_j^{\psi} | x_\psi) \cdot P(A_1;\psi) \cdot \prod_{\psi=1}^{\Psi} P(x|A_\psi)$$  \hspace{1cm} (3)$$
Toy example

\[ P(\hat{m}) = \frac{2}{3} P(\text{Café}) \cdot \left( P(\text{Café A}|\text{Café}) + P(\text{Café B}|\text{Café}) \right) + \frac{1}{3} P(\text{Platform}) \cdot P(\text{Platform 1}|\text{Platform}) \]
Observations: activity patterns in a transport hub

Activity types

Waiting for the train (on platform 1)
Having a coffee (in Café A)
Buying a ticket (at the machine)
Activity path

Activity types

$A_1$

$A_2$

\vdots

$A_k$

Activity network

$S$ \quad \cdots \quad e

1 \quad 2 \quad \cdots \quad T \quad \text{Time units}$
Activity network

Convenience store
Fast food
Cafe
Service
Walking
Not in the train station

S

08:00-08:01
08:02-08:03
08:04-08:05
08:06-08:07
08:08-08:09
e
Challenge 1: Choice set generation

- Simple random sampling: observations dominate alternatives
- Importance sampling using Metropolis-hastings algorithm [FB13]
  - Observation score [Che13]
  - Strategic sampling [LK12]
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A path choice approach to activity modeling

Correlation between activity paths
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 \[\text{[BAL85]}\]
  - 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 $A_p$: relative majority of nodes
  - Size of node: nb of paths using it, with primary activity $A_p$
- Similarity measure: shared pattern
  - Pattern $p$: ordered sequence of activity types, without duration
    - Activity pattern: Home-Work-Shop-Home
  - Size of node: number of paths using the node, with pattern $p$
Primary Activity Path Size

• Node $A_{k,\tau}$ corresponds to primary activity $A_p$

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

• Node $A_{k,\tau}$ does not correspond to primary activity $A_p$

$$M_{A_{k,\tau}} = \left[ \frac{x^{T-1}}{(T-1)!} \right] \sum_{j \geq 0} x^j j! \left(1 + x + \frac{x^2}{2!} + \cdots + \frac{x^{j-1}}{(j-1)!}\right)^{K-2} \left(1 + x + \frac{x^2}{2!} + \cdots + \frac{x^{j-2}}{(j-2)!}\right)$$
Activity Pattern Path Size

$$M_{A_k,\tau} = \sum_{i=1}^{|p_k|} \left( \frac{\tau - 1}{L_i - 1} \right) \left( \frac{T - \tau}{|p| - L_i} \right)$$

- $|p|$: number of elements in pattern $p$
- $|p_k|$: number of times activity type $k$ appears in pattern $p$
- $L_i$: index of the $i$th occurrence 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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