Activity choice in pedestrian facilities

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1 Motivation: Pedestrian demand management strategies

2 Detection: A Bayesian approach for WiFi traces

3 Modeling: Path choice in activity network

4 Conclusion: Forecasting behavior and building decision-aid tools
Swiss context

By 2030, 100’000 passengers per day between Geneva and Lausanne

- 2000: > 25’000 travellers/day between Geneva and Lausanne*
- 2010: > 50’000 travellers/day between Geneva and Lausanne*
- 2030: > 100’000 travellers/day between Geneva and Lausanne*

* Forecast by Swiss Railways for the maximum scenario

= 2000 travelers/day
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)
WiFi traces: No stop, no semantics
Generation of activity-episode sequences
Generation of activity-episode sequences

\[
\begin{align*}
  x_j &+ 1 \\
  x_j &- 1 \\
  \hat{x}_j &+ 1 \\
  \hat{x}_j &- 1
\end{align*}
\]
Probabilistic measurement model

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

where

- \( P(a_{1:K} | \hat{m}_{1:J}) \), the activity probability of an activity-episode sequence
- \( P(\hat{m}_{1:J} | a_{1:K}) = \prod_{k=1}^{K} \prod_{j=1}^{J} P(\hat{x}_j^k | x_k) \), the measurement likelihood
- \( P(a_{1:K}) \), the prior based on attractiveness of the POI
Intermediary measurements
Eliminate intermediary measurement if
\[ E(t^+) - E(t^-) < T_{min} \]
since we generate an activity episode at each measurement
Individual results

Legend
- Pedestrian network
- Wrong activity type
- Correct activity type
Aggregate results
Demand analysis

- Model and forecast individual behavior
- Impact on the system

(Kirk Anderson)
Observations: activity patterns in a transport hub

Activity types

- Waiting for the train (on platform 9)
- Having a tea (in Tekoe)
- Buying a ticket (at the machine)
Discrete choice models

- Utility theory: we maximize our satisfaction
- Evaluation of the trade-off between the attributes of the alternatives
  - e.g., willingness to pay (value of time)
Modeling assumption

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

- **Motivations:**
  - Behavior: precedence of activity choice over destination choice
  - Dimensional: destinations $\times$ time $\times$ position in the sequence is not tractable
Activity network

Activity types

$A_1$

$A_2$

$\vdots$

$A_k$

Activity network

$S$

$e$

1 2 \cdots T Time
Activity network

Convenience store
Fast food
Cafe
Service
Shop
No activity
Challenges

- **Choice set generation**
  What are the considered alternatives during the choice process?

- **Utility**
  What is the mathematical expression of the utility?

- **Correlation structure**
  Different alternatives share unobserved attributes.

One can get inspired by the route choice literature...

e.g., Metropolis-Hastings algorithm for sampling routes in a network
Utility function

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

where

- \( \eta_k \) the satiation parameter for activity type \( k \)
- \( \sum_{k,\tau} \beta_{k,\tau} l_{k,\tau} \) the time-of-day utility
- \( \ln \left( \frac{k_{\Gamma n}}{b(\Gamma)} \right) \) is a sampling correction
Conclusion: Forecasting behavior and building decision-aid tools

Forecasting behavior

- Where are the pedestrians?
  WiFi tracking is cheap, covers the whole area and - mixed with other data - is precise enough (Danalet et al.; 2014)

- Why are they here?
  Parameters of the utility function answer this question (Danalet and Bierlaire; 2014)

- What would happen if some environmental characteristics change?
  For small variations, the utility function answer this question
Thank you!

Questions?

**URL:** [http://dx.doi.org/10.1016/j.trc.2014.03.015](http://dx.doi.org/10.1016/j.trc.2014.03.015)

Visiosafe in Lausanne train station

Animation
January 16, 2013
7h40-7h46