Activity pattern modeling: A path choice approach

Antonin Danalet, Michel Bierlaire

Transport and Mobility Laboratory
School of Architecture, Civil and Environmental Engineering
Ecole Polytechnique Fédérale de Lausanne

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Outline

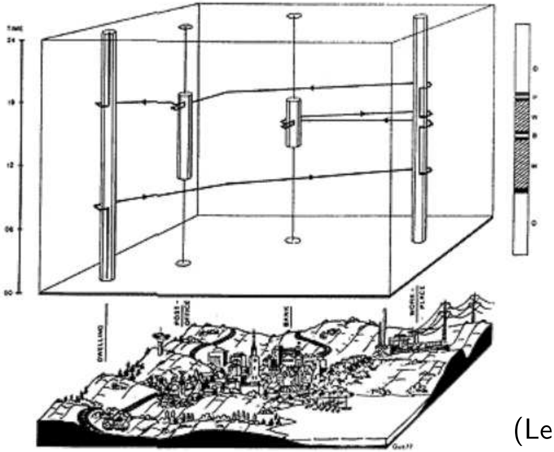
1. Motivation: Pedestrian demand management strategies
2. A path choice approach to activity modeling
3. Case study: EPFL campus
4. Conclusion

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
  - ...

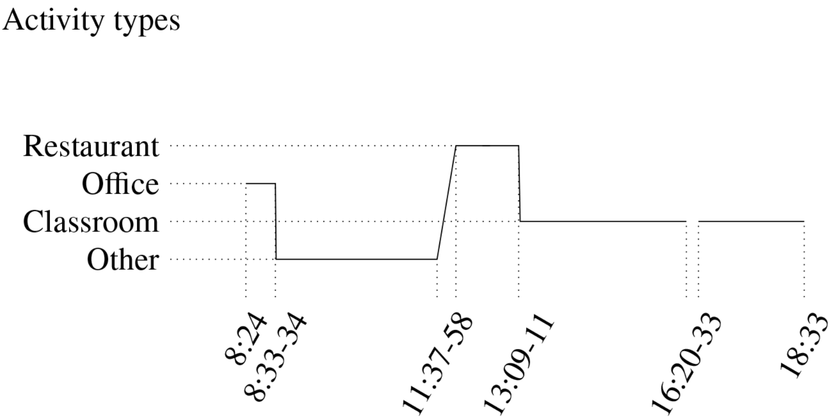
$\Rightarrow$ Pedestrian demand management strategies

Activity modeling: Sensitivity to policies



(Lenntorp; 1978)

Observations: Activity-episode sequences



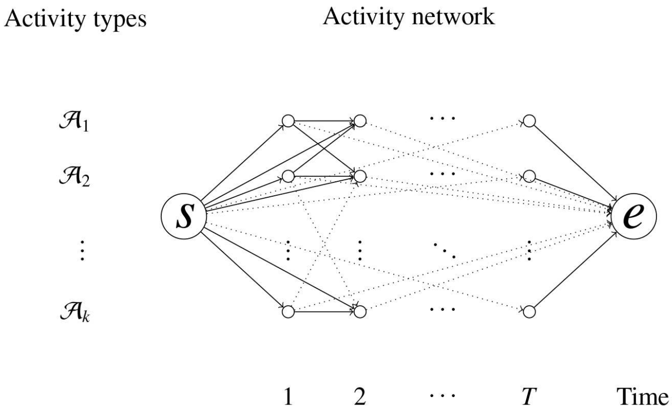
Modeling assumption

- **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

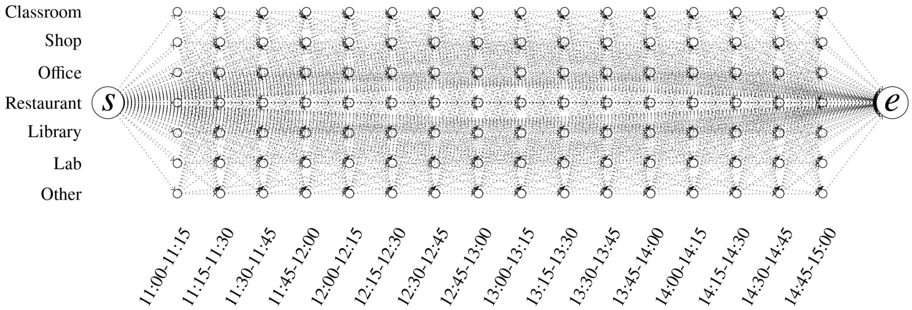
Here we focus on 1.

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

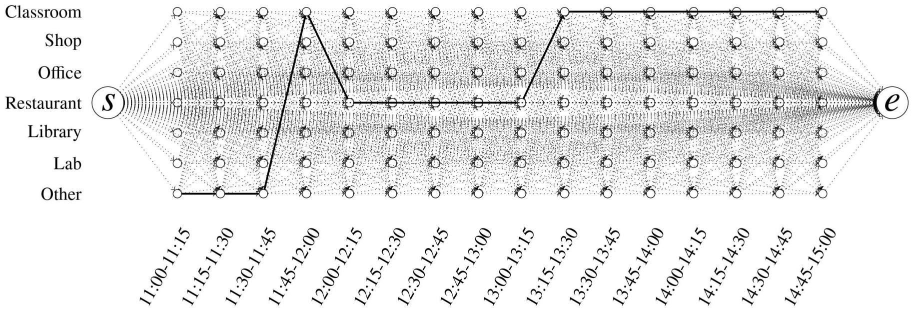
Activity network



Activity network



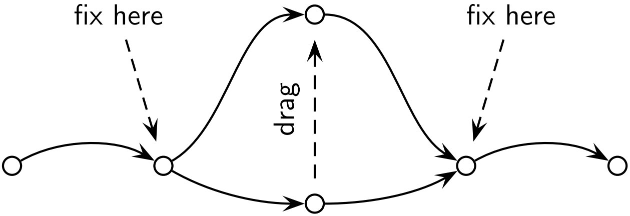
Activity network



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

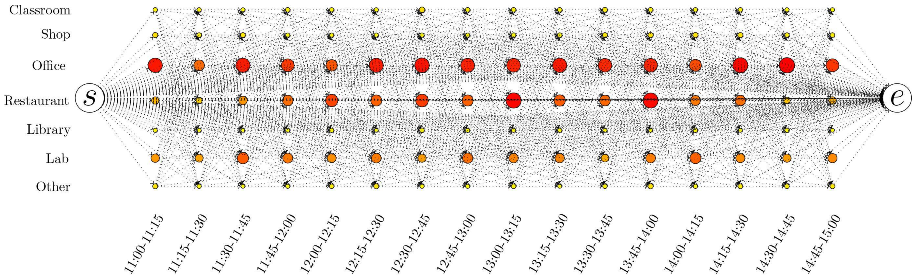
- With Metropolis-Hastings algorithm, possibility to define non-link additive cost
- Target weight defined as

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

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

$$\ln q(\mathcal{C}_n|\Gamma) = \ln \frac{k_{\Gamma n}}{q(\Gamma)}$$

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

- Sampling probability require full enumeration

$$q(\Gamma) = \frac{b(\Gamma)}{\sum_{\Gamma' \in \mathcal{U}} b(\Gamma')}$$

  but cancels out in logit

Activity path choice model for WiFi traces: additive utility function

$$V_\Gamma = \sum_\tau V(\mathcal{A}_{k,\tau})$$

Inpired by Ettema et al. (2007):

$$V(\mathcal{A}_{k,\tau}) = \eta_k \ln(t_k) + \sum_{k,\tau} \beta_{k,\tau} I_{k,\tau}$$

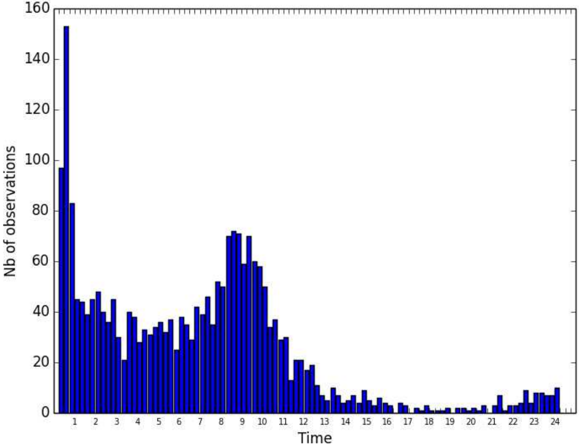
with

- η_k the satiation parameter for activity type k
- $\sum_{k,\tau} \beta_{k,\tau} I_{k,\tau}$ the time-of-day utility

Case study: EPFL campus

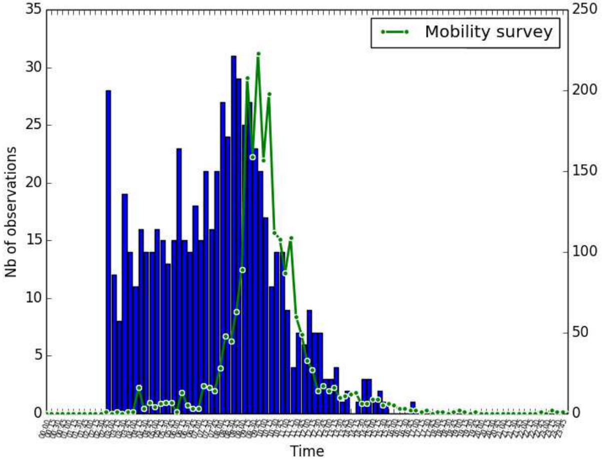
- EPFL campus approximately hosts 13'000 people per day
- Similar to transport hubs: some users follow schedules
- Different activities on campus: working, eating, ...
- Recent development of the campus: 1 billion investment in real estate
- WiFi traces processed as in Danalet et al. (2014) with $L =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

Length of activity paths

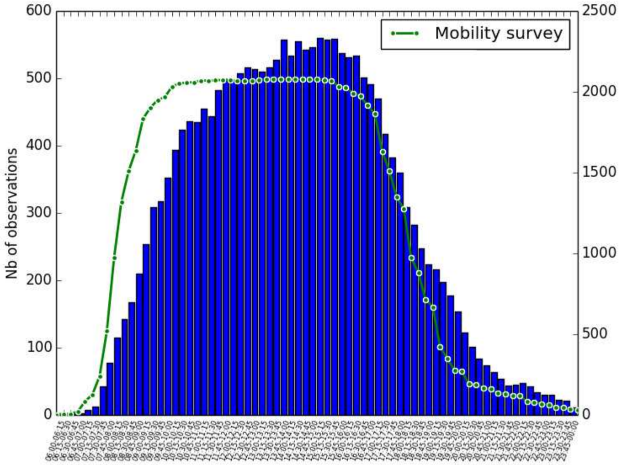


Length of activity paths: filtering

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



Time of day


Mobility survey
Nb of observations
0
100
200
300
400
500
600
0
500
1000
1500
2000
2500

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

$$\begin{aligned} \mathcal{L}(\beta_0) &= -17952.561 \\ \mathcal{L}(\hat{\beta}) &= -1484.635 \\ -2[\mathcal{L}(\beta_0) - \mathcal{L}(\hat{\beta})] &= 32935.852 \\ \rho^2 &= 0.917 \\ \bar{\rho}^2 &= 0.917 \end{aligned}$$

Estimation results for the model

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	β_{Lab}	-0.337	0.0949	-3.55	0.00
2	β_{Library}	-2.74	0.0795	-34.45	0.00
3	β_{Other}	-2.78	0.0483	-57.62	0.00
4	$\beta_{\text{Restaurant}}$	-0.725	0.0612	-11.85	0.00
5	β_{Shop}	-0.473	0.103	-4.59	0.00
6	η_{Lab}	2.55	0.895	2.85	0.00
7	η_{Office}	-0.787	0.600	-1.31	0.19
8	η_{Other}	9.66	1.27	7.63	0.00
9	$\eta_{\text{Restaurant}}$	5.56	0.789	7.05	0.00
10	$\eta_{\text{Shop, Library, Classroom}}$	-3.26	0.782	-4.16	0.00

Conclusion

- 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?

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