Assessment of A Route Choice Model Based on Mental Representations for Practical Applications

Evanthia Kazagli[1], Michel Bierlaire[1] & Gunnar Flötteröd[2]

[1]Transport and Mobility Laboratory
School of Architecture, Civil and Environmental Engineering
École Polytechnique Fédérale de Lausanne

[2]KTH Royal Institute of Technology,

Department of Transport Science, Stockholm, Sweden

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Agenda

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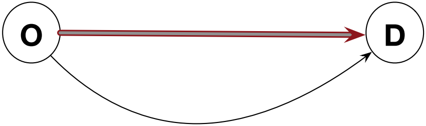
Route choice (RC)

Predict the route that a traveler would choose to go from the origin (O) to the destination (D) of her trip.



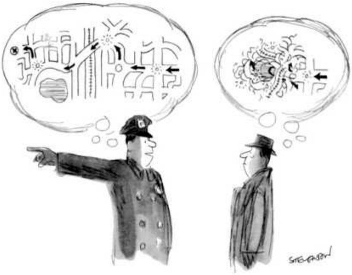
Challenges

Estimation of RUMs[1] with RP[2] data and path assumption is challenging

Operational aspects

- Data
- Choice set
- Structural correlation

Behavioral aspects



[1] Random Utility Models.
[2] Revealed Preferences.

Proposed framework

Main features:

1. Not based on paths
2. Modeling element: *mental representation*
3. The general framework may be network-free

Applications:

1. Traffic assignment
2. Design of route guidance systems

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Main idea behind the MRI model

A *path* is solely the implementation of the route choice.

How can we represent a route in a behaviorally realistic way without increasing the model complexity?

→ Mental Representation Item (MRI)

Kazagli, E., Bierlaire, M., and Flötteröd, G. (2015). Revisiting the Route Choice Problem: A Modeling Framework Based on Mental Representations. Technical report TRANSP-OR 150824. Transport and Mobility Laboratory, ENAC, EPFL.

Mental Representation Item (MRI)

- MRIs are associated with mental representations used in daily language to describe a route.
- An MRI is an item characterising the mental representation of an itinerary:

  E.g. a highway, the city center or a bridge.
- Strategic decisions.
- A route is one MRI or a sequence-of-MRIs.

Borlänge data

✓ GPS data → `map-matched trajectories`

✓ Borlänge road network:

1. 3077 nodes and 7459 unidirectional links
2. Link travel times
3. Clear choices

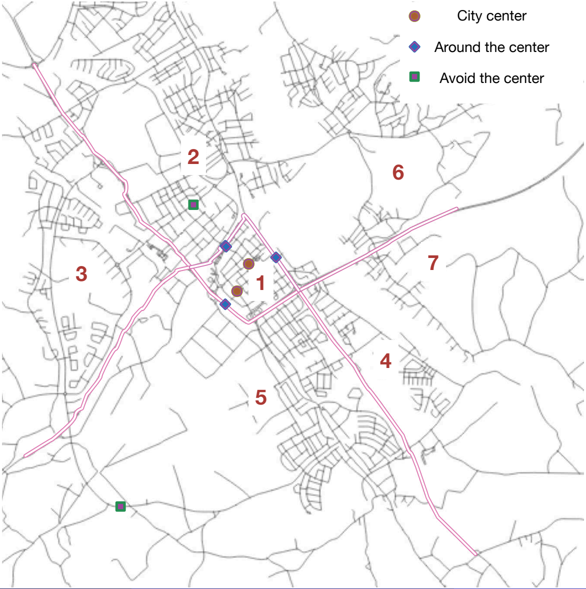
Borlänge road network and MRI choice set

$\mathcal{C}_n$ ={through the city center (CC), clockwise movement around the CC, counter-clockwise movement around the CC, avoid the CC}

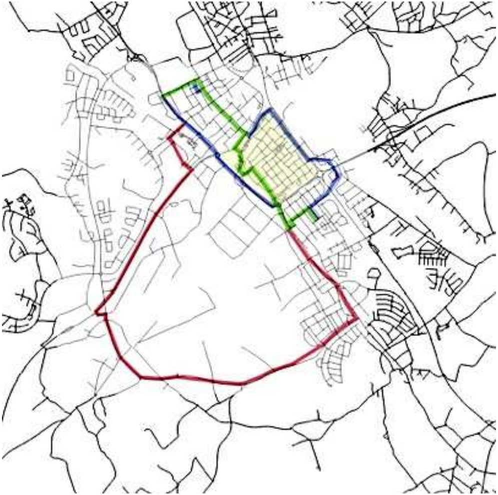
$\rightarrow \mathcal{C}_n = \{CC, CL, CO, AV\}$

for all individuals n

Representative nodes



Example of MRI choice set based on representative paths



CC alternative

CL & CO alternatives

AV alternative

Choice model

$$\text{MRI} \longrightarrow \begin{array}{c}\text{Representative path}\\ \text{for MRI}\end{array} \longrightarrow V_{\text{MRI}}$$

The MRIs consist of physically disjoint network elements. A logit is sufficient:

$$P(i|\mathcal{C}_n) = \frac{e^{V_{in}}}{\sum_{j \in \mathcal{C}_n} e^{V_{jn}}}$$

where i is an MRI alternative and V_{in} the deterministic part of the utility function that is specified based on the representative paths.

Estimation results

Parameters	**Parameter value**; Rob. Std **(Rob. t-test 0)**
$ASC_{\texttt{CL, CO}}$	-**2.11**; 1.44; **(-1.47)**
$ASC_{\texttt{AV}}$	**1.87**; 2.09; **(0.89)**
$\beta\, TIME_{\texttt{CC}}$	-**0.772**; 0.274; **(-2.82)**
$\beta\, TIME_{\texttt{CL, CO}}^{(0-10min)}$	-**0.286**; 0.165; **(-1.74)**
$\beta\, TIME_{\texttt{CL, CO}}^{(>10min)}$	-**0.616**; 0.216; **(-2.86)**
$\beta\, TIME_{\texttt{AV}}$	-**0.583**; 0.187; **(-3.11)**
$\beta\, LEFT$	-**0.288**; 0.130; **(2.22)**
$\beta\, IS$	-**0.0474**; 0.022; **(-2.16)**
Number of observations	139
Number of parameters	8
$\overline{\rho}$	0.375
$\mathcal{L}(0)$	-183.201
$\mathcal{L}(\hat{\beta})$	-106.563

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Traffic assignment

Consider the assignment of a single n with known OD. We are interested in $P(a \mid \mathcal{C}_n)$ that traveler n crosses any link a, given her MRI choice set $\mathcal{C}_n$

$$P(a \mid \mathcal{C}_n) = \sum_{i \in \mathcal{C}_n} P(a \mid i) \cdot P(i \mid \mathcal{C}_n)$$

operational component behavioral component

where $P(a \mid i)$ is the probability of using link a given that MRI i is chosen, expressed by

$$P(a \mid i) = \sum_{p} \mathbf{1}(a \in p) \cdot P(p \mid i)$$

where $\mathbf{1}(a \in p)$ is the zero/ one indicator of path p containing link a and $P(p \mid i)$ is the probability of traveling along path p given that MRI i is chosen.

Path vs link MRI consistency

Specification of $P(p \mid i)$

- Let s_v^i be the *consistency* of node v with MRI i.
- s_v^i follows the definition of the `MRIs`

  if v is contained in the `MRI`'s geographical span
  $\rightarrow s_v^i = 1$, and 0 otherwise.

- For each path p compute $s_p^i = \sum_{v \in p} s_v^i$ for every `MRI` $i \in \mathcal{C}_n$.
- Then

$$P(p \mid i) \sim \exp\left(\alpha \frac{s_p^i}{\sum_{j \in \mathcal{C}_n} s_p^j} + \beta t_p\right)$$

where $\sum_{j \in \mathcal{C}_n} \cdot$ spans over all `MRIs` in $\mathcal{C}_n$, t_p is the travel time on path p, and $\alpha > 0$, $\beta < 0$ are real-valued coefficients.

Metropolis-Hastings sampling of paths

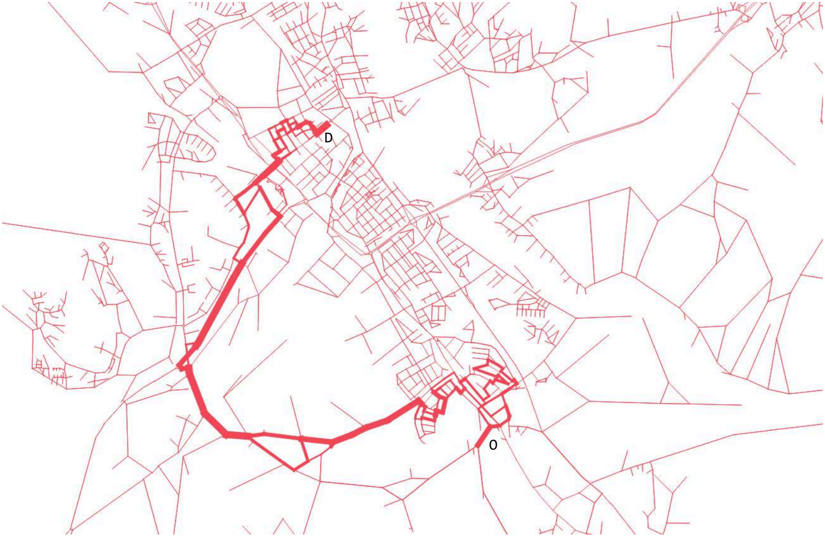
The number of paths with nonzero probability of being selected given that `MRI` i is chosen may be too high to be enumerated for the computation of the link choice probabilities $P(a \mid \mathcal{C}_n)$.

Solution: Metropolis-Hastings Algorithm [Flötteröd and Bierlaire, 2013] to draw, for each i, a large number of Q_i paths from $P(p \mid i)$. Then

$$\hat{P}(a \mid i) = \frac{1}{Q_i} \sum_{q=1}^{Q_i} \mathbf{1}(a \in p_i^q)$$

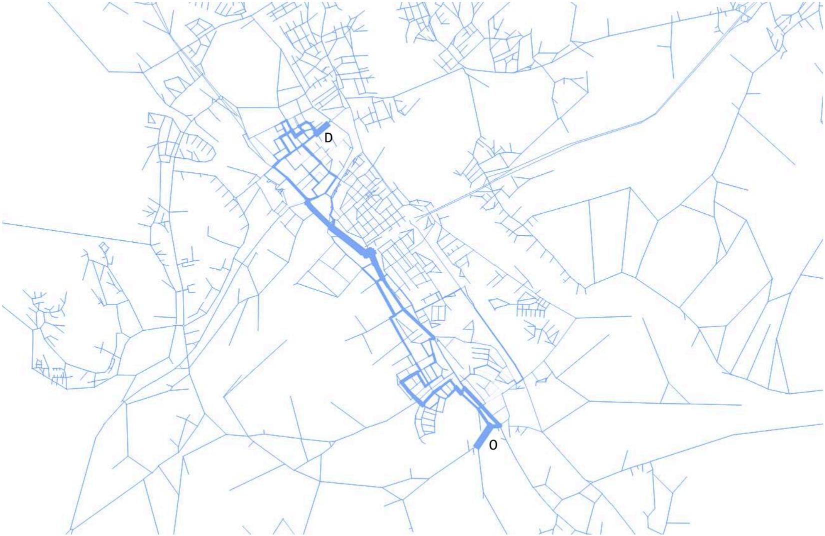
Link choice probabilities given the MRI choice set

Link choice probabilities conditional on the AV alternative



Link choice probabilities conditional on the CC alternative

Link choice probabilities conditional on the CL alternative



Link choice probabilities conditional on the CO alternative

Route guidance

Provision of information:

1. Guidance on VMS[3]
2. Radio announcements
3. Oral instructions in in-vehicle navigation systems

[3] Variable message signs.

Route guidance in Borlänge following the MRI model

$$P(i \mid a) = \frac{P(a \mid i)P(i)}{\sum_{j \in \mathcal{C}_n} P(a \mid j)P(j)}$$

$$P(\texttt{AV} \mid a) = 0.000$$

$$P(\texttt{CC} \mid a) = 0.069$$

$$P(\texttt{CL} \mid a) = 0.186$$

$$P(\texttt{CO} \mid a) = 0.745$$

"Avoid the city center (i.e. use AV), and in particular do not travel through Backaviadukten (i.e. avoid CO)."

Agenda

Conclusion

Main points

- Possible to have a meaningful model using simple heuristics.
- Distinction between the high level decisions from the operational ones.

Achievements

- Simple and flexible.
- Behaviorally realistic.
- Easily embedded in traffic assignment framework.

Challenges

- Involved modeling.
- Data processing.

Future steps

1. More case studies and model specifications.
2. MRI sequences.
3. Multiple-level representation.
4. Comparison & combination with the RL model [Fosgerau et al., 2013] and the cross-nested logit model.

Thank you!

Questions...?

evanthia.kazagli@epfl.ch

http://people.epfl.ch/kazagli
transp-or.epfl.ch

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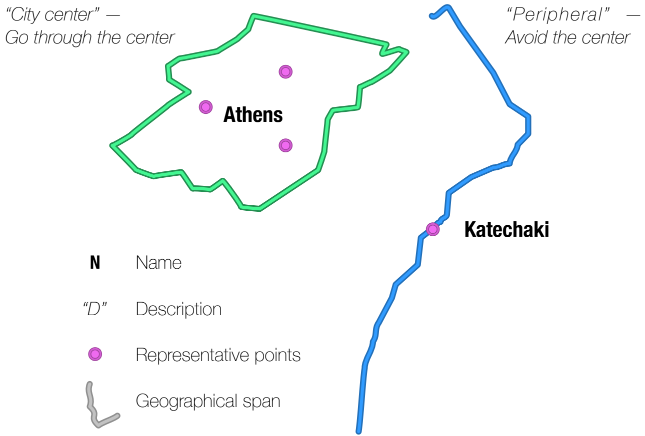
Metropolis-Hastings sampling of paths.
Transportation Research Part B: Methodological, 48:53–66.

Fosgerau, M., Frejinger, E., and Karlstrom, A. (2013).
A link based network route choice model with unrestricted choice set.
Transportation Research Part B: Methodological, 56(0):70 – 80.

The MRI components

Perceptual: a name and a description; Tangible: a point and a span



Specification of utility functions

Deterministic approach assuming a representative path per MRI

1. For each MRI determine a representative node r.
2. For each alternative, consider the sequence of nodes associated with the sequence of MRIs.
3. Generate the path starting from the O and connecting the nodes in the sequence through the shortest path up to the D.
4. The attributes and utility functions of the MRIs are those of the representative path.

Example of observed routes (1)

Around the CC movements

Example of observed routes (2)

Avoid the CC alternatives

Example of observed routes (3)

Through the CC movements