Assessing complex route choice models using an abstracted network based on mental representations

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Agenda

1. Context
2. Methodological framework
3. Playground
4. Conclusion

Agenda

Route choice modeling

- Data

1. Choice set generation

2. Correlation of alternatives

Recent advances

1. [Fosgerau et al., 2013] Recursive logit (RL) model
    1. Sequential link choice in a dynamic framework.
    2. Avoids full enumeration.
    3. No need for sampling.

    Further extended by [Mai et al., 2015] to the nested RL.

2. [Lai and Bierlaire, 2015] Cross-nested logit (CNL) model *with sampling* of alternatives
    1. Avoids full enumeration.
    2. Metropolis-Hastings for route choice proposed by [Flötteröd and Bierlaire, 2013].
    3. Expansion factor inspired by [Guevara and Ben-Akiva, 2013].

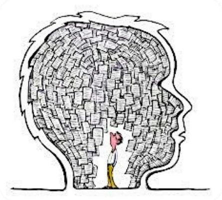
The MRI approach

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

→ Model the strategic decisions of people instead of the *operational* ones.

✓ 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.



Current work Objective

Potential of the MRI approach in simplifying complex route choice models:

1. RL
2. CNL

Comparison of the performance under the two representational approaches:

1. path
2. MRI

→ Identify the trade-offs:

- model fit
- complexity
- computational time

Current work Goal

Specification and comparison

model type	MRI	path
logit	✓	x
CNL	✓	x
RL	✓	✓

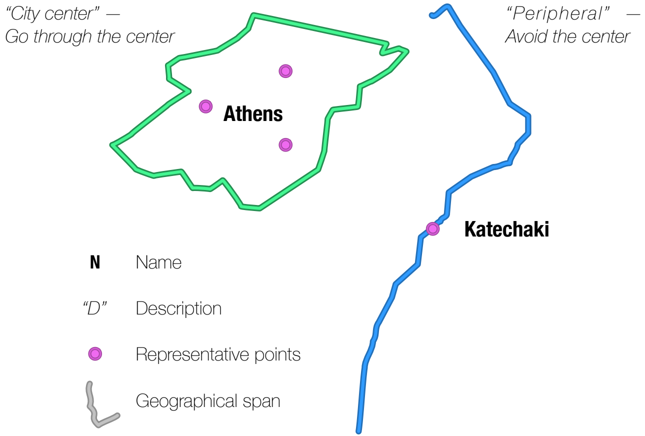
⊙ Operational issues

→ Modeling

Agenda

Recap The MRI definition

Conceptual: *a name and a description;* *Operational:* *a point and a span*



Recap Definition of alternatives

Following the definition of the `MRI`, a route is defined as:

1. an origin,
2. an ordered sequence of `MRIs` (possibly only one), and
3. a destination.

The MRI network

For a given case study & scope of analysis

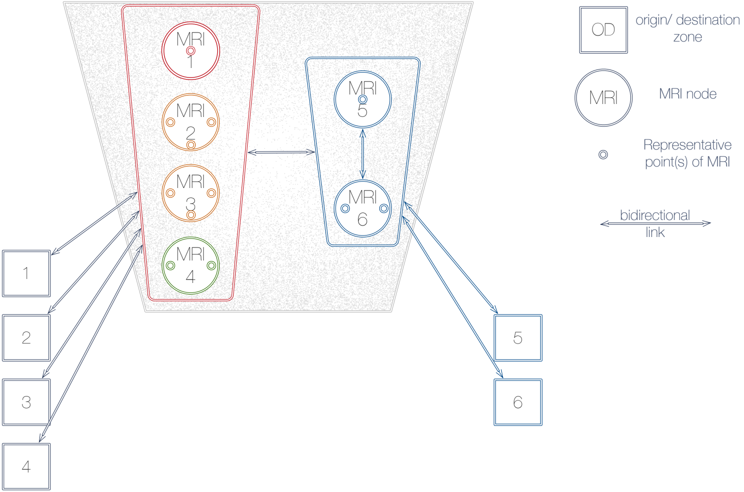
1. Determine the MRIs and the origin (O) and destination (D) zones.
2. For each MRI m create a node $\rightarrow$ a vertex in the MRI network.
3. For each O and D determine the centroid s of the zone $\rightarrow$ a vertex in the MRI network.

   $\Rightarrow$ The number of vertices of the MRI network equals the summation of the number of MRIs M and zone centroids $\mathcal{S}$.
4. For each pair of nodes in the MRI network create a link (edge) ℓ if the transition from one node to another is allowed.
5. Generate the attributes of the MRI links ℓ.

   ⊙ Different heuristics can be considered and evaluated.

The MRI network

Blueprint example

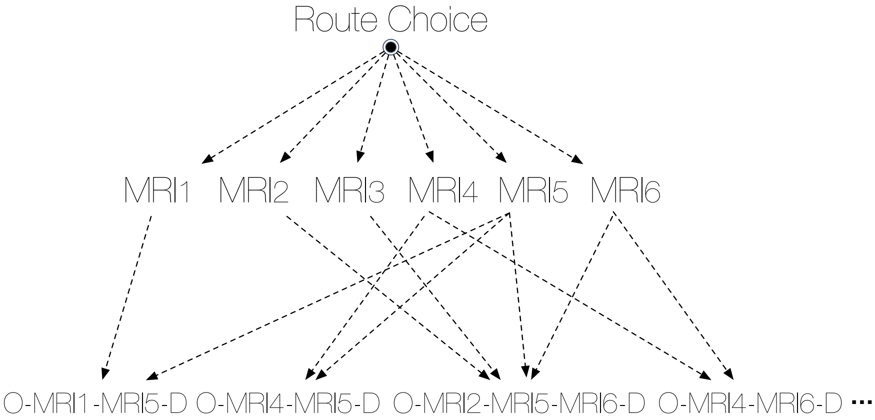


CNL with MRIs

- Each MRI is a nest.
- An alternative i belongs to nest m if MRI m appears in the sequence i.

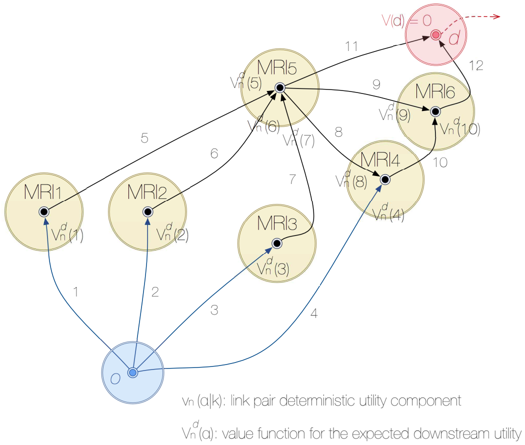
This is similar to [Vovsha and Bekhor, 1998] and [Lai and Bierlaire, 2015], but nests correspond to MRIs instead of links.

The underlying MRI nesting structure



RL with MRIs

As soon as the MRI network is defined it is trivial to apply the formulation proposed by [Fosgerau et al., 2013] for the RL model.



Evaluation

1. Direct comparison
    - Probabilities
    - Elasticities
2. Indirect comparison
    - Link flows
3. Computational times

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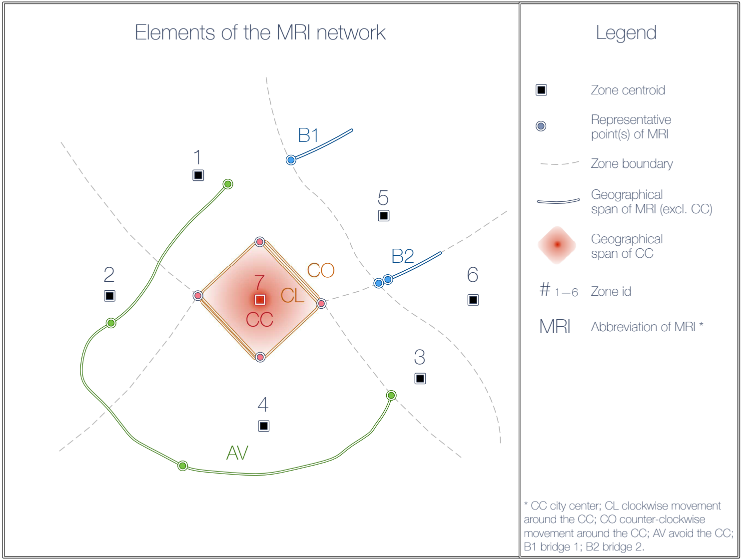
Borlänge dataset

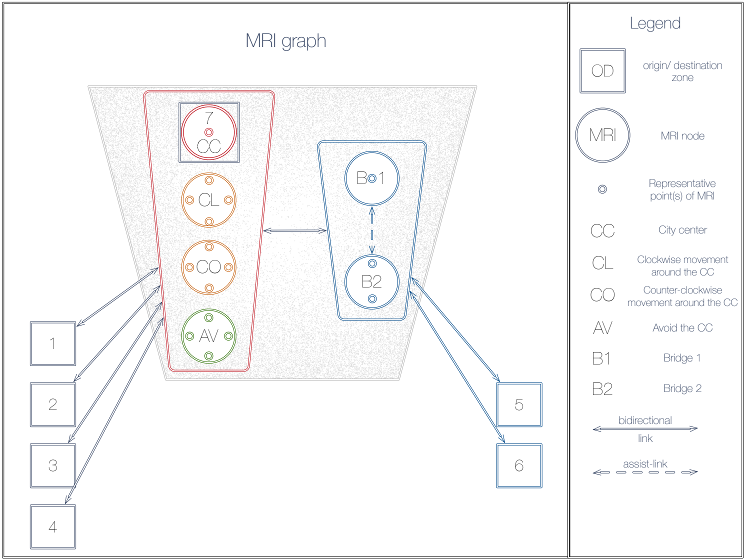
1. GPS data → `map-matched trajectories`
2. Borlänge road network:
   1. 3′077 nodes and 7′459 unidirectional links
   2. Link travel times
   3. Clear choices
3. We use a sample of 239 observations.

Borlänge road network

Borlänge MRI network elements



Borlänge MRI network



CNL

$$G(y) = \sum_{m=1}^{M} (\sum_{j=1}^{J} \alpha_{jm}^{\frac{\mu_m}{\mu}} y_j^{\mu_m}) \quad (1)$$

1. Impose α[1] and estimate μ_m[2]
2. Estimate both α and μ_m
   1. Parametrization of α to reduce the # of parameters $\alpha_{im} = \frac{\delta_{im} e^{w_m}}{\sum \delta_{jm} e^{w_\ell}}$
   2. w for groups of similar alternatives
3. Regress μ_m to `MRI` characteristics

[1] Parameter capturing the level of membership in a nest.

[2] Nest specific scale.

Estimation results

Parameters	**CNL with MRIs** Parameter value; Rob. Std (Rob. t-test 0)
ASC_{CC}	-2.08; 0.532 (-3.92)
ASC_{AV}	1.51; 0.253 (5.99)
ASC_{B1}	-1.94; 0.310 (-6.27)
β_{TIME}	-0.400; 0.049 (-8.22)
$\beta_{LEFTTURNS}$	-0.085; 0.058 (-1.47)
β_{IS}	-0.056; 0.030 (-1.87)
μ_{CC}	1.29; 0.872 (-0.33)[3]
Number of observations	239
Number of parameters	7
$\mathcal{L}(\hat{\beta})$	-189.485

[3] against 1

Estimation results (cont.)

Parameters	**logit with MRI constants** Parameter value; Rob. Std (Rob. t-test 0)	**RL with paths** Parameter value; Rob. Std (Rob. t-test 0)
ASC_{CC}	-2.09; 0.532 (-3.94)	
ASC_{AV}	1.54; 0.251 (6.12)	
ASC_{B1}	-1.99; 0.292 (-6.83)	
β_{TIME}	-0.402; 0.049 (-8.22)	-3.735; 0.235 (-15.91)
$\beta_{LEFTTURNS}$	-0.087; 0.058 (-1.50)	-1.035; 0.029 (-36.16)
β_{IS}	-0.056; 0.030 (-1.87)	-0.322; 0.083 (-3.86)
Number of observations	239	239
Number of parameters	6	3
$\mathcal{L}(\hat{\beta})$	-189.603	10.992

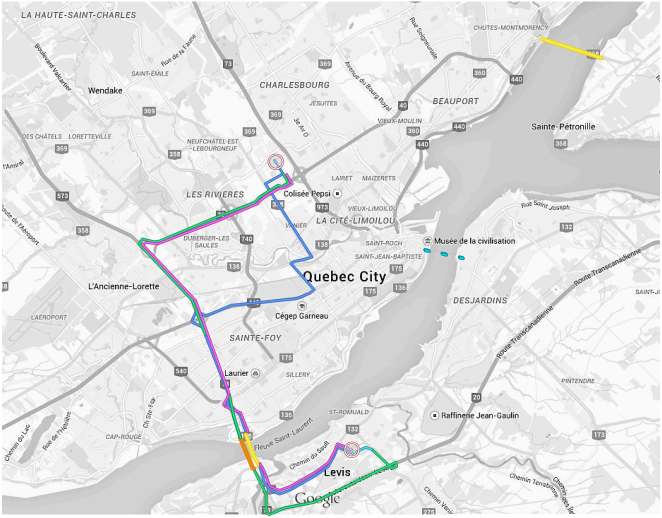
Quebec dataset

1. Smartphone data collection → `more than` 20′000 `GPS trajectories`
   - ✓ Departure times
   - ✓ Trip purposes
   - ✓ Land use information
2. Quebec road network:

   $\sim$ 80′000 nodes and 300′000 links

Quebec

Autoroutes and bridges



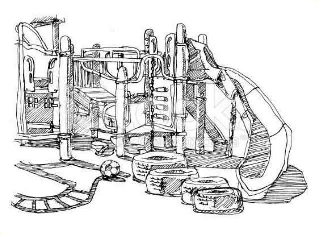
Quebec

Bridge vs ferry boat

Agenda

Conclusion

from



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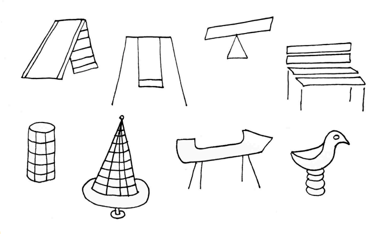
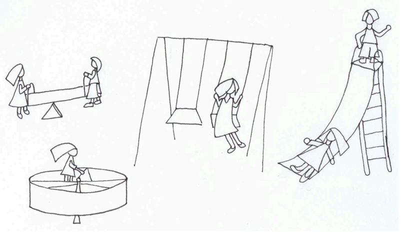
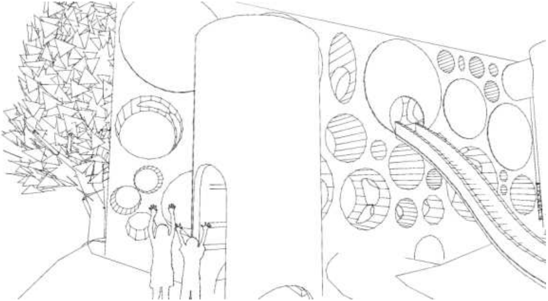


then





Thank you!

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RL model

- Link based (Akamatsu, 1996; Baillon and Cominetti, 2008);
- Dynamic discrete choice model (following Rust, 1987):

  → Path choice as a sequence of link choices.

  → At each node utilty-maximizing outgoing link.

  → Link utilities: instantaneous cost, EMU to the destination by means of value functions.

  → Link choice probabilities by MNL[4] model and expected downstream utilities by Bellman equations.

- Unrestricted choice set with infinite number of alternatives.

[4] Multinomial logit