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
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Route choice modeling

- Data
- Choice set generation
- Correlation of alternatives
Recent advances

1. [Fosgerau et al., 2013] Recursive logit (RL) model
   - Sequential link choice in a dynamic framework.
   - Avoids full enumeration.
   - 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
   - Avoids full enumeration.
   - Metropolis-Hastings for route choice proposed by [Flötteröd and Bierlaire, 2013].
   - 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)

**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

<table>
<thead>
<tr>
<th>model type</th>
<th>MRI</th>
<th>path</th>
</tr>
</thead>
<tbody>
<tr>
<td>logit</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>CNL</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>RL</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Operational issues

→ Modeling
Agenda

1. Context

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Recap The MRI definition

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

"City center" — Go through the center

"Peripheral" — Avoid the center

N  Name

"D" Description

Representative points

Geographical span

Katechaki
**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.

\[ \Rightarrow \text{The number of vertices of the MRI network equals the summation of the number of MRIs } M \text{ and zone centroids } S. \]

4. For each pair of nodes in the MRI network create a link (edge) \( \ell \) if the transition from one node to another is allowed.
5. Generate the attributes of the MRI links \( \ell \).

- 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.

\[ V_n(0) : \text{value function for the expected downstream utility} \]

\[ V_n^d(\alpha|k) : \text{link pair deterministic utility component} \]

\[ V_n^d(\alpha) : \text{value function for the expected downstream utility} \]
Evaluation

1. Direct comparison
   - Probabilities
   - Elasticities

2. Indirect comparison
   - Link flows

3. Computational times
Agenda

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Borlänge dataset

1. GPS data $\rightarrow$ map-matched trajectories

2. Borlänge road network:
   - 3’077 nodes and 7’459 unidirectional links
   - Link travel times
   - Clear choices

3. We use a sample of 239 observations.
Borlänge road network
Borlänge MRI network elements

Elements of the MRI network

Legend

- Zone centroid
- Representative point(s) of MRI
- Zone boundary
- Geographical span of MRI (excl. CC)
- Geographical span of CC
- # 1–6 Zone id
- MRI Abbreviation of MRI *

* CC city center; CL clockwise movement around the CC; CO counter-clockwise movement around the CC; AV avoid the CC; B1 bridge 1; B2 bridge 2.
Borlänge MRI network

Legend
- OD: origin/destination zone
- MRI: MRI node
- CC: city center
- CL: clockwise movement around the CC
- CO: counter-clockwise movement around the CC
- AV: avoid the CC
- B1, B2: bridges 1 and 2

Bidirectional link
Assist-link

Kazaghi & Bierlaire (EPFL, TRANSP-OR) DCA workshop 2016 April 21, 2016 19 / 27
CNL

\[ G(y) = \sum_{m=1}^{M} \left( \sum_{j=1}^{J} \alpha_{jm}^{\mu} y_j^{\mu_m} \right) \]  

1. Impose \( \alpha^1 \) and estimate \( \mu_m^2 \)
2. Estimate both \( \alpha \) and \( \mu_m \)
   1. Parametrization of \( \alpha \) to reduce the \# of parameters \( \alpha_{im} = \frac{\delta_{im} e^{wm}}{\sum \delta_{jme^{w\ell}}} \)
   2. \( w \) for groups of similar alternatives
3. Regress \( \mu_m \) to MRI characteristics

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1. Parameter capturing the level of membership in a nest.
2. Nest specific scale.
## Estimation results

<table>
<thead>
<tr>
<th>Parameters</th>
<th>CNL with MRIs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parameter value; Rob. Std (Rob. t-test 0)</td>
</tr>
<tr>
<td>$ASC_{CC}$</td>
<td>$-2.08; 0.532$ ($-3.92$)</td>
</tr>
<tr>
<td>$ASC_{AV}$</td>
<td>$1.51; 0.253$ ($5.99$)</td>
</tr>
<tr>
<td>$ASC_{B1}$</td>
<td>$-1.94; 0.310$ ($-6.27$)</td>
</tr>
<tr>
<td>$\beta_{TIME}$</td>
<td>$-0.400; 0.049$ ($-8.22$)</td>
</tr>
<tr>
<td>$\beta_{LEFTTURNS}$</td>
<td>$-0.085; 0.058$ ($-1.47$)</td>
</tr>
<tr>
<td>$\beta_{IS}$</td>
<td>$-0.056; 0.030$ ($-1.87$)</td>
</tr>
<tr>
<td>$\mu_{CC}$</td>
<td>$1.29; 0.872$ ($-0.33$)</td>
</tr>
</tbody>
</table>

| Number of observations | 239 |
| Number of parameters | 7 |
| $\mathcal{L}(\hat{\beta})$ | $-189.485$ |

[^3]: against 1
### Estimation results (cont.)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>( \text{logit with MRI constants} )</th>
<th>( \text{RL with paths} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parameter value; Rob. Std (Rob. ( t )-test 0)</td>
<td>Parameter value; Rob. Std (Rob. ( t )-test 0)</td>
</tr>
<tr>
<td>( ASC_{CC} )</td>
<td>(-2.09; 0.532) ((-3.94))</td>
<td></td>
</tr>
<tr>
<td>( ASC_{AV} )</td>
<td>(1.54; 0.251) (6.12)</td>
<td></td>
</tr>
<tr>
<td>( ASC_{B1} )</td>
<td>(-1.99; 0.292) ((-6.83))</td>
<td></td>
</tr>
<tr>
<td>( \beta_{TIME} )</td>
<td>(-0.402; 0.049) ((-8.22))</td>
<td>(-3.735; 0.235) ((-15.91))</td>
</tr>
<tr>
<td>( \beta_{LEFTTURNS} )</td>
<td>(-0.087; 0.058) ((-1.50))</td>
<td>(-1.035; 0.029) ((-36.16))</td>
</tr>
<tr>
<td>( \beta_{IS} )</td>
<td>(-0.056; 0.030) ((-1.87))</td>
<td>(-0.322; 0.083) ((-3.86))</td>
</tr>
</tbody>
</table>

| \( \text{Number of observations} \) | \(239\) | \(239\) |
| \( \text{Number of parameters} \) | \(6\) | \(3\) |
| \( \mathcal{L}(\hat{\beta}) \) | \(-189.603\) | \(10.992\) |
Quebec dataset

1. Smartphone data collection $\rightarrow$ 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
Conclusion

from

then

to
Thank you!

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Transportation Research Part B: Methodological, 56(0):70 – 80.

Sampling of alternatives in multivariate extreme value (mev) models.
Transportation Research Part B: Methodological, 48(0):31 – 52.

Specification of the cross-nested logit model with sampling of alternatives for route choice models.

A nested recursive logit model for route choice analysis.
Transportation Research Part B: Methodological, 75:100 – 112.

Link-Nested Logit Model of Route Choice: Overcoming Route Overlapping Problem.
Transportation Research Record: Journal of the Transportation Research Board, 1645:133–142.
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 utility-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