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

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Agenda

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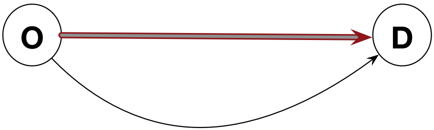
Route choice modeling



- Data

1. Choice set generation
2. Correlation of alternatives

Recent advances

1. [Fosgerau et al., 2013] Recursive logit (RL)
    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) *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].

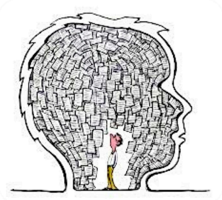
The MRI approach

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. EC[1]
3. CNL

→ Identify the trade-offs:

- model fit
- complexity
- computational time

[1] Error components

Current work *Goal*

Specification and comparison using real data

model type	MRI	path
MNL[2]	✓	–
RL	⊕	✓
EC	✓	–
CNL	⊕	–

[2] Multinomial logit

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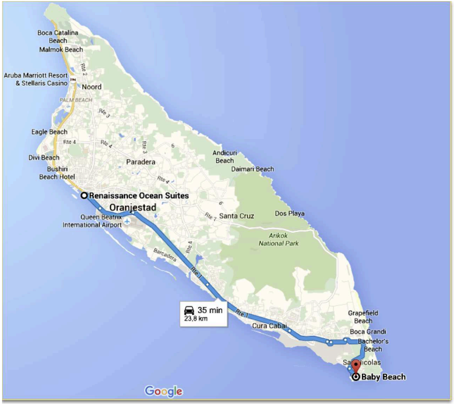
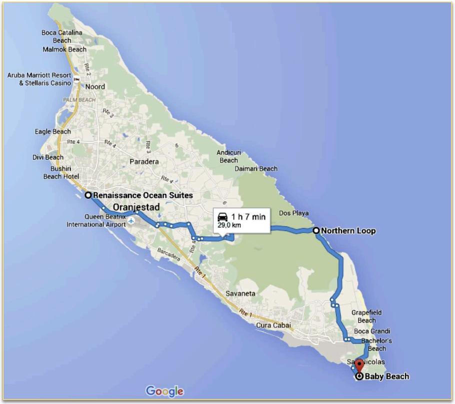
MRI example in Aruba





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

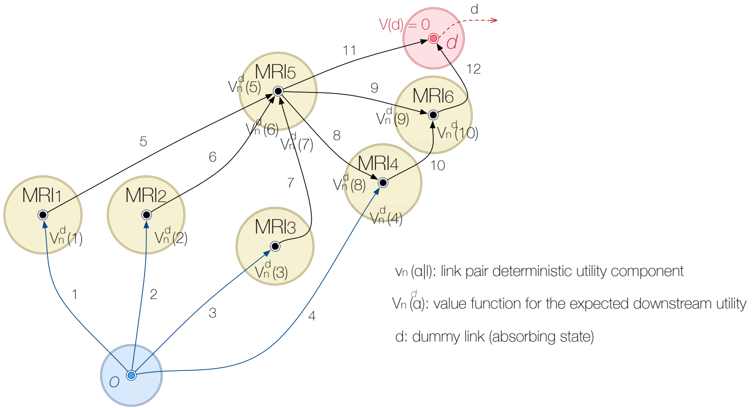
For a given case study & scope of analysis

1. Define the MRIs and the origin o and destination d zones.
2. For each MRI r creat a node.
3. For each o and d zone determine the centroid s of the zone and create a node corresponding to it.

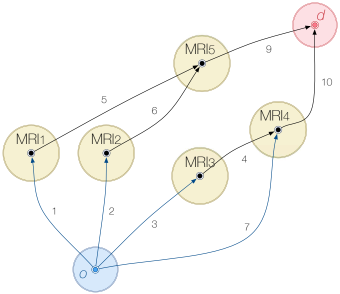
   The number of vertices of the MRI network equals the summation of the number of MRIs $\mathcal{R}$ and zone centroids $\mathcal{S}$.
4. For each pair of nodes in the MRI network create a link (edge) ℓ if the transition from one node to another is allowed.

RL model 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.



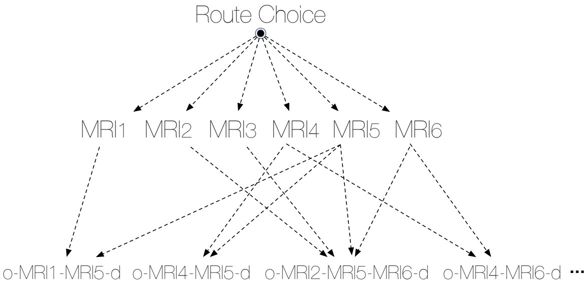
EC model with MRIs



- Each MRI is associated with an error component.
- An alternative i is correlated with alternative j if they use the same MRI.

This is similar to the subnetwork approach proposed by [Frejinger and Bierlaire, 2007], but the MRIs are also the building blocks of the alternatives in the choice set.

CNL model 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.

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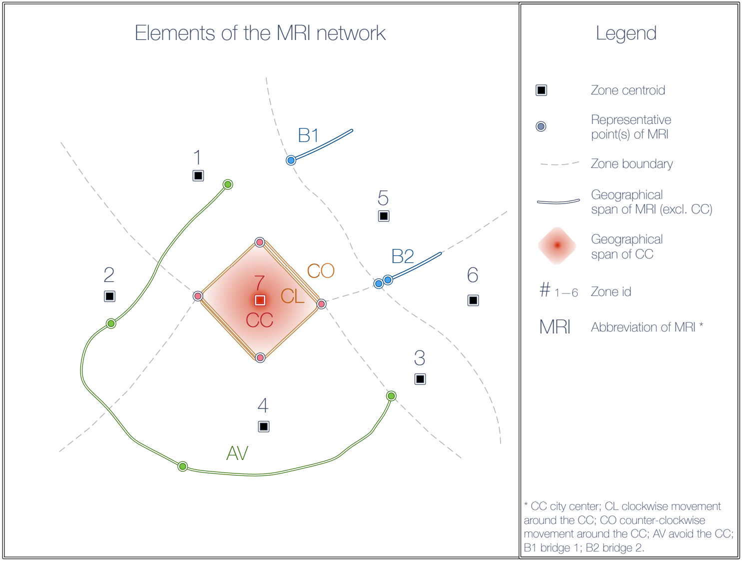
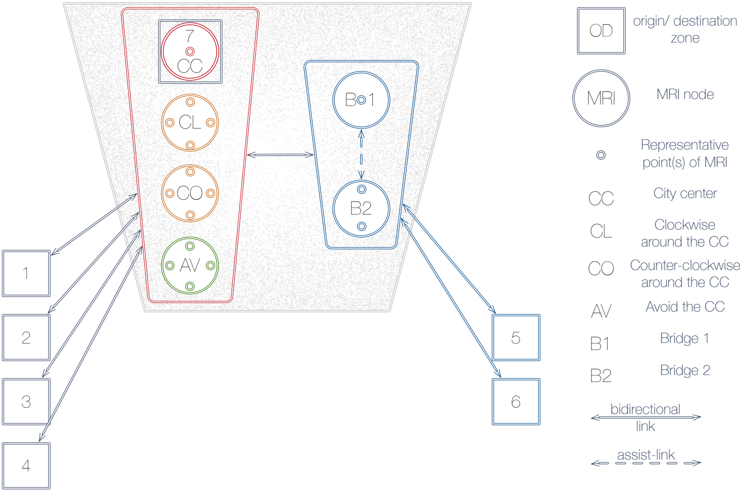
Borlänge dataset

1. GPS data → `map-matched trajectories`
2. Borlänge road network:
   1. 3077 nodes and 7459 unidirectional links
   2. Link travel times
   3. Clear choices
3. We identified 6 MRIs.
4. We use a sample of 239 observations.

Borlänge MRI network elements



Borlänge MRI network



Analysis

model type	MRI	path
MNL	✓	–
RL	$\oplus$	✓
EC	✓	–
CNL	$\oplus$	–

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

Specification table

Parameter name	**Model** 1 **MNL with** MRIs	**Model** 2 **EC with** MRIs	**Model** 3 **RL with paths**
ASC_{AVOID}	1	1	$\times$
ASC_{CC}	1	1	$\times$
$ASC_{BRIDGE1}$	1	1	$\times$
β_{TIME}	TT[3] (min)	TT (min)	TT (min)
β_{IS}	# intersections	# intersections	# intersections
β_{LT}	# left turns	# left turns	# left turns
ω_{AVOID}	$\times$	$\sim \mathcal{N}(0, \sigma^2_{AVOID})$	$\times$
ω_{CC}	$\times$	$\sim \mathcal{N}(0, \sigma^2_{CC})$	$\times$
$\omega_{BRIDGE1}$	$\times$	$\sim \mathcal{N}(0, \sigma^2_{BRIDGE1})$	$\times$

[3] TT: travel time

Estimation results

Parameter name	Model 1: MNL with MRIs Parameter value; (Rob. t-test 0)	Model 2: EC with MRIs Parameter value; (Rob. t-test 0)	Model 3: RL with paths Parameter value; (t-test 0)
ASC_{AVOID}	**1.69; (5.51)**	**2.25; (5.24)**	-
ASC_{CC}	**-2.07; (-3.96)**	**-6.38; (-1.11)**	-
$\mathrm{ASC}_{BRIDGE1}$	**-1.93; (-5.01)**	**-4.14; (-2.93)**	-
β_{TIME}	**-0.474; (-14.94)**	**-0.596; (-13.86)**	**-3.735; (-15.91)**
β_{IS}	**-0.041; (-1.45)**	**-0.115; (-3.01)**	**-0.322; (-3.86)**
β_{LT}	**-0.076; (-1.50)**	**-0.104; (-1.58)**	**-1.035; (-36.16)**
ω_{AVOID}	-	**2.05; (3.46)**	-
ω_{CC}	-	**3.96; (1.24)**	-
$\omega_{BRIDGE1}$	-	**4.59; (2.17)**	-
Number of observations	239	239	239
Number of parameters	6	9	3
Number of draws	-	1000	-
$\mathcal{L}(0)$	-619.617	-629.983	
$\mathcal{L}(\hat{\beta})$	-193.633	-183.558	10.992

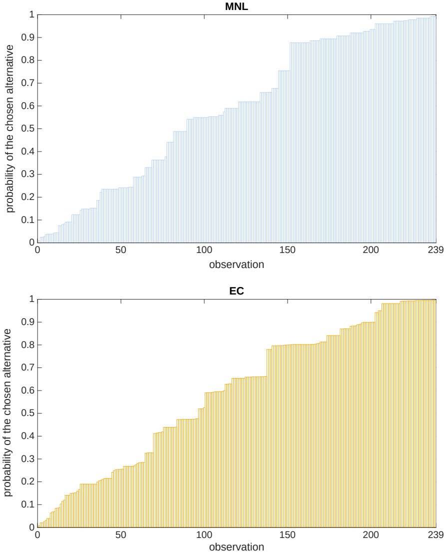
Ratios of parameters

Model	β_{TIME}	β_{IS}	β_{LT}	β_{IS}/β_{TIME}	β_{LT}/β_{TIME}	β_{IS}/β_{LT}
MNL	-0.474	-0.0408	-0.0761	0.086	0.161	0.536
RL	-3.735	-0.322	-1.035	0.086	0.277	0.311
EC	-0.596	-0.115	-0.104	0.193	0.174	1.106

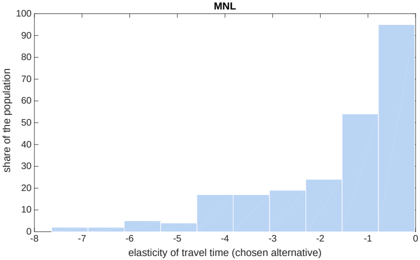
Computational times

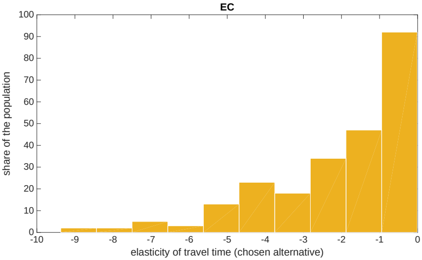
Model	MRI representation	path representation
MNL	0 min	–
RL	?	$\sim$ 20 min
EC	$\sim$ 60 min	–

Probability of the chosen alternative

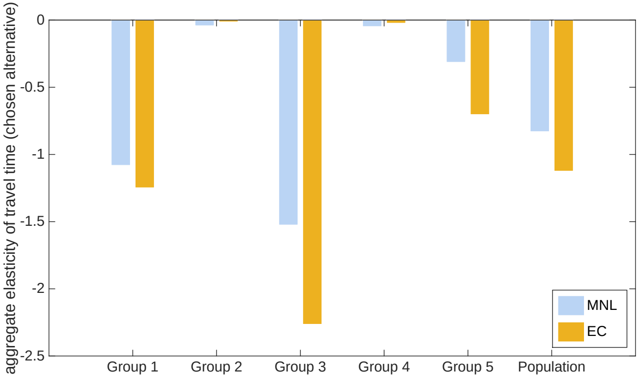


Elasticity of travel time (chosen alternative)

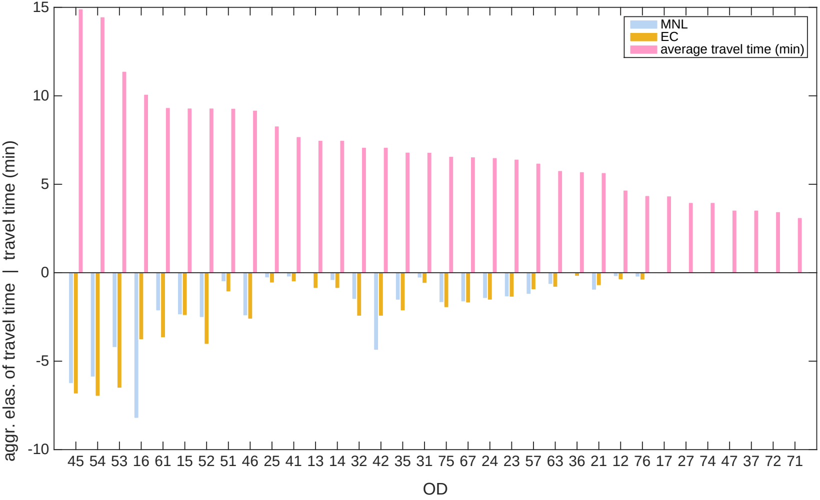




Aggregate elasticity of travel time (chosen alternative)



Aggregate elasticity of travel time (chosen alternative)



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Conclusion

- Exploiting behavioral rationale to facilitate the estimation and application of route choice models to large networks.
  1. MNL as a benchmark.
  2. EC: `MRI` approach to capture perceptual correlation.
  3. RL: `MRI` approach to reduce the state space.
  4. CNL: `MRI` approach to reduce the number of nests.
- Comparison under the `MRI` approach.

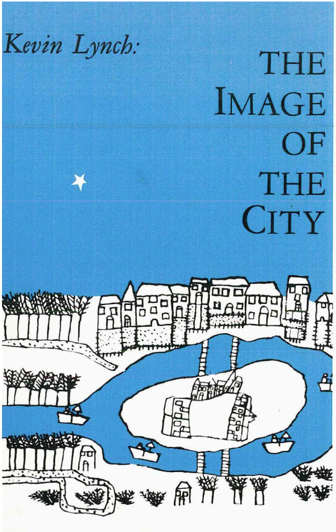
Future work

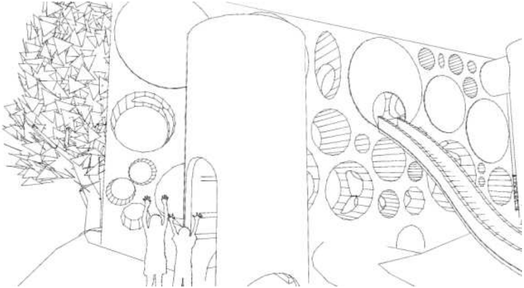
1. Apply MRI approach to a large network and dataset.
   - City of Québec.
   - More than 20000 GPS trajectories.
2. Relevance for route guidance and map design.
   - [Gallotti et al., 2016] Lost in transportation: Information measures and cognitive limits in multilayer navigation.

Mapping, Beirut-style: how to navigate a city without using any street names.

Jenny Gustafsson in Beirut, for The Guardian (June, 2015)

"It is about learning how a city works. There is usually a very clear order; you just have to understand it. Once you know this, navigation is not hard. ... references and directions like 'nearby', 'opposite' and 'in between', because roads often have no signs. ... creative names like "The Road with the Oak Tree"..."





Thank you!

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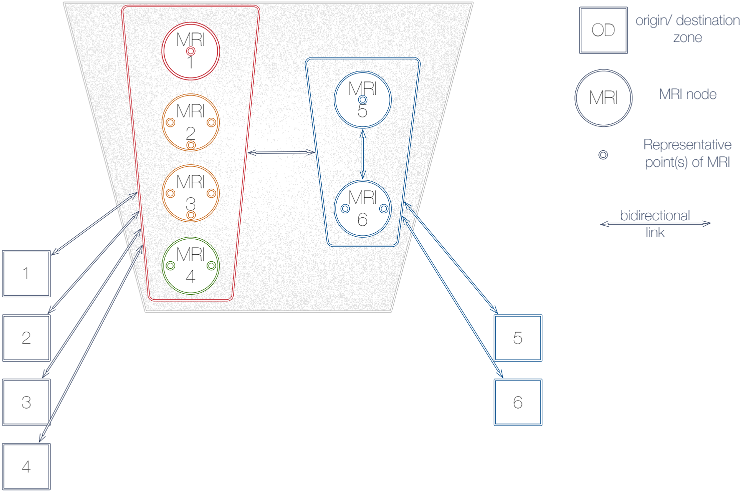
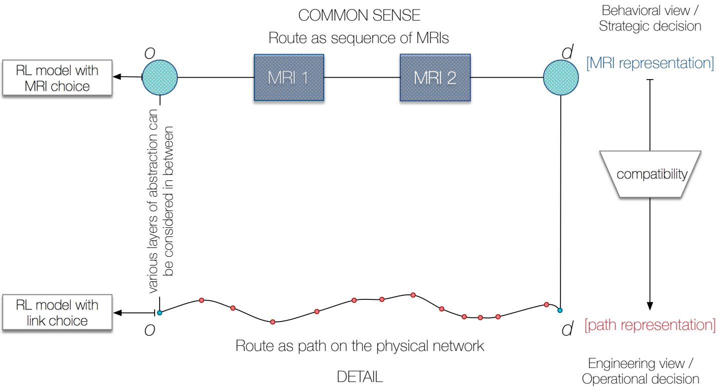
The MRI network

Blueprint example



From MRIs to paths



Québec dataset

1. Smartphone data collection → `more than 20000 GPS trajectories`

   ✓ Departure times

   ✓ Trip purposes

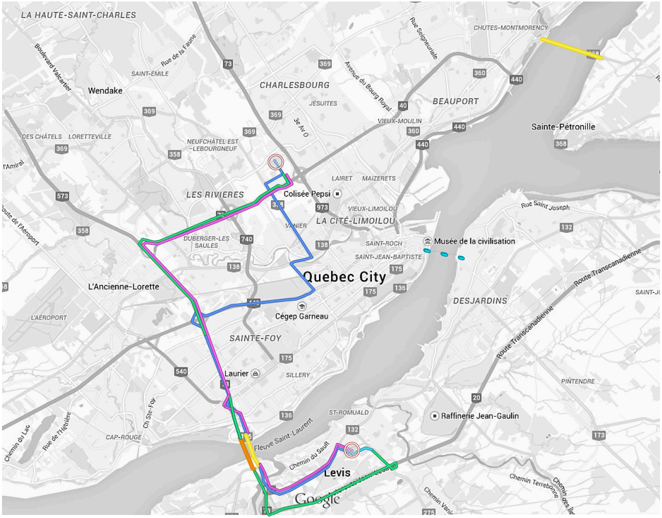
   ✓ Land use information

2. Quebec road network:

   ∼ 20000 nodes and 40000 unidirectional links

Québec

Autoroutes and bridges



Québec

Bridge vs ferry boat