Workshop on Discrete Choice Models 2014

Revisiting Route Choice Modeling: A Multi-Level Modeling Framework for Route Choice Behavior

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Agenda

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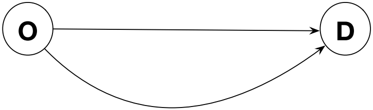
Route choice (RC)

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



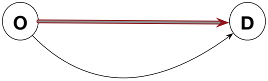
→ Off-line and real time services and applications:

- Transportation policies;
- Decision-aid tools;
- Real time operations;
- Informed decision-making.

Random utility models for RC

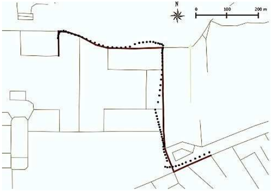
Goal

Understand, describe, predict route choice behavior.



Route representation:

Paths are used to model route choice.



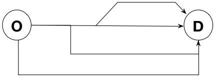
Challenges

- High requirements in data and data processing;

  Dealing with errors: Bierlaire & Frejinger, 2008; Bierlaire et al., 2013

- Physical overlap of paths;

  Capturing correlation: Cascetta et al., 1996; Ben-akiva & Bierlaire, 1999; Vovsha & Bekhor, 1998; Bekhor et al., 2002; Ramming, 2002; Frejinger & Bierlaire, 2007



- Size and composition of choice set.

  Path generation and sampling: Ben-Akiva et al., 1984; Azevedo et al., 1993; de la Barra et al., 1993; Zijpp & Fiorenzo Catalano, 2005; Friedrich et al., 2001; Hoogendoorn-Lanser, 2005; Prato & Bekhor, 2006; Bovy & Fiorenzo-Catalano, 2007; Frejinger et al., 2009; Flötteröd & Bierlaire, 2013; Lai & Bierlaire, 2014

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Objective

Tackle the challenges related to RC analysis while keeping the model as *simple* as possible, yet *behaviorally realistic*.

1. Develop a flexible framework for analysing and predicting RC behavior;
2. Operational for large-scale networks.

Scope

Car route choice.

Distinctive feature

Representation of routes: *Mental representation item* (MRI).

Agenda

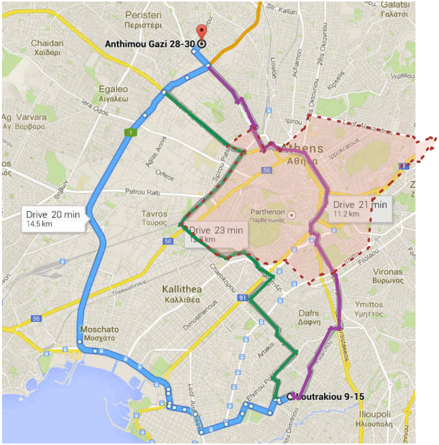
Representation of decision

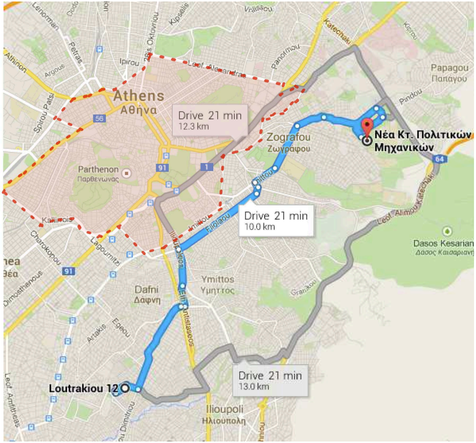
A *path* is solely the manifestation of the route choice –the way the traveler implements her decision to take a specific route.

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

- Hypothesis: Choice takes place in a higher conceptual level → Aggregate route representation (ARR).
- Concept: *Mental Representation Item* (MRI).

From my home to i) a friend's place, ii) N'TechUniAth



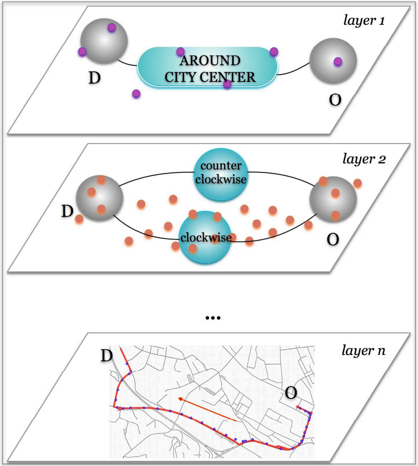


MRIs

- The MRI approach is behaviorally realistic and convenient.
- The MRIs are geo-marked elements elicited from the network.
- An MRI may be the highway or the city center.
- Several possible paths connecting the OD pair on the transportation network correspond to the same MRI.
- Hierarchical ordering of the MRIs, based on varying level of abstraction/ detail in the ARR.

MRI vs path example

Definition of layers: modeling considerations, i.e. trade-off btw complexity and tractability, & data.



strategic decision

operational decision

Model structure

Each layer is characterised by a choice set of MRIs. Starting from the top layer ℓ corresponding to choice set $\mathcal{C}_\ell$, the probability of choosing MRI (or MRI sequence) r given the set of MRIs $\mathcal{C}_\ell$ is:

$$P_\ell(r|\mathcal{C}_\ell;\beta^\ell) \tag{1}$$

where β denotes the vector of the unknown parameters to be estimated.

Similarly for layer $\ell+1$ the choice set is $\mathcal{C}_{\ell+1}$ and the probability is then:

$$P_{\ell+1}(r|\mathcal{C}_{\ell+1};\beta^{\ell+1}) \tag{2}$$

All layers refer to the same choice. The difference is the level of detail in the representation.

Route choice analysis can be conducted in each layer of the underlying hierarchy.

Arising issues

Framework hierarchy and consistency

The choice probability in layer ℓ can also be derived from layer $\ell+1$ as follows:

$$\bar{P}_\ell(r|\mathcal{C}_\ell;\beta^\ell) = \sum_{k\in\mathcal{C}_{\ell+1}} P(r|k,\mathcal{C}_\ell;\beta^\ell)P(k|\mathcal{C}_{\ell+1};\beta^{\ell+1}) \quad (3)$$

where $P(r|k)$ is the probability that representation r in layer ℓ is consistent with representation k in layer $\ell+1$, and $P(k|\mathcal{C})_{\ell+1}$ is the choice model in layer $\ell+1$.

Consistency is evaluated on the basis of the choice probabilities derived from the different layers.

Arising issues

Definition of MRIs

For the operationalization of the items we ask for:

1. Behaviorally realistic definition.
2. Appropriate definition to keep the model simple.

Relevant literature wrt representation of large-scale environment and spatial behavior:

Tolman (1948), Lynch (1960); Suttles (1972); Chase (1983); Couclelis et al. (1987); Golledge (1999); Golledge and Gärling (2003); Arentze and Timmermans (2005); Hannes et al. (2008).

Agenda

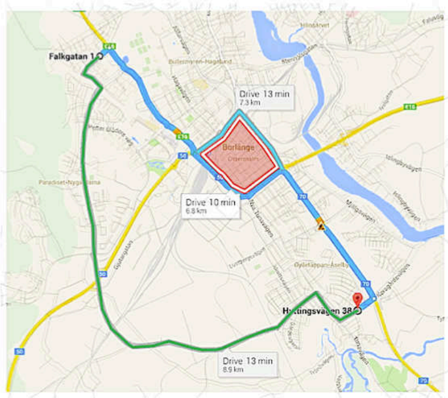
Borlänge data

- GPS data from 24 vehicles:
  401 observations, 329 observed routes
  341 OD pairs
- Borlänge road network:
  3077 nodes and 7459 unidirectional links

Borlänge road network

Example of route options for given OD pairs

Google Maps Directions API



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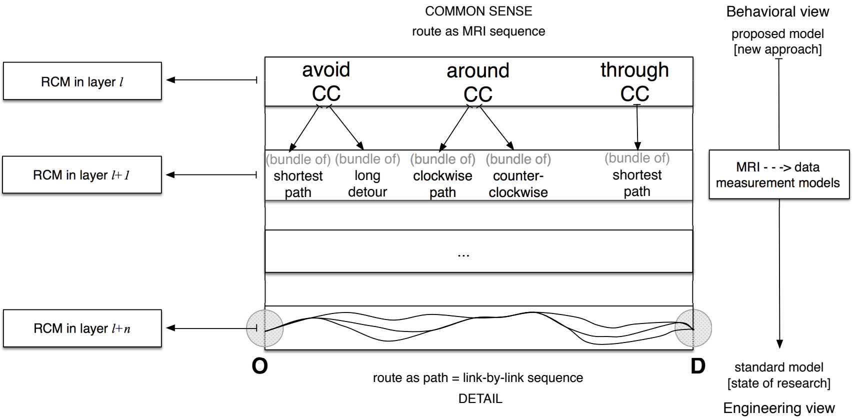
MRI choice set

No need for choice set generation. CS independent of OD.



Assignment of observed routes to MRIs

Currently we assign each observation to an MRI manually.

OBS: the most used links are traversed by bus lines.

Example of observed route (1): R70N–around_CC–R50N

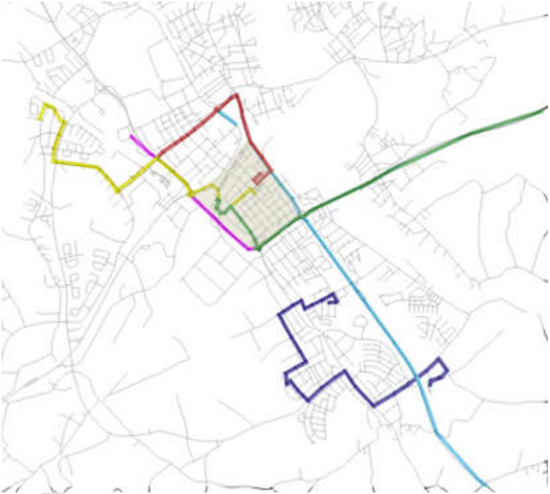
Example of observed route (2): Bridge (avoid_CC)

Example of observed route (3): Paradisvägen (avoid_CC)

Example of observed routes (4)

Example of observed route (5)

Example of observed routes (6)



Assigning attributes to MRIs (unchosen alternative)

Deterministic approach

1. Assume that given the choice in the upper layer the corresponding action for its implementation is: e.g. the shortest or the fastest path.
2. Elicit the attributes from this path solely.

The approach may be adjusted accordingly, to accommodate the trade-offs between complexity/ realism and tractability of the model.

MRI choice set and type of model

The way the CS is defined and the assumed structure determines the appropriate type of model.

- We can assume that the IIA property holds for the CS of the upper layer → a simple logit model can be used.
- Alternative types of models can be investigated (e.g. the PSL or the EC model with subnetworks could be appropriate).
- First priority is to keep the model as simple as possible.

Model specification

The deterministic part of the utility for alternative r is:

$$V_r = \beta + \beta_{TT} Est.Time_r + \beta_{SB} nbSpeedBumps_r +$$

$$+\beta_{LT} nbLeftTurns_r + \beta_{LL} avgLinkLenght_r$$

- At the moment, same specification as the one of the models presented in Frejinger and Bierlaire (2007).
- Aggregate attributes, e.g. congestion index for each MRI depending on the time of day when the trip takes place, or ratings denoting how scenic an MRI is.

Agenda

Conclusion

1. Flexibility

   Trade-off between complexity and realism explicitly controlled by the analyst, depending on the availability of data and the application.

2. Tackels choice set challenges:
   - Simplification of the composition of the CS;
   - Reduction in the size of the CS.

3. Simplification of the correlation $\rightarrow$ reduction in model complexity.

4. Behaviorally realistic approach.

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THANK YOU!