Estimation of choice models in dynamic traffic simulations

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Outline

Introduction

A macroscopic path flow estimator

A microscopic behavioral estimator

Application to DRACULA

Application to MATSim

Summary, outlook

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A macroscopic path flow estimator

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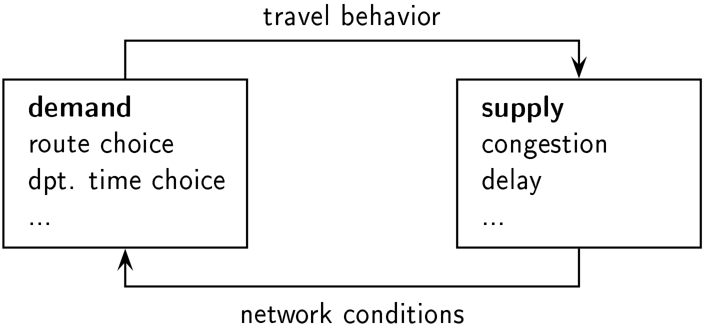
Summary, outlook

Iterated DTA microsimulations



- account for arbitrary demand dimensions
- capture arbitrary demand heterogeneity
- handle complex and large systems

Calibration of iterated DTA microsimulations

- OD matrix / path flow estimation is of limited use
  - cannot estimate all demand dimensions
  - hardly accounts for demand heterogeneity
  - computationally involved
- supply calibration: not the topic of this talk

Outline

Prior path flows

- a minimum of notation

n	origin/destination (OD) pair, $n = 1 \dots N$
d_n	number of trips between OD pair n
C_n	set of available routes for OD pair n
d_{ni}	number of trips on route $i \in C_n$

- path flows $\mathbf{d} = (d_{ni})$ are consistent with network conditions

$$d_{ni} = P_n(i|\mathbf{d})d_n \quad \forall n, i \in C_n$$

where $P_n(i|\mathbf{d})$ is the congestion-dependent route choice model

Derivation of estimator

1. consistent path flows maximize **prior entropy function**

$$W(\mathbf{d}) = \sum_{n=1}^{N} \sum_{i \in C_n} d_{ni} \ln \frac{P_n(i|\mathbf{d})}{d_{ni}}$$

2. relate traffic counts $\mathbf{y}$ to path flows $\mathbf{d}$ through likelihood $p(\mathbf{y}|\mathbf{d})$
3. path flows given counts maximize **posterior entropy function**

$$W(\mathbf{d}|\mathbf{y}) = \ln p(\mathbf{y}|\mathbf{d}) + W(\mathbf{d})$$

4. evaluate optimality conditions...

Posterior path flows

- route choice model given the traffic counts $\mathbf{y}$ fulfills

$$P_n(i|\mathbf{d}, \mathbf{y}) \sim \exp\left(\frac{\partial \ln p(\mathbf{y}|\mathbf{d})}{\partial d_{ni}}\right) P_n(i|\mathbf{d})$$

- replace iterative optimization by path flow distribution scaling
- apart from local linearizability, no modeling assumptions

Outline

Reinterpretation of the macroscopic setting

- notation, revisited

n	individual traveler, $n = 1 \dots N$
d_n	number of repeated choice situations
C_n	set of available **travel plans** for individual n
d_{ni}	number of times traveler n chooses plan $i \in C_n$
$P_n(i\|\mathbf{d})$	congestion-dependent plan choice distribution

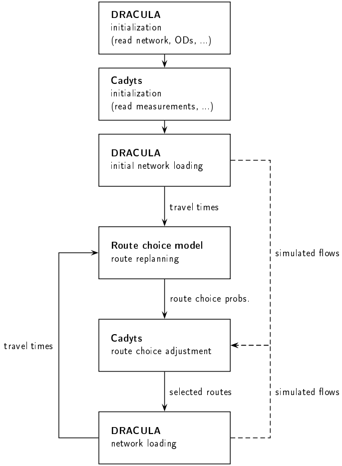
- estimation: select plans from **posterior choice distribution**

$$P_n(i|\mathbf{d},\mathbf{y}) \sim \exp\left(\frac{\partial \ln p(\mathbf{y}|\mathbf{d})}{\partial P_n(i|\mathbf{d},\mathbf{y})}\right) P_n(i|\mathbf{d})$$

...as before!

Outline

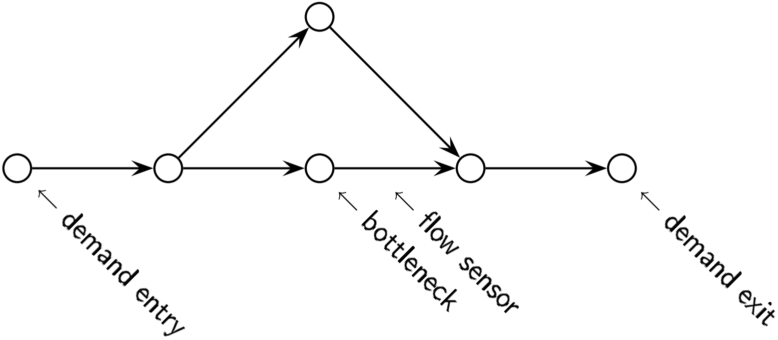
Application to DRACULA



- file-based interaction via Python script
- in every iteration
  1. route choice model computes choice probs.
  2. Cadyts[a] writes chosen routes
  3. DRACULA writes travel times

[a] "Calibration of dynamic traffic simulations", see `transp-or2.epfl.ch/cadyts/`

Test case: network



- route length difference is 1 km
- free-flow travel time difference is 23 s

Test case: choice model

- choice model:
  - stay at home with prob. P_0 (used $\approx$0.091 $\Rightarrow$ little variability)
  - otherwise, choose route according to logit model
- formally:

$$\begin{aligned} P(\text{stay at home}) &= P_0 \\ P(\text{take route } i) &= (1 - P_0)\frac{\exp(\beta t_i)}{\sum_j \exp(\beta t_j)} \end{aligned}$$

where

- β captures sensitivity to travel time (used -0.01 s^{-1} $\Rightarrow$ fair variability)
- t_i is travel time along route i in previous iteration

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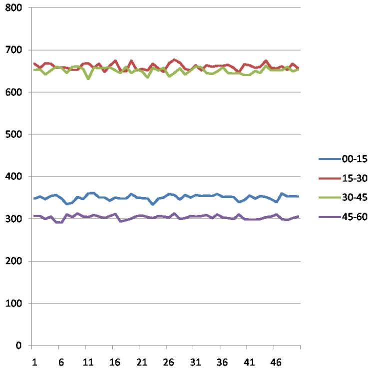
Results in numbers

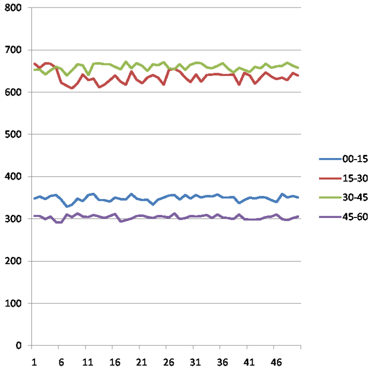
flow[veh] \ time	0:00-0:15	**0:15-0:30**	**0:30-0:45**	0:45-1:00
sim. demand	351	**659**	**653**	303
sim. sensor flow	164	**297**	**321**	212
"real" sensor data	–	**200**	**450**	–
estim. demand	350	**639**	**662**	303
estim. sensor flow	164	**188**	**331**	225

- all values averaged over 15 iterations
- for now, replace significance test by visual inspection ...

Results: demand dynamics



simulated demand over iterations



estimated demand over iterations

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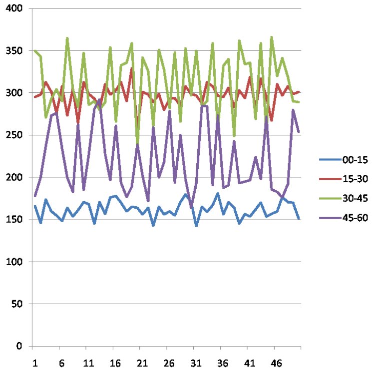
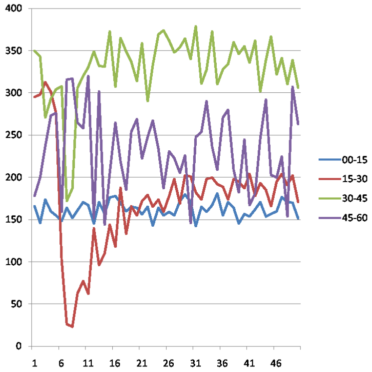
Results: sensor flow dynamics



simulated flow over iterations



estimated flow over iterations

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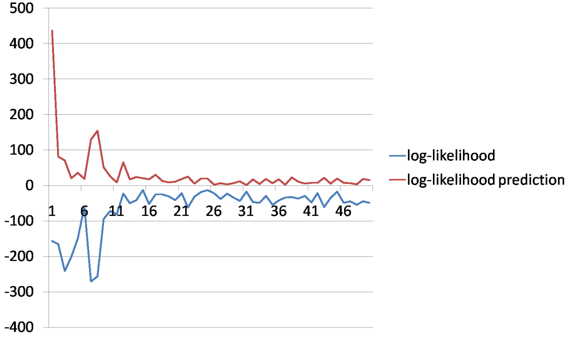
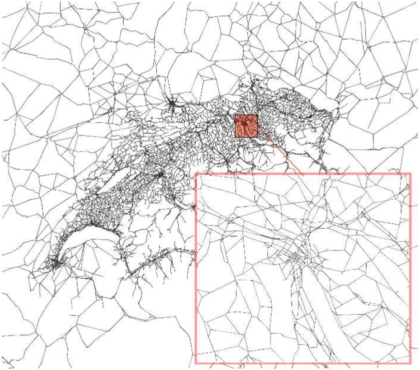
Results: dynamics of log-likelihood



(predicted) log-likelihood over iterations

Outline

Zurich case study

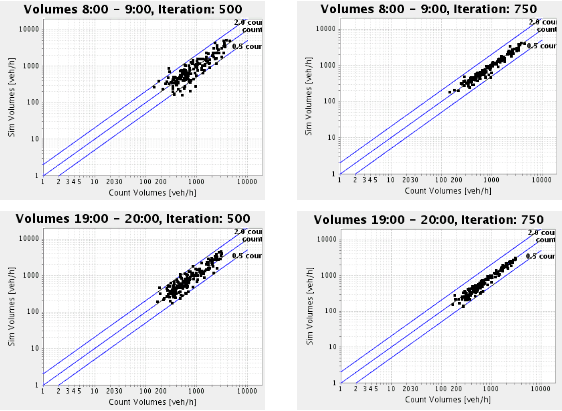


- network with 60 492 links and 24 180 nodes
- 187 484 agents
- hourly counts from 161 counting stations
- jointly estimate route + dpt. time + mode choice

Results: qualitatively

plain simulation | with calibration

morning | evening



Results: quantitatively

	reproduction $(\cdot)^2$ error	validation $(\cdot)^2$ error	comp. time until stationarity
plain simulation	103.6	103.6	$18^1/_2$ h
estimated simulation	20.9	75.1	$20^1/_4$ h
relative difference	- 80 %	- 28 %	+ 9 %

Outline

Summary, outlook

- disaggregate and dynamic calibration of arbitrary choice dimensions from traffic counts
- freely available software: `transp-or2.epfl.ch/cadyts`
- ongoing work:
  - computation of posterior choice model *parameters*
  - applications: MATSim, DRACULA, SUMO
- future work:
  - disaggregate data sources
  - within-day replanning
  - supply calibration