Online calibration of dynamic traffic assignment

Gunnar Flötteröd and Michel Bierlaire

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Calibration of iterated DTA microsimulations

- DTA microsimulations
  - simulate more than route choice (e.g., dpt. time, mode)
  - capture arbitrary demand heterogeneity
  - handle complex and large systems

- existing demand calibration: OD matrix estimation / PFE of limited use
  - cannot estimate all demand dimensions
  - hardly accounts for demand heterogeneity
  - computationally involved

- supply calibration: more amenable to physically motivated techniques
Online demand calibration

- parameters are stable over many days
- what changes are the states (here: choices, plans)
- online demand calibration: update the individual-level choice distributions in the simulated traveler population from sensor data
- (offline demand calibration: update the underlying parameters)
Outline

A macroscopic path flow estimator

Microsimulation perspective

Case study

Summary, outlook
Outline

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Summary, outlook
Prior path flows

- a minimum of notation

  - $n$ origin/destination (OD) pair, $n = 1 \ldots N$
  - $d_n$ 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 $d = (d_{ni})$ are consistent with network conditions

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

  where $P_n(i|d)$ is the congestion-dependent route choice model
Derivation of Bayesian estimator

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

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

2. relate traffic counts \( y \) to path flows \( d \) through likelihood \( p(y|d) \)

3. path flows given counts maximize **posterior entropy function**

\[
W(d|y) = \ln p(y|d) + W(d)
\]

4. evaluate optimality conditions...
Posterior path flows

• route choice model given the traffic counts \( y \) fulfills

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

• replace iterative optimization by path flow distribution scaling
• apart from local linearizability, no modeling assumptions
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Summary, outlook
Reinterpretation of the macroscopic setting

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

- calibration: select plans from posterior choice distribution
  \[
P_n(i|d, y) \sim \exp \left( \frac{\partial \ln p(y|d)}{\partial P_n(i|d, y)} \right) \cdot P_n(i|d)
  \]
  ...as before!
How to implement the calibration

Algorithm

1. choose initial network conditions
2. repeat until consistency
   2.1 linearize log-likelihood function in given network conditions
   2.2 select plans for all agents from scaled choice distributions
   2.3 load all agents on the network

\[\text{analytically, based on proportional assignment or regression}\]
\[\text{by actual prob. scaling, adjustment of ASCs, rejection sampling, ...}\]
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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
- Off-line calibration for an entire day
Results, qualitatively

plain simulation

morning

Volumes 8:00 - 9:00, Iteration: 500

evening

Volumes 19:00 - 20:00, Iteration: 500

with calibration

Volumes 8:00 - 9:00, Iteration: 750

Volumes 19:00 - 20:00, Iteration: 750
## Results, quantitatively

<table>
<thead>
<tr>
<th></th>
<th>Reproduction $(\cdot)^2$ Error</th>
<th>Validation $(\cdot)^2$ Error</th>
<th>Computing Time for 24 h Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain Simulation</td>
<td>103.6</td>
<td>103.6</td>
<td>133 sec</td>
</tr>
<tr>
<td>Calibrated Simulation</td>
<td>20.9</td>
<td>75.1</td>
<td>146 sec</td>
</tr>
<tr>
<td>Relative Difference</td>
<td>-80%</td>
<td>-28%</td>
<td>+9%</td>
</tr>
</tbody>
</table>

- Global improvements, no overfitting: lower validation improvement due to limited scope of sensor data
- Computationally ready for real time applications
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Summary, outlook
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- Disaggregate and dynamic calibration of arbitrary choice dimensions from traffic counts.
- Freely available software toolbox: transp-or2.epfl.ch/cadyts.
- Ongoing work:
  - Calibration of choice model parameters.
  - Applications: MATSim, SUMO, DRACULA.
- Future work:
  - Supply calibration.
  - Disaggregate data sources.