Recent advances in the calibration of travel demand models from traffic counts

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June 24, 2009
Outline

Introduction and motivation

Microsimulation-based traffic monitoring

Real world case study – the city of Zurich

Summary
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Summary
Aggregate demand calibration from traffic counts

• typical modeling approaches
  – demand = time-dependent origin/destination matrix + route assignment logic
  – supply = move flows/vehicles along routes, account for congestion

• typical demand calibration techniques
  – OD matrix calibration
  – path flow estimation
Why not calibrate the *causation* of traffic?

- **plan A**
  1. sleep late 😊
  2. 9:00 – 18:00 work
  3. shop afterwards
  4. late at home 😞

- **plan B**
  1. get up early 😞
  2. shop beforehand
  3. 9:00-18:00 work
  4. early at home 😊
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Microsimulation-based DTA

- **demand simulator**
  - individual travel behavior
    - route choice
    - dpt. time choice
    - act. (location) choice
  - chooses **plan** for every single traveler

- **supply simulator**
  - interactions of vehicles
    - traffic flow dynamics
    - congestion
    - travel times
  - joint plan execution yields **network conditions**

**network conditions**

- **travel behavior: plans**
Measurements provide additional information

- Bayes theorem combines prior demand model with traffic counts into posterior demand model:

\[
P(\text{plans}|\text{counts}) \propto P(\text{plans}) \cdot P(\text{counts}|\text{plans})
\]

1. **prior**: simulation system draws from this distribution
2. **likelihood**: prob. of traffic counts given simulated plans
3. **posterior**: revised distribution given the measurements

- Calibration objective is to make the simulator draw from the posterior plan choice distribution.
Realization of calibrated behavior

- It is possible to approximately enforce the desired posterior plan choice – only by external manipulations of the individual choice behavior of (re)planning travelers.

- Two possible methods:
  1. Accept the choice of a plan only with a certain probability. Otherwise, ask for another choice.
  2. Add a correction term to the systematic utility of every plan a traveler considers before making a choice.
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- network with 60,492 links, synthetic population of size 187,484
- calibrate all-day motorist behavior from 159 inductive loops
Settings

• modeling assumptions (Matsim)
  – fully disaggregate demand representation
  – combined choice of route, departure time, mode
  – disaggregate supply model (queuing simulation)
  – (some kind of) stochastic user equilibrium

• estimator setting
  – utilize 159 flow sensors
  – adjust all choice dimensions at once
  – influence driver behavior by accept/reject procedure
  – quality evaluation only at measurement locations
# Results – scatterplots

<table>
<thead>
<tr>
<th>Time</th>
<th>Plain Simulation</th>
<th>With Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td><img src="image1" alt="Morning Graph" /></td>
<td><img src="image2" alt="Morning Graph" /></td>
</tr>
<tr>
<td>Evening</td>
<td><img src="image3" alt="Evening Graph" /></td>
<td><img src="image4" alt="Evening Graph" /></td>
</tr>
</tbody>
</table>
Results – all day

- Measurements available from 7:00 to 20:00
- Red curve is mean relative flow error $\frac{|q_{\text{estim}} - q_{\text{true}}|}{q_{\text{true}}}$
- Drastic improvement of results in real-world conditions
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- broadly applicable disaggregate demand calibration method
  - flexible with respect to workings of DTA simulator
  - consistent with equilibrium and non-equilibrium models
- mathematically consistent
  - adopted formal view on microscopic modeling and simulation
  - Bayesian approach accounts for model and data uncertainties
- computationally efficient
  - is applicable to problems of practically relevant size
  - is applicable in real-time conditions
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Thank you for your attention.