A framework for the data-consistent deployment of urban microsimulations

Gunnar Flötteröd and Michel Bierlaire

July 9, 2010
Outline

Integrated transportation land use simulation

An old criticism of OD matrices

Truly microscopic urban traffic state estimation

Outlook & summary
Outline

Integrated transportation land use simulation

An old criticism of OD matrices

Truly microscopic urban traffic state estimation

Outlook & summary
Basic processes

- activity participation
- facilities
- relocation
- congestion
- accessibility
- transportation
- mobility demand
- infrastructure
- travel demand management
- socio-economics, needs / strategies
- land development
- regulations
- transportation management
Basic processes
Basic processes: dynamics, data, resolution

<table>
<thead>
<tr>
<th></th>
<th>time scales</th>
<th>data sources</th>
<th>data resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>transportation</td>
<td>short (seconds)</td>
<td>network sensors</td>
<td>aggregate or by vehicle</td>
</tr>
<tr>
<td>activity participation</td>
<td>medium (days)</td>
<td>surveys, personal sensors</td>
<td>by individual actor</td>
</tr>
<tr>
<td>relocation</td>
<td>long (years)</td>
<td>measurable</td>
<td>by individual actor</td>
</tr>
</tbody>
</table>

- process interactions are reflected in the data
- exploit this when estimating the model system
Outline

Integrated transportation land use simulation

An old criticism of OD matrices

Truly microscopic urban traffic state estimation

Outlook & summary
Activity participation $\rightarrow$ transportation

1. individual-level microsimulation of activity participation
2. OD matrices represent *aggregations* of realized choices
3. transportation microsimulation samples *anonymous* vehicles
OD matrix estimation

- adjustment of trip intensities is at most a mesoscopic technique
- does not account for
  - behavioral a priori information
  - trip linkage (reduces problem dimension)
  - individual-specific behavior (heterogeneity)
- same holds for path flow estimators
- why not estimate the individual-level choices directly?
Outline

Integrated transportation land use simulation

An old criticism of OD matrices

Truly microscopic urban traffic state estimation

Outlook & summary
Multiple rolling horizons

- **estim. window**
- **pred. window**
- **transportation state, within day**
  - **congestion (today)**
  - **mobility demand (today)**
- **activity state, per day**
- **facilities (this year)**
- **relocation state, per year**

---

**STANSP-OR**

**ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE**
Multiple rolling horizons

- **estim. window**
- **pred. window**
- **transportation state, within day**
- **congestion (today)**
- **mobility demand (today)**
- **activity state, per day**
- **facilities (this year)**
- **relocation state, per year**
Example: Zurich scenario

- configuration
  - network with 60,492 links and 24,180 nodes
  - 187,484 travelers
  - hourly vehicle counts from 161 sensors

- estimate
  - route choice
  - departure time choice
  - mode choice

for every single agent
Example: estimate activities from network data

- discrete choice model of travel behavior
  - $V_n(i)$ is utility of travel plan $i$ as perceived by individual $n$
  - $P_n(i) \sim \exp(V_n(i))$ is respective plan choice probability

- network data: traffic counts
  - $y_{ak}$ is traffic count on link $a$ in time step $k$
  - $\sigma^2_{ak}$ is variance of counting error

- inference yields

\[
P_n(i|\{y_{ak}\}_{ak}) \sim \exp \left( V_n(i) + \sum_{ak \in i} \frac{y_{ak} - q_{ak}}{\sigma^2_{ak}} \right)
\]

  - $q_{ak}$ is simulated flow on link $a$ in time step $k$
  - increases utility of more plausible plans
Example: 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
Example: 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>

- 10-fold cross-validation
- computationally feasible
Outline

Integrated transportation land use simulation

An old criticism of OD matrices

Truly microscopic urban traffic state estimation

Outlook & summary
Outlook: some challenges

- disaggregate models need disaggregate data
  - vehicle re-identification
  - smart phones
  - anonymous yet disaggregate (online) estimation
- estimation of choice models needs choice context
  - non chosen alternatives, attributes of alternatives
  - integrated calibration: *impute* choice context
  - tractability issues
- ...

*TRANSP-OR*
Summary

- urban microsimulations comprise many processes
  - different time scales
  - different data sources

- exploitation of disaggregate models and data sources needs
  - microscopic process interfaces
  - microscopic estimation techniques

- the OD matrix estimation paradigm
  - does not reflect information generated by microsimulations
  - can be replaced by disaggregate techniques