Using VISSIM to model traffic in the city of Zürich

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Traffic Engineering (SVT) group
What does the Strassenverkehrstechnik (Traffic Engineering) group do?

- Develop **models to better replicate real traffic conditions**, improve the understanding of traffic phenomena, and contribute to a better definition of the role of cars in cities, while assessing their external costs and impacts.

- Understand and quantifying how different **technologies and management strategies influence the performance** of transportation systems, identifying new and efficient methods for using in-vehicle and infrastructure technologies.

- Develop innovative solutions to improve traffic performance and reduce congestion both in highways and urban networks, while **optimizing the operations of transportation systems** from a multi-modal perspective.

**SVT’s ultimate goal is to achieve more efficient and sustainable transportation systems mostly from the traffic operations perspective.**
How is traffic in Zürich?
What is the city of Zürich doing about it?

To that end, the municipal Traffic Planning Department here in Zürich has been working overtime in recent years to torment drivers. Closely spaced red lights have been added on roads into town, causing delays and angst for commuters. Pedestrian underpasses that once allowed traffic to flow freely across major intersections have been removed. Operators in the city’s ever expanding tram system can turn traffic lights in their favor as they approach, forcing cars to halt.

ZURICH — While American cities are synchronizing green lights to improve traffic flow and offering apps to help drivers find parking, many European cities are doing the opposite: creating environments openly hostile to cars. The methods vary, but the mission is clear — to make car use expensive and just plain miserable enough to tilt drivers toward
What is the city of Zürich doing about it?

Introduction

Background

Research

Conclusions

Actuated traffic control

Züritraffic

Improvement of short term prediction and control

Network level control

Today

Speed limits

Basic traffic routing

Optimization of traffic routing based on real time information
How? What software is required?

**Tools:**
- VISUM
- VISSIM

**Levels:**
- **Macro Level**
  - Transport Model
  - Canton of Zurich (GVM-ZH)
- **Micro Level**
  - Microsimulation
  - City of Zurich
- **Operating Level**
  - Control <<live>>
  - Sensors (>3’500)
  - VRZSim
  - VRZ
  - FCD
  - TomTom Traffic Stats

Source: Stadt Zürich, Dienstabteilung Verkehr. Presentation by Christian Heimgartner (2011)
How do they intend to use specifically the microsimulation?

- Development and optimization of traffic control logics and traffic routing
- Analysis and visualisation of the traffic flow
- Analysis and visualisation of other traffic impacts
- Operating simulation of Zürich Public Transportation System

- Current traffic states
- Specific projects
- Construction sites

Source: Stadt Zürich, Dienstabteilung Verkehr. Presentation by Christian Heimgartner (2011)
What is the study area?

Source: Stadt Zürich (2011)
How is the microsimulation being developed?

- **PTV**
  - VISSIM development

- **TransSol / TransOptima**
  - Demand model development

- **SVT ETH Zürich**
  - Model calibration

- **Modeling & Simulation City of Zürich**
  - Microsimulation Zürich Inner City

- **Traffic Control City of Zürich**
  - Signal control algorithm

- **Modeling & Simulation City of Zürich**
  - Network modifications & enhancements

- **Public Transport Zürich**
  - Public transport schedule
What is the role of the SVT group?

To optimize the calibration process, so the City of Zürich could calibrate the VISSIM model in the most efficient way, tailored to its specific needs and requirements.
What are the challenges of the calibration process?

- VISSIM model is complicated, and it behaves like a black box
- Computational cost is very high (> 30 min per simulation run)
  - Cannot use a brute-force approach for the calibration
How did we go about this project?

- **Phase 1**: investigation of city characteristics and literature review of the calibration procedures

- **Phase 2**: sensitivity analysis to select the most important parameters for calibration

- **Phase 3**: calibration of the model
What did we learn during Phase 1?

Calibration methods & strategy

1. Design Manual for Roads and Bridges (UK, 1996)
3. DTO Modelling Guidelines (UK, 2006)
4. Guidelines for the Use of Microsimulation Software (UK, 2007)
5. The Use and Application of Microsimulation Traffic Models (Australia, 2006)
8. Hinweise zur mikroskopischen Verkehrsflußsimulation: Grundlagen und Anwendung (Germany, 2006)

VISSIM parameters & calibration

3. Calibration of VISSIM to the traffic conditions of Khobar and Dammam, Saudi Arabia (Ahmed, 2005)
4. Calibration of VISSIM for a Congested Freeway (Gomes et al., 2004)
5. Calibration of VISSIM for Bus Rapid Transit Systems in Beijing Using GPS Data (Yu et al., 2006)
6. Calibration of VISSIM for Shanghai Expressway Using Genetic Algorithm (Wu et al., 2005)
9. Developing a Procedure to Identify Parameters for Calibration of a VISSIM Model (Miller, 2009)
Is Zürich alone? What do other cities do?

Use of guidelines/scientific publications in the calibration of traffic simulation programs

Methods applied for calibration of traffic simulation programs

Source: Survey from COST Action TU 0903 - MULTITUDE (2011)
What did we do then?

Each parameter was analyzed individually, and categorized according to its relevance within the Zürich model.
What were the results?

192 total VISSIM parameters
148 relevant
14 SA Parameters
How was Phase 2 different from that?

Parameters

192 total VISSIM parameters
148 relevant
14 SA
5 for calibration

<table>
<thead>
<tr>
<th>#</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Average Standstill Distance</td>
</tr>
<tr>
<td>2</td>
<td>Additive Part of Desired Safety Distance</td>
</tr>
<tr>
<td>3</td>
<td>Multiplicative Part of Desired Safety Distance</td>
</tr>
<tr>
<td>11</td>
<td>Safety Distance Reduction Factor</td>
</tr>
<tr>
<td>13</td>
<td>Lane Change Distance</td>
</tr>
</tbody>
</table>
How did we go from 14 parameters to 5?

EE Trajectory Generator (MATLAB)
- Input: parameters range (min, max)
- Process: randomly generate EE trajectories
- Output: EE trajectories

Automatic VISSIM Simulator (C#.NET)
- Process: automatically change the parameter values in the VISSIM INP file and run the simulation
- Output: simulation results for each EE trajectory

Analyzer (MATLAB)
- Process: analyze and compare multiple sensitivity measures, e.g. mean, absolute mean and standard variation
- Output: ranking of parameters
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- **77 days** Basic EE method
- **41 days** EE + use of trajectories as a sampling strategy
- **2 + 50 days** EE + use of optimized trajectories as a sampling strategy
- **2 days** EE + use of quasi-optimized trajectories as a sampling strategy
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Sensitivity Ranking of Parameters
(Aggregated across all scenarios)
How do we then calibrate those 5 parameters?

**Tabu Search**: metaheuristic method that guides a local search procedure to explore the solution space beyond local optimality.

- Generate initial solution and initialize memory structures
- Construct modified neighborhood based on existing Tabu restrictions
- Run VISSIM
- Select best neighbor
- Stop – Select best global solution
- Update memory structures (short and long term)
- Update best solution

Use a Tabu Search algorithm focusing on the five most important parameters.
Do we have real data for the calibration?

TomTom provides average speeds and cumulative travel times per route based on GPS data.
So what did we do?

…We had some extra time to test the model

- Ran 240 simulations
- Further tested the influence of the important parameters
- Used the adaptive signal control algorithms
- Evaluated speeds (and counts) in the network
So what did we do?
What did we observe?

VISSIM consistently over-predicted the speeds in the network.
• Importing a macroscopic demand into a microscopic traffic simulator presents some challenges, e.g., accounting for:
  – Intra-zone demand
  – Parking surge traffic
  – Turning ratios at intersections

• ???
What are the next immediate steps?

- Figure out what is driving the large discrepancies in the demand at the microscopic level
- Resume calibration once those issues are solved
Why all this work? Is it really needed?

Simulation results should match reality as closely as possible.
Why all this work? Is it really needed?

- Learnings for other cities, and dissemination of best practices in calibration and sensitivity analysis
- Modeling and testing of multiple traffic management strategies
- Monitoring and control of the whole network both at specific locations and at an aggregate level
- Combined use of modeling techniques and real data collection and analysis

The City of Zürich could become a center for research and development in the area of Traffic Operations and Control – ZürichLAB
Questions?

Thank you!