Using OpenStreetMap to model bicycle traffic in an agent-based transport simulation

Dominik Ziemke and Simon Metzler
State of the Map | Milano | 29 July 2018
Cycling

- Inexpensive
- Fast
- Healthy
- Quiet
- Energy-efficient
- Less land-consuming
- Enjoyable

- Societal, environmental, economic, and public health problems of motorized vehicle traffic

- Cities promote cycling for everyday use
- Increasingly included into plans for travel behavior change
Need for appropriate infrastructures
Need for appropriate infrastructures
Transport (Planning) Models

- Important tool for effective planning of transport systems
- A means to evaluate proposed policies in a structured and systematic fashion
- State-of-the-practice for motorized individual transport and public transport
MATSim: Multi-Agent Transport Simulation Framework

- Travelers (decision makers) represented individually (“agents”)
- Daily activity-travel patterns are modeled (“plans”)
- Implemented in Java
- Modular and extendable
- Open source
- Designed for large-scale scenarios
- Various analysis options
- www.matsim.org
MATSim: Basics

Traffic Simulation
• Agents travel on network

Plan Scoring
• Agents score their executed activities and trips

Replanning
• Agents modify their plans along various possible choice dimensions
• Agents select a plan based on a multinomial logit model
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Modeling cyclists' behavior and choices realistically

Patna scenario created by Amit Agarwal
MATSim Input Data

Network

Daily Plans

Transport Supply

Transport Demand

Home (dep: 06:43) trip (car)
Work (dep: 16:04) trip (car)
Shopping (dep: 18:04) trip (car)
Home

Home (dep: 12:42) trip (bike)
Shopping (dep: 14:05) trip (bike)
Home

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Slide 9
MATSim Input Data

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Network

Daily Plans

Home (dep: 06:43)
trip (car)

Work (dep: 16:04)
trip (car)

Shopping (dep: 18:04)
trip (car)

Home

Home (dep: 12:42)
trip (bike)

Shopping (dep: 14:05)
trip (bike)

Home

Transport Supply

Transport Demand
Network creation for MATSim

- Parse `way` and `node` objects in study region
- Optional: Remove ways below certain `highway` type
- Create MATSim node if `node` at end of `way` or at intersection
- Create MATSim links connecting nodes on that way
  - Compute length
  - Process `maxspeed`
  - Consider `oneway` → MATSim network = directed graph
  - Estimate flow capacity (based on `highway` type, lanes etc.)
- Clean up: Remove unconnected nodes and links etc.
Network creation: Extension for lanes and signals

- Poster here at SotM 2018 by Theresa Thunig

### node – traffic signal:

<table>
<thead>
<tr>
<th>key</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>highway</td>
<td>traffic_signals</td>
</tr>
<tr>
<td>traffic_signals:direction</td>
<td>backward</td>
</tr>
</tbody>
</table>

### way – bidirectional:

<table>
<thead>
<tr>
<th>key</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>highway</td>
<td>tertiary</td>
</tr>
<tr>
<td>lanes</td>
<td>4</td>
</tr>
<tr>
<td>lanes:backward</td>
<td>2</td>
</tr>
<tr>
<td>lanes:forward</td>
<td>2</td>
</tr>
<tr>
<td>name</td>
<td>Müller-Breslau-Straße</td>
</tr>
<tr>
<td>postal_code</td>
<td>10623</td>
</tr>
<tr>
<td>turn:lanes:backward</td>
<td>left;through</td>
</tr>
</tbody>
</table>
Network creation: Extension for bicycle traffic

• Focus of this talk
People are different
People are different

- … but less so when traveling by car

➤ Minimize travel time
How do cyclists choose their routes?

• Travel time
• Route length
• Gradient
• Comfort
  • Smoothness / Surfaces
• Cycling infrastructure
  • Bicycle lanes
  • Bicycle tracks
• Intersections
• Volumes of motorized traffic
• Parking facilities along route
• ...

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Bicycles in MATSim

Routing:
- Travel time
- Distance
- Infrastructure
- Comfort
- Gradient

- Interaction with other traffic
- Vehicle passings

- Travel time
- Distance
- Infrastructure
- Comfort
- Gradient
- Interaction with other traffic

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Bicycles in MATSim

Routing:
- Travel time
- Distance
- Infrastructure
- Comfort
- Gradient

Input

Traffic Simulation

Physical Simulation

Mental Simulation

Plan Scoring

Replanning

Output

$S_{trav,q} = C_b + \beta_{trav,b} \cdot t_{trav,q} + \beta_{d,b} \cdot d_{trav,q}$
$+ \sum_{a \in q} \left( \beta_{inf(a)} + \beta_{comf(a)} + \beta_{grad(a)} \right) \cdot \ell_a$

• Interaction with other traffic
• Vehicle passings

• Travel time
• Distance
• Infrastructure
• Comfort
• Gradient
• Interaction with other traffic
INFRASTRUCTURE
Cycling-relevant Data on OpenStreetMap

• Determine cycling Infrastructure
  • Main road with a bicycle lane
    • highway=? and cycleway=lane
  • Bicycle lane on the sidewalk
    • highway=? and cycleway=track
  • A bicycle track away from roads
    • highway=cycleway

• Further information
  • cycleway:right/left/both
  • Cyclists allowed to travel in opposite direction
  • ...
COMFORT
Key Smoothness

n = 5722

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Key Surface

n = 44842
Street surface ≠ cycleway surface
Key: Cycleway

n = 9204
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Key: Cycleway: Smoothness

n = 252
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Key: Cycleway:Surface

n = 586
GRADIENT
Gradient

• Tag `ele` on OSM, but mainly intended for `natural = peak`
• “…not try to be a general elevation database…” (OSM Wiki)

• Digital elevation model (DEM)
  • Digital surface models (DSM)
    • Satellite imaging
    • Surface of earth incl. all objects on it, e.g. buildings
    • E.g. SRTM (Shuttle Radar Topography Mission)
  • Digital terrain models (DTM)
    • Photogrammetric measurement using aerial picturing and laser scanning
    • Ground surface of the earth without objects on it

➢ Enrich MATSim network nodes with z-Coordinate
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Elevation Data: SRTM3
Elevation Data: SRTM1
Elevation Data: LIDAR 20m
Elevation Data: LIDAR 1m
OTHER INFORMATION ON OSM
### Monitoring Station

<table>
<thead>
<tr>
<th>Tag</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>description</td>
<td>Kontaktsscheife der Fahrradzählstelle</td>
</tr>
<tr>
<td>display</td>
<td>no</td>
</tr>
<tr>
<td>man_made</td>
<td>monitoring_station</td>
</tr>
<tr>
<td>monitoring:bicycle</td>
<td>yes</td>
</tr>
<tr>
<td>monitoring:traffic</td>
<td>yes</td>
</tr>
<tr>
<td>name</td>
<td>Zählstelle</td>
</tr>
<tr>
<td></td>
<td>Jannowitzbrücke</td>
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<tr>
<td></td>
<td>Richtung</td>
</tr>
<tr>
<td></td>
<td>Alexanderplatz</td>
</tr>
<tr>
<td>operator</td>
<td>Senatsverwaltung für Stadtentwicklung Berlin</td>
</tr>
<tr>
<td>recording</td>
<td>yes</td>
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<tr>
<td>recording:automated</td>
<td>yes</td>
</tr>
<tr>
<td>website</td>
<td><a href="http://www.stadtentwicklung.berlin.de/verkehr/lenkung/vib/de/radzahlen.shtml">http://www.stadtentwicklung.berlin.de/verkehr/lenkung/vib/de/radzahlen.shtml</a></td>
</tr>
<tr>
<td>website2</td>
<td><a href="http://www.eco-public.com/public2/?id=102024661">http://www.eco-public.com/public2/?id=102024661</a></td>
</tr>
</tbody>
</table>
Conclusion

- OSM very useful resource for transport modeling

- Tagging system specific enough for high-resolution bicycle transport modeling

- Some cycling-relevant tags not so frequently used

- MATSim transport simulation is open source
  - Check out [www.matsim.org](http://www.matsim.org) and run a small bicycle example: [www.matsim.org/extensions](http://www.matsim.org/extensions) → Bicycle → RunBicycleExample
References

• Network creation for MATSim based on OSM in general

• Passing of vehicles

• Bicycle routing and scoring

• Network creation based on OSM for lanes and signal
  • Thunig, T., K. Nagel (2018). Modeling traffic signals in an agent-based transport simulation based on OpenStreetMap data. Poster at SotM 2018
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