From Big Data to Smart Data

Developing a large-scale public transport simulation that runs on Smart Card Data

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MATSim Singapore

Simulating the mobility of 5.4 million people
Multi Agent Transport Simulation
MATSim Singapore

Flashes indicate agent activities starting:

- home
- work
- school
- shopping
- errands
- leisure

Full video available at https://vimeo.com/74432255
Making MATSim accessible for planning practice
From Big Data to Smart Data

Applying MATSim for Predictive Modelling based on Smart Card Data
The potential of data driven transport planning
Turning Big Data into Smart Data

Data → Models

- Dwell times
- Speed
- Behavior

Simulation → Insight

MATSim
Dwell time model

Boarding and alighting process

Results of statistical model

Critical occupancy at 63% of total capacity.

Low floor allows short dwell processes.

Double decker alighting time per pax 0.285 seconds longer.

With higher occupancy and number of boarding and alighting passenger -> shorter activity time

Heteroscedasticity of dwell times

Accounting for travel time variability
Modelling stop to stop travel times

Derive from Smart Card Data records travel times between stops

Each observed travel time between two subsequent stops constitutes one observation

Independent variables to be either derived from smart card data or GIS data, but do not require any other data source (e.g. traffic flow)

Static variables

- Availability of bus lane
- Number of intersections
- Number of left/right turns
- Curviness
- Deviation from crowfly distance
- Number of traffic lights
- Intersection density

Time-dependent variables

- Boarding/alighting activities in 500m radius
Validation

**Bus speed**

- MATSim
- EZ Link

**Transfer times**

- MATSim
- EZ Link

**Trip duration (Bus)**

- MATSim
- EZ Link

**Journey duration all modes**

- MATSim
- EZ Link

Access, egress times removed from MATSim bus times.
Case study: network reconfiguration

Evaluation of new services and routes:

- How can new network designs improve reliability and tackle overcrowding?
- How many passengers will be attracted by a new service?

Simulation and analysis:

- A full day simulated in just about 40 minutes.
- Leverage on off-the-shelf business analytic software for interactive analysis.
The reliability of a long bus line

Time-space diagram of bus line with 94 stops
Simulating and evaluating a line split

seats available
all seats take
very cr
The effect of splitting the line

Time-space graph after split

Stop number

Time of day

Occupancy

Split
Reliability before and after line split
Reliability: Excess waiting time along line

Excess Waiting Time - East to West

- orginal line
- after split

Stop number vs. Excess waiting time [sec]
Conclusion

From Big Data to Smart Data
• Use Big Data to understand the underlying operational patterns of public transport operations
• Agent-based simulation to model the inherent dynamics of public transport operations

A tool to evaluate alternative service provision
• How do different fare collection alternatives impact service quality?
• Which bus type for which line?
• How to adjust service provision in case of road works or congestion?
• How is the performance of alternative network designs?

Further research
• Inferring activity purposes and locations
• Integration of induced demand
The team to make it happen

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The Multi-Agent Transport Simulation
MATSim

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Questions?
Quantifying the impact of local accessibility
Evaluating Future Mobility Solutions with MATSim

Electric vehicles (EV)
Agent-based transport simulation allows to track each vehicle’s battery level and charging state. This allows to simulate electricity demand, analyse how EV can contribute to a Smart Grid and how people might react to fluctuating energy prices.

ERP 2
MATSim allows to account for taste heterogeneity among travellers. Therefore it is ideally suited to evaluate different pricing strategies. Researchers at the FCL are currently developing tools that allow to identify optimal pricing strategies.

Shared AVs
The new technology has the potential to be a game changer for urban transport. Agent-based models are ideally tailored to evaluate the impact of autonomous cars for different stages of its market introduction, e.g.: How different penetration rates increase road capacity? How can autonomous cars replace public transport?
MATSim applications beyond mobility

Economic potential
The basic unit of spatial analysis in MATSim is the individual building. For each building, MATSim models the number and type of activities people perform. This allows to quantify the potential for commercial activities and to assess the need for public amenities nearby.

Disease spreading
Agent-based simulation is the tool of choice to model the spreading of contagious diseases. Knowing the collocation of people while traveling, working and spending leisure time, MATSim Singapore can be applied to test prevention strategies on a nation-wide scale.

Accessibility analysis
Beside personal attributes and preferences, accessibility to destinations is one of the key determinants of travel behaviour. The data framework behind MATSim allows customised accessibility on the level of individual buildings and across travel modes, including walking and cycling.
Iterative learning approach:

- Profitable lines increase frequency by adding more buses
- Non-profitable lines lower frequency and may die out

New lines created either from scratch or by altering existing lines

The model automatically adapts supply to demand
Validation of optimisation model: the case of Berlin

Berlin Steglitz-Zehlendorf

Algorithm constructs transit system similar to the one that BVG has in place

Purple: BVG network
Capacity as proposed by optimisation
Capacity as provided by operator