Francesco Ciari

MATSim Work in Zurich: An Overview

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

MATSim Multi-Agent Transport Simulation

PhD Students/ Post Docs

- Balac Milos (CS)
- Becker Henrik (SM)
- Bösch Patrick (AV)
- Dubernet Thibaut (Ride sharing)
- Janzen Maxim (C-Tap)
- Müller Kirill (Population)

- Horni Andreas (Book)
- Waraich Rashid (EV)

Activities

- Research
- Teaching
- Book

Research

New Population (I)

Data can be obtained from the following sources:

- Registererhebung (RE, 2010-2012)
- Mikrozensus Verkehr (MZ, 2010)
- Betriebszählung (BZ, 2008)
- Strukturerhebung (SE, 2010-2012)
- Taxation data (TAX, 2010-2012)
- Comparis (COM, 2009-2014)

New Population (II)

- Age
- Gender
- Employment percentage (categorical)
- Driving license: Car
- Driving license: Motorcycle
- Car availability
- Home location
- Primary activity location
- Public transport discount cards: Halbtax
- Season ticket ownership: regional
- Season ticket ownership: GA
- Income
- Household structure
- Parking availability: Home
- Parking availability: Work
- Activity chain

OSM Multimodal Network

- Development of a functionality to generate a multimodal MATSim-network from OSM

- Building on the work by M. and N. Rieser on OSM-based multimodal network generation without any additional information on the network
- PT generation by integrating publicly available, official transport schedules (expected in MATSim-schedule format)

- Procedure:
    1. Creation of a multimodal MATSim network from OSM
    2. Creation of PT lines (stops and scheduled times) from OSM and official transport schedules
    3. Routing of PT lines given the stop sequence (shortest path with weighting of known OSM PT links)
    4. Manual correction of PT routes

Joint Travel (I)

- MATSim relies on a game theoretic view of the transportation system
- Agents try to maximize their utility, given the behavior of the others
- *Solution Concept* similar to the Nash Equilibrium
- A state where no agent/player can improve its payoff by *unilaterally* changing its strategy (*i.e.* daily plan)
- Essentially, agents take the (randomized) behavior of other as granted
- In reality, *coordination* has an important influence on travel behavior
- Coordination: individuals *agree* on a joint behavior
- Shared rides, joint activities...

Joint Travel (II)

- Including joint decisions requires a shift in the solution concept
- “Absence of Improving Coalition”: a state where no *group of agent* can *all* be better off by simultaneously switching their strategies
- Example: two agents have the preferences (restaurant together) > (alone at home) > (alone at the restaurant)
- The state where both agents stay at home is a Nash Equilibrium
- The two agent constitute an improving coalition for this state: they are both better off by simultaneously switching to the strategy “going to the restaurant”
- Two major kinds of modifications necessary
- Modification of the co-EA process to embed the right solution concept
- New mutation modules to give new possibilities to the agents
- Plus: specific utility parameters, extension of Qsim to represent waiting for passengers...

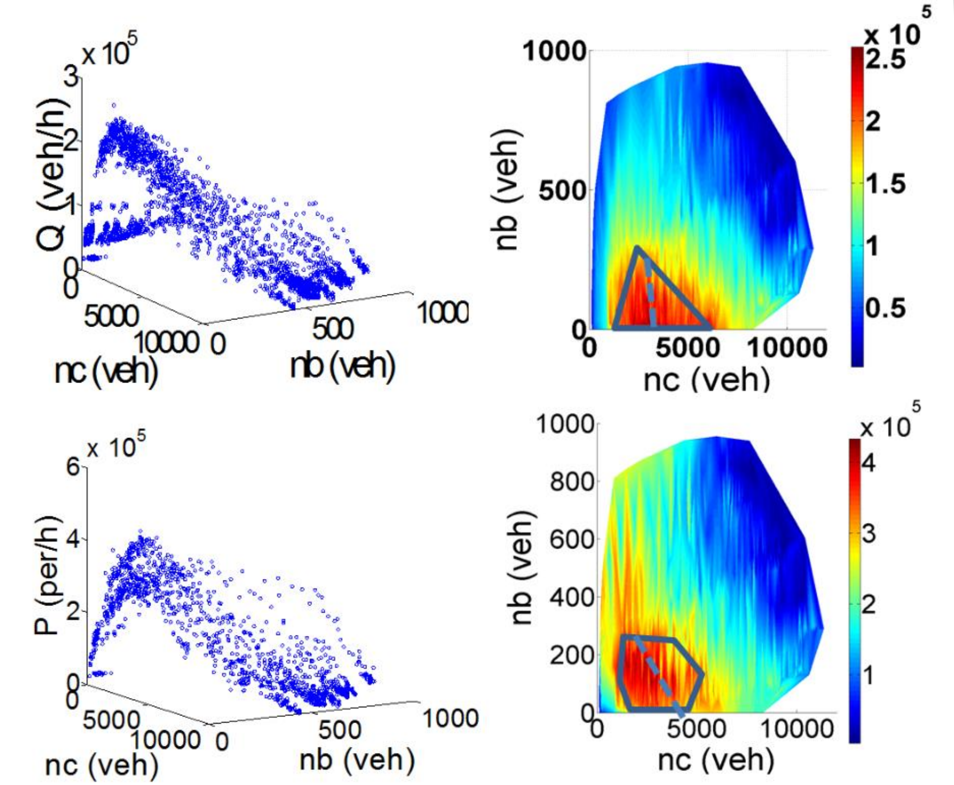
Joint Travel (III)

- Joint decisions are represented by *joint plans*: plans of individual agent selected simultaneously
- Score allocated to an individual plan in a joint plan takes into account the fact that other plans in the joint plan are executed
- A copy of the same plan can be part of different joint plans (*e.g.* going to the restaurant alone or with friends)
- Process is modified, such that agents with joint plans are handled simultaneously, as well as with (random) social contacts with whom they do not yet have joint plans
- The selection process is modified to account for those constraints
- Replacement of SelectExpBeta searches for an allocation without improving coalition, given randomized scores
- Removal removes the combination of joint plans which contains the maximum amount of worst plans

Joint Travel (IV)

- Memory size is defined per joint plan composition: each agent typically keeps 3 plans per joint plan composition
- In addition, upper limit on agent's memory to avoid memory issues (typically 20)
- Requires a lot of iterations to converge
- New modules:
- Inclusion of shared (car) rides
- Joint choice of a leisure location
- The “collaboration structure” becomes part of the evolution

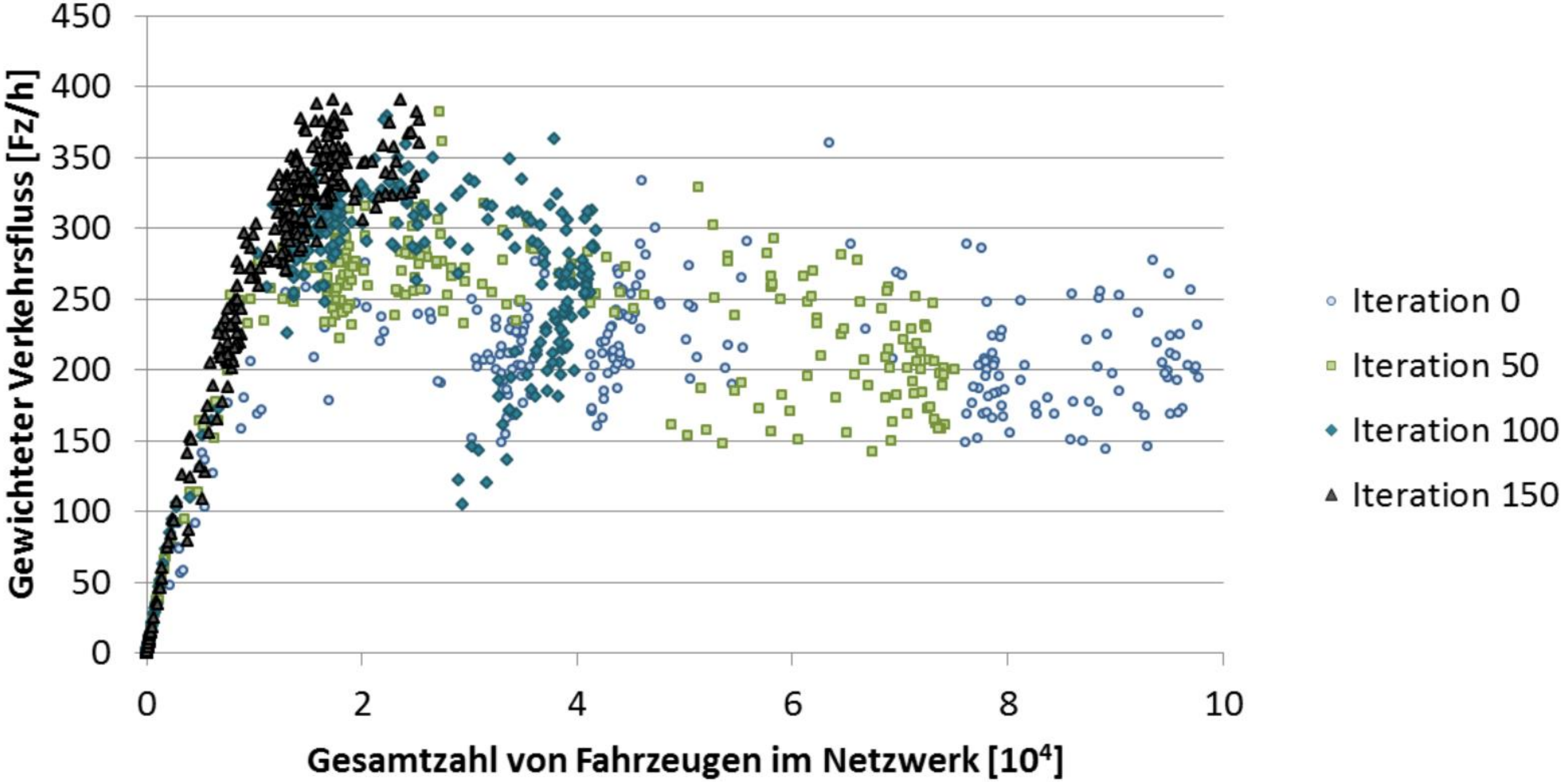
Project Netcap – Tasks



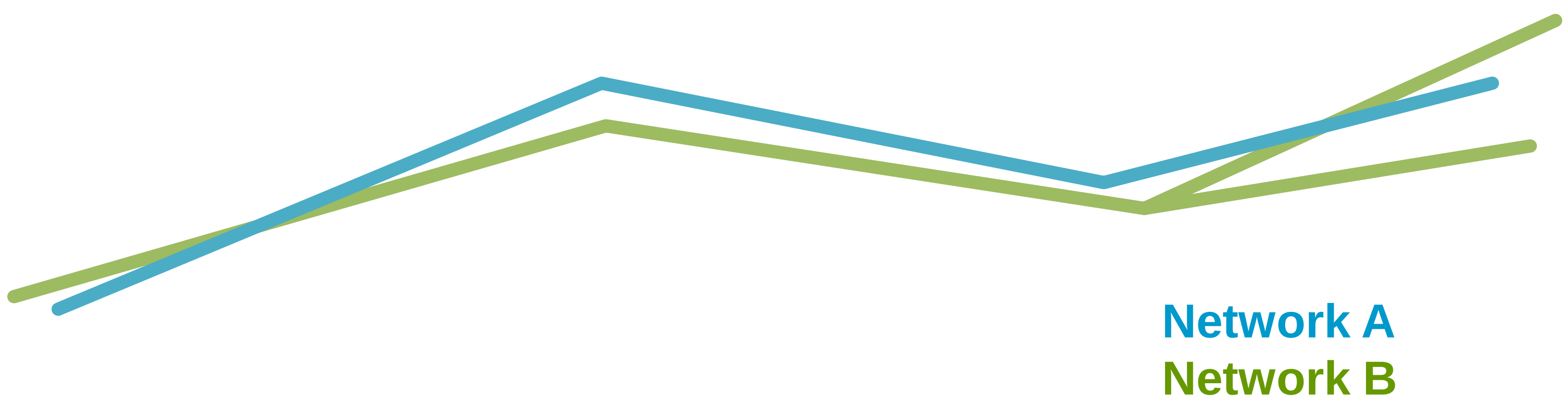
- **MFD**-Analysis with MATSim
- Export function to create **VISSIM** demands from MATSim results
- Automated creation of a MATSim multimodal network from **OSM**

MFDs with MATSim

- MFD analysis with MATSim



Export to Vissim (I)



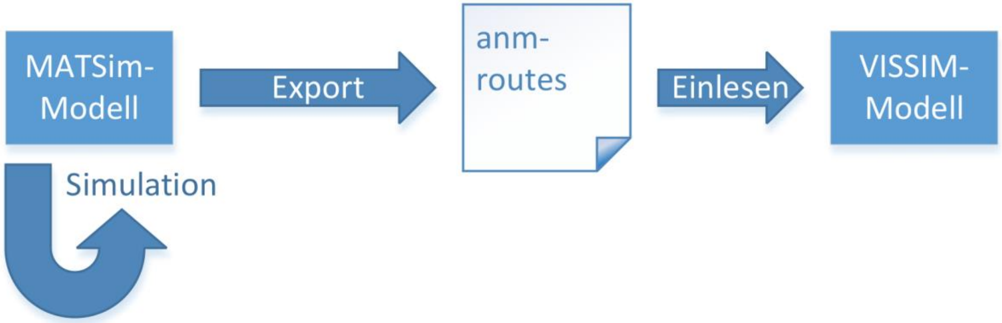
- Develop a function to export MATSim results to VISSIM

- Problem: Two different street networks
- Solution: For each MATSim route find the best matching route from a given a set of VISUM/VISSIM-routes and increase its demand accordingly.

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

MATSim
Multi-Agent Transport Simulation

Export to Vissim (II)

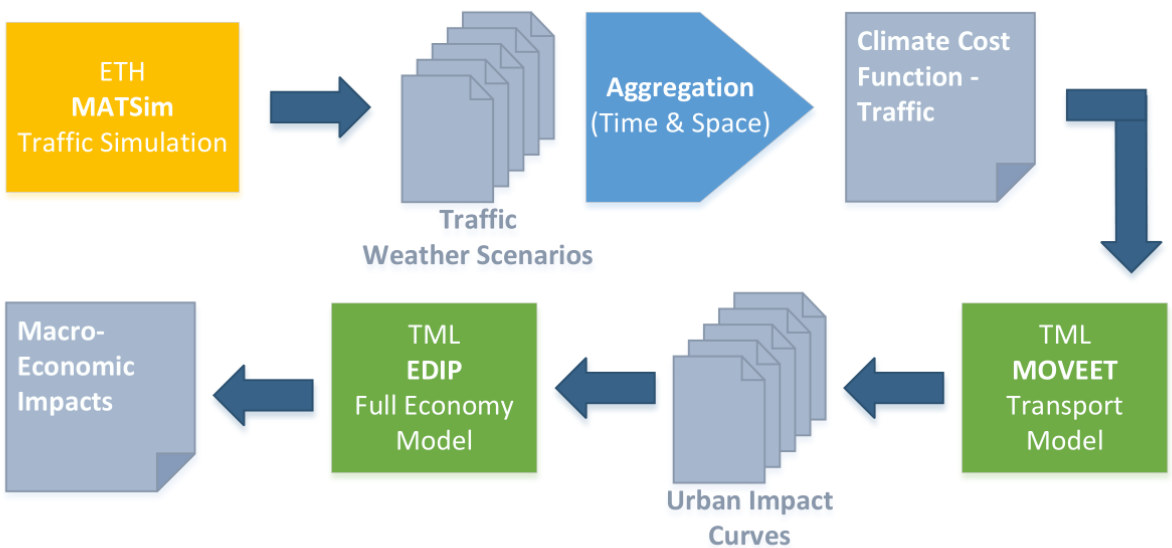


- Procedure:

1. Create simple mutual base grid
2. Map MATSim network to base grid
3. Map VISUM/VISSIM network (anm) to base grid
4. Find mutual base grid representation for MATSim routes
5. Find mutual base grid representation for VISUM/VISSIM routes (anmroutes)
6. Match MATSim routes to VISUM/VISSIM routes
7. Export VISUM/VISSIM routes (anmroutes) with new MATSim demand

Project ToPDAd – Weather Extremes and Traffic

- Case study together with TML (Christophe Heyndrickx)
- Economic cost of traffic disturbances and disruptions due to extreme weather events
- ETH with MATSim: Analysis of traffic in Zurich under extreme weather influence (e.g. heavy rain, snow or floods)

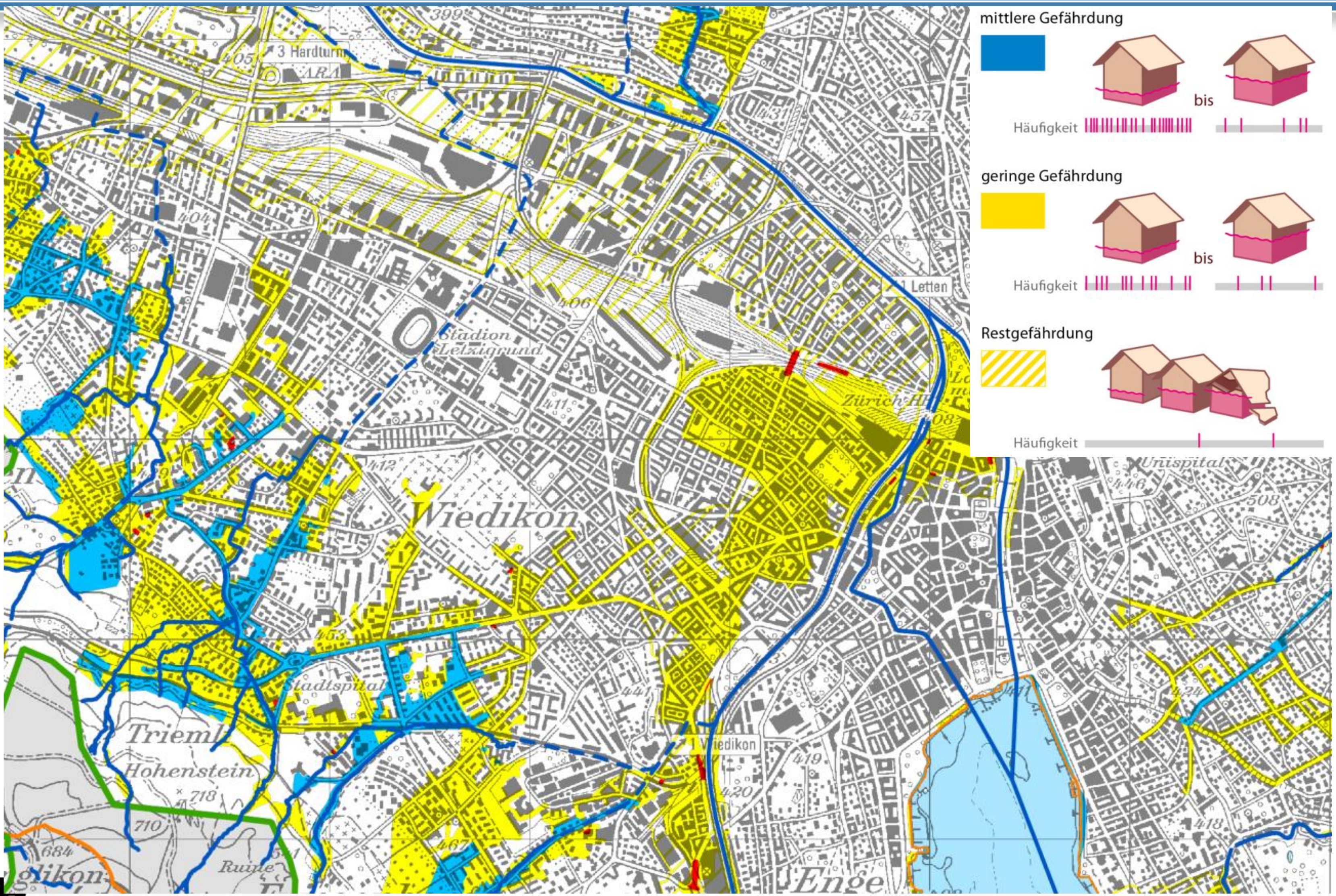


Project ToPDAd – Weather Influence

- Scenarios investigated with MATSim:

1. Baseline: Zurich 2030 standard scenario, no change.
2. Disturbance: Reduced traffic network capacity and speed due to unfavourable weather conditions.
3. Disruption (momentary/when occurring): Traffic network capacity becomes largely unavailable during simulation due to unfavourable weather conditions (WDR)
4. Disruption (momentary/when occurring): Traffic network capacity becomes largely unavailable during simulation due to unfavoraauble weather conditions. Level of informedness is varied to mimic effects of innovations.(WDR)
5. Disruption (lasting):Traffic network capacity is largely unavailable during the whole simulation due to earlier, unfavourable weather conditions.

Project ToPDAd – Zurich Scenario



Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

MATSim
Multi-Agent Transport Simulation

The “Parking Game”

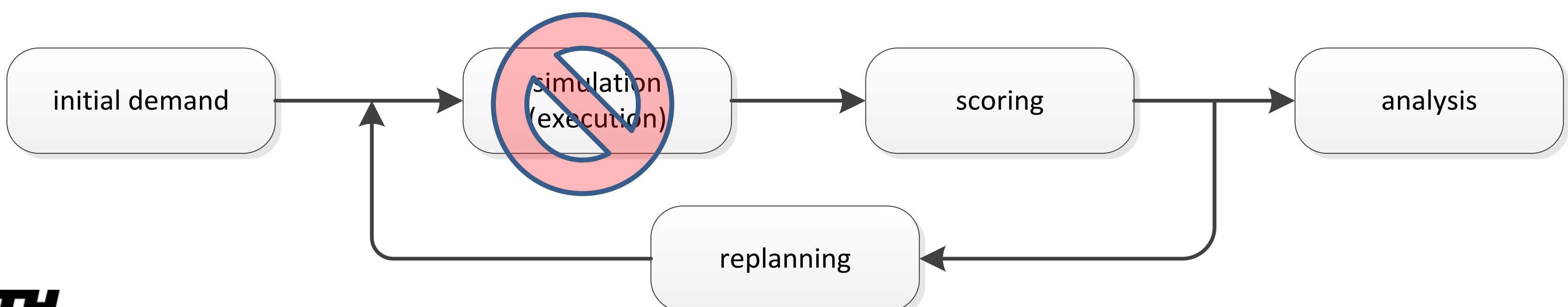
- Parking game played by people/agents as part of a bigger game against each other (in the context of activity/travel demand). Goal of the game is to choose/find a parking strategy, which maximizes the parking utility of the agent
- Utility score used to provide feedback to the higher level game

MATSim Simulation with Parking Search

Physical Simulation (e.g. Qsim or JDEQSim) — physical simulation not directly connected to MATSim events anymore

↕ update link travel time matrix of PSim each n-th iteration

PSim + withinday + parking search — new simulation



Experiments

- We have implemented around 15 strategies – mostly based on ideas from Axhausen and Polak (1989) + Park Agent + other Heuristics
- Scenario: Zürich – replanning only for parking search strategies – other replanning fixed

Slow-Metric City (I)

- Goal: achieving more sustainable form of accessibility by reducing the modal share of car, reducing the travel time and distances covered by car and increasing the overall satisfaction of people.
- First, different speed limit policies and their impacts on the behavior of people are tested using MATSim.
- Second, these policies are coupled with the relocation of facilities in the simulation area

Slow-Metric City (II)

- Together with colleagues from the Uni Avignon (Geography and OR)
- TRA Paper with preliminary results
- Orange Contest
- Horizon 2020 Project?

Autonomous Cars

- Patrick's dissertation
- Autonomous Cars in MATSim – MATSim-Servants

- Assistive entities in MATSim
- **Serve** the current MATSim agents

- Behave according to **strategies** when not serving
  - Redistribute
  - Park
  - Pick-up goods
  - Pick-up other agents

- Need **on-the-fly replanning** considering
  - the agents' wishes
  - their current strategy
  - their current state

Carsharing

- Milos dissertation
  - Optimization of carsharing supply

- Mobility Project
  - Free-floating pilot project (Basel, 2 years)
  - Tracking + Questionnaires → Modal choice
  - Testing of different carsharing scenarios
  - We should also get more transaction data!

2030 Scenario

- Population for 2030 based on an official prediction of the Swiss gouvernment.
- Network based on the current one + the projects to which the gouvernment firmly committed
- PT Schedule based on HAFAS projection
- Different scenarios based on assumptions on (changed) mobility behavior:
  - More teleworking
  - More teleshopping
  - Combination of 1) and 2)

NFP: «Sharing is saving»

- The project searches for solutions to limit energy consumption of transport sector.
- How collaborative mobility system such as carsharing, bikesharing, ridesharing etc. - can be extended beyond their current size limits and how they would interact with the existing transport system and among them.
- Stated choice survey aimed at understanding if and under which conditions such solutions would be accepted by the public → Mode choice models.
- Various future scenarios are tested with MATSim

Post Car World

- A non-car oriented world.
- We will investigate the changes in mobility system (surveys + MATSim).
- Increase in the demand for other alternatives including carsharing.
- Accelerated active mobility (moving pathways) as a new solution for the mobility of people (simulated in MATSim).

Long-Term C-TAP Simulation

•Long-Term **C**ontinuous-**T**arget-Based **A**ctivity **P**laning Simulation

•Focusing on long distance trips (>100km)

•Generating travel demand for a long period

•Complement to MATSim

•Can be used to forecast traffic volume based on long distance trips

•In combination of daily life traffic (e.g. based on MATSim results) it is possible to simulate traffic volume on a bis scale including seasonal effects

Long-Term C-TAP: Main ideas

- Initialization:
- Agents representing virtual people are generated
- Each agent has targets representing his motivations for activities
- Targets may be: percentage of time, duration or frequency
- Each activity can be executed on specific locations

- Algorithm ideas:
- Event-based iteration over time (events: end of an activity execution)
- Agents decide on their next activity based on their targets, their current state, travel time, etc.
- No possibility of decision changes
- During decision process we consider more than one following activity

Long-Term C-TAP: MATSim Comparison

- Similarities with MATSim
  - Activity-based travel demand generation
  - Fully agent-based approach
  - Based on a synthetic population
  - Generating activity chains
- Differences from MATSim
  - Continuous Planning instead of iterative replanning
  - Simulating a long period (e.g. one year) instead of a single day
  - Target-based approach

Long-Term C-TAP: State of Work

- In the current state we can simulate reasonable:
    - Trip durations
    - Trip frequencies
    - Weekly travel patterns
    - Yearly travel patterns (seasonal effects)

- Also the simulation runtime is acceptable.

Future Challenges:

- Location choice
- Mode choice
- Population model
- Traffic assignment

Teaching

«Projektarbeit»

- Bachelor students (2014: 22)
- Students learned how to use MATSim without touching the code
- They could do that either changing parameters in the confing files or changing the network
- Following this scheme, they made a policy study on a small scale scenario (Zurich 1%, actual PT included)
- Report + poster

Agent Based Modeling in Transportation

- Master Students (7 as of yesterday…)
- Introduction to the agent-based paradigm and overview on existing agent-based models in transportation, including MATSim
- Learn how to setup MATSim for policy analysis
- Learn about the interfaces available to enhances the software (includes Java programming)
- Create, run and analyse a policy studyMATSim paper
- Write a Paper

MATSim Book

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Multi-Agent Transport Simulation

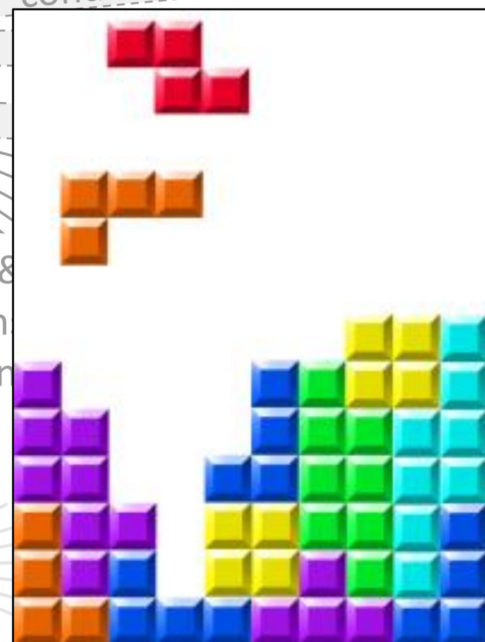
MATSim Book

guided

transfer & contextualize

condense & contextualize

link &
(tran
clean



not so guided

webpage

implicit knowledge

MATSim book 1.0

presentations

publications

tutorials

3 guides

javadoc

FAQ

examples docu

mailing lists

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

MATSim
Multi-Agent Transport Simulation