First Results of a Household Joint Activity-Travel Multi-agent Simulation Tool

Thibaut Dubernet, Kay W. Axhausen

Institute for Transport Planning and Systems (IVT)
ETH Zurich

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Introduction

Agent’s Coordination in MATSim

Results

Conclusions
Introduction

- most travel simulation tools simulate behavior of *isolated* individuals
  - individuals make decisions independently, given traffic conditions influenced by others
- in reality, individuals coordinate their travel behavior with social contacts
  - household: joint activities, limited number of cars, altruism
  - social contacts: joint activities
  - car-pools: pick-up and drop-off times and locations
- such coordinated behavior has a quite important empirical influence
  - joint trips
    - MZ2010: 18% daily traveled distance as “car passenger”
    - MZ2010: 32.5% all car stages done with 2+ persons in the car
- leisure location choice
Aim of this presentation

- present an approach to integrate coordination mechanisms in the MATSim framework
- analyze the results of runs on scenarios for the Zurich area
- identify directions of future work
Agent’s Coordination in MATSim
The MATSim View of (Individual) Decision Making

- agents try to optimize their daily plan given their knowledge of the state of transport system
- this state depends on other agent’s behavior
  - random from the agent’s perspective
- search for a good daily plan by a co-evolutionary algorithm: all agents perform an EA simultaneously
  - start with an initial plan
  - iteratively:
    - execute plan, score it
    - delete worst plan if more plans than allowed
    - select a past plan randomly based on score
    - (optional) copy it and modify it
Introduction

Introduction of Coordination

- need to link plan choice for certain plans of certain agents
- no need to link plan choice for unrelated plans: risks on convergence (slow / toward a wrong state)
- \[ \Rightarrow \] individual plans needing coordination are grouped in “joint plans”: sets of individual plans to be selected together.
- \[ \Rightarrow \] “incompatibility” between (joint) plans
- redefine replanning:
  1. identify groups of agents to replan together
  2. remove plans part of the worst “non-blocking” plan combination if needed
  3. select feasible combination of individual plans based on scores
  4. (optional) copy and modify those plans
Group Identification

- Some agents have joint plans
- They use common resources
- "Social ties" along which coordination behavior can be created
- Agents with coordination must be in the same group
Group Identification

- some agents have joint plans
Group Identification

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- or use common resources
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Plan Selection

1  2  3  4  5
Plan Selection

- agents have plans
Plan Selection

- agents have plans
- joint plans constraints
Plan Selection

- agents have plans
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- incompatibility constraints

1 2 3 4 5
Plan Selection

- agents have plans
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- incompatibility constraints
- aim: model the choice of individual plans, given the constraints
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Plan Selection for Removal

▶ when removing plans, there must remain feasible combinations
Plan Selection for Removal

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Plan Selection

- weighted selection: select the feasible combination which maximizes the sum of weights of individual plans
  - scores
  - Gumbel distributed (Logit-like)
  - random
- “utility transfers” in joint plans
- without contraints, same as selecting the plan of highest weight for each agent
- can be done efficiently (branch-and-bound)
Plan Mutation
Plan Mutation

1  2  3  4  5

- copy
Plan Mutation

- copy
- modify:
Plan Mutation

- copy
- modify:
  - agents interactions
Plan Mutation

- copy
- modify:
  - agents interactions
  - other dimensions
Introduction

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Aims

▶ use the approach for the case of *intra-household ride sharing*, using a pre-existing scenario for the Zurich area
▶ see how the approach performs when “plugging” it in a pre-existing scenario, with a minimal amount of adaptation
  ▶ Hope: structural constraints can explain important aspects of joint travel patterns
▶ identify limitations of scenario/approach
Scenario

- Zurich scenario:
  - planning network
  - schedule-based public transport
  - individuals grouped in households (Census 2000)
  - *working day* activity chains from National Travel Survey 2005
  - only households for which at least one member passes at least once closer than 30km to *Bellevue* Place are retained
  - 10% sample

- validation data:
  - National Travel Survey 2005
  - consider only trips with origin and destination closer than 20km to *Bellevue*
Network
Utility Function
Utility Function Parameters

- re-calibrated from existing scenario
- no explicit marginal disutility of traveling by car (opportunity cost only)
- “desired durations” differ from agent to agent
- opening times defined at the facility level
## Replanning Modules

<table>
<thead>
<tr>
<th>Module</th>
<th>Weight</th>
<th>Deactivated in Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logit-like Selection</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Time Allocation Mutation</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Subtour Mode Mutation</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Re-routing</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Joint Trip Mutation</td>
<td>0.1</td>
<td>base</td>
</tr>
<tr>
<td>Joint Leisure Location Choice</td>
<td>0.1</td>
<td>base, jt</td>
</tr>
</tbody>
</table>

- full household always replanned together
- Joint Trip Mutation: *joins* a car and a public transport trip
- Joint Leisure Location Choice: allocates randomly a leisure location *from the set of leisure locations of the household*
- “innovations” deactivated after 900 iterations
Variants of the Scenario

1. *base*: no joint travel
2. *jt*: joint trips are randomly included
3. *jt.l*: joint trips are randomly included, leisure location choice
4. *jt.l.s*: joint trips are randomly included, leisure location choice, score linearly time passed with household members
5. *jt.l.sl*: joint trips are randomly included, leisure location choice, score linearly time passed with household members *in leisure activities*
6. *jt.l.sll*: joint trips are randomly included, leisure location choice, score logarithmically time passed with household members *in leisure activities*, with the same parameters as for leisure
Score Evolution (Base Scenario)
Mode Evolution (Base Scenario)
Mode Share Comparison
Distance Distribution per Mode
Passenger Share per Purpose: NTS vs jt
Passenger Share per Purpose: NTS vs jt.l
Passenger Share per Purpose: NTS vs jt.l.s

### Results

#### Destination Type vs Origin Type

<table>
<thead>
<tr>
<th>Origin Type</th>
<th>Leisure</th>
<th>Home</th>
<th>Education</th>
<th>Shop</th>
<th>Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>7.3%</td>
<td>5.3%</td>
<td>15.7%</td>
<td>6.8%</td>
<td>12.0%</td>
</tr>
<tr>
<td>Home</td>
<td>8.4%</td>
<td>16.8%</td>
<td>17.6%</td>
<td>8.0%</td>
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<td>Leisure</td>
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<td>7.6%</td>
<td>3.7%</td>
<td>4.8%</td>
</tr>
<tr>
<td>Shop</td>
<td>0.0%</td>
<td>8.3%</td>
<td>10.4%</td>
<td>13.1%</td>
<td>4.0%</td>
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<tr>
<td>Work</td>
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## Passenger Share per Purpose: NTS vs jt.l.sl

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  - work: 12.0%

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  - work: 4.8%

- **leisure**
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  - NA: 8.3%
  - work: 10.4%

- **shop**
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- **work**
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  - leisure: 4.1%
  - shop: 1.8%

Passenger Share per Purpose: NTS vs jt.l.sll
Summary

▶ though “utility transfers” seems a strong hypothesis, joint travel share underestimated
  ▶ no explicit cost of travel
  ▶ no limited vehicle resources (no data)
▶ “drive to work/school” trips quite well predicted, the rest underestimated
▶ driver detours are overestimated, probably due to the absence of explicit disutility of travel
▶ associating a positive utility to joint presence at leisure activity did not improve the share of joint modes to leisure activities
  ▶ no joint generation of schedules
  ▶ no generation of pure serve passenger tours
  ▶ only intra-household ride-sharing
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- most travel simulation tools do not include joint travel
- an approach applicable with general social network topologies was implemented in MATSim
- comparison of the results with travel diary data allows to identify limitations of the approach and plan the next steps
Next Steps

- improve accuracy of driver detours
  - re-calibrate a scenario with cost of travel
  - joint activities w/ location choice?
    - not a significant impact for the approach used here
- improve overall passenger share
  - household-level correlation of plan construction / co-adaptation of plan structures
  - consider limited vehicle resources
  - generate pure *serve-passenger* tours?
    - purpose “service” represents only 10% of the driver trips in the National Travel Survey
  - include friendship relationships?
- improve specificity of leisure purpose
  - consider friendship relationships?
  - co-adaptation of plan structure