Including Individual’s Coordination in a Multi-Agent Transport Simulation

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Introduction

Agent’s Coordination in MATSim

Performance

Conclusions
Introduction

- Most travel simulation tools simulate behavior of *isolated* individuals
  - Individuals make decisions independently, given traffic conditions influenced by others
- Actual 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
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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 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)
- ⇒ individual plans needing coordination are grouped in “joint plans”: sets of individual plans to be selected together.
- ⇒ “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
- Or use common resources
- "Social ties" along which coordination behavior can be created
- Agents with coordination must be in the same group
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Plan Selection

1 2 3 4 5

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

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 - joint plans constraints
 - incompatibility constraints
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Plan Selection for Removal

- when removing plans, there must remain feasible combinations
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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 constraints, 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

1  2  3  4  5

- copy
- modify:
  - agents interactions
Plan Mutation

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

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**Test Scenario: Shared Vehicles in Households**

- “corridor” network, with large capacity (no congestion)
- H-W travel time by car: 6min
- 10010 agents with H-W-H plans
- “desired” work duration 4h, always open
- even-sized fixed cliques, from 2 to 20 members
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- all agents start with all-car plans
- all agents start with the same time allocation
- one vehicle for 4 agents in the clique.
## Replanning Strategies

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Probability</th>
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<tbody>
<tr>
<td>Logit-like choice</td>
<td>0.6</td>
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<tr>
<td>Mode mutation</td>
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<tr>
<td>Random vehicle reallocation</td>
<td>0.05</td>
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<tr>
<td>Joint plans recomposition</td>
<td>0.05</td>
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<tr>
<td>Time mutation</td>
<td>0.2</td>
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</tbody>
</table>
Mode Evolution, Own Car
Mode Evolution, Limited Car, No Coordination
Mode Evolution, Limited Car, Coordination
Introduction

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▶ motivations:
  ▶ coordination of individuals is an important behavior
  ▶ most travel forecasting models/simulation tools are individual based

▶ performance of the approach:
  ▶ behaves *quite* well for joint trips (*c.f.* paper)
  ▶ behaves *reasonably* well for shared vehicles
  ▶ group level plan selection can be very slow!

▶ demonstrated here on cliques, but more complex network structures are possible

▶ next steps:
  ▶ validation for intra-household ride-sharing (*requires calibrated scenario*)
  ▶ joint trips *and* limited vehicle resources
  ▶ joint activities
Questions?
Evolution of Joint Plans Size

![Graph showing the evolution of joint plans size over iterations.](image-url)
Example of Final Joint Plan Structure

<table>
<thead>
<tr>
<th>person-2880</th>
<th>person-2881</th>
<th>person-2882</th>
<th>person-2888</th>
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# Running Times

<table>
<thead>
<tr>
<th>Run</th>
<th>Total Dur. (min.)</th>
<th>Avg. Repl. Dur. (ms)</th>
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</thead>
<tbody>
<tr>
<td>Own Car</td>
<td>23</td>
<td>2</td>
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<tr>
<td>Lim. Car, No Coord.</td>
<td>20</td>
<td>1</td>
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<tr>
<td>Lim. Car, Coord.</td>
<td>42</td>
<td>799</td>
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</tbody>
</table>
### Final Mode Shares

<table>
<thead>
<tr>
<th>Mode</th>
<th>Mode Share (%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Own Car</td>
</tr>
<tr>
<td>Walk</td>
<td>3.71</td>
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<tr>
<td>Bike</td>
<td>3.85</td>
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<tr>
<td>Public Transport</td>
<td>3.51</td>
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<tr>
<td>Car</td>
<td>88.94</td>
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</tbody>
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