Long Term Simulation of a Continuous Target-Based Model

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IVT, ETH Zürich

10th July 2014
Outline

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   - Acitivities and State Values
   - Core Algorithm

2 Activity Planning
   - C-TAP Decision Model
   - Long-Term-C-TAP Decision Model

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Motivation

Current State:
Microscopic traffic flow simulations focus on daily life behavior.

But:
There is a significant part of traffic volume caused by long term activities.

Our goal:
Cover the long term activities.
Continuous Target-Based Model

Core ideas:

- microscopic travel demand model,
- agents represent virtual people,
- make decisions continuously / without any replanning,
- our goal: long term / long distance travel demands.

Continuous Target-based Activity Planning (C-TAP) simulation (Ph.D. thesis by F. Märki (2014)).
Behavioral Targets:
Describe the motivation of agents to perform an activity.

Possible targets are:
- percentage of time target
- frequency target
- duration target
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Describe the motivation of agents to perform an activity.

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- frequency target
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Note: definitions of the first two target types include observation windows.
C-TAP: Activities and State Values

For each target there is a corresponding activity and possibly a state value.

**Activities:**
Activities are executed by the agents in order to satisfy their motivations / targets.

**State Values:**
Targets with observation windows include state values for the agents. They increase during the execution of the relevant activity, respectively decrease during non-execution.
C-TAP: Core Algorithm

Algorithm 1 Core C-TAP Algorithm

while simulation end not reached do
    for all agent with no activity do
        state ← UpdateAgentState(agent)
        nextActivity ← MakeDecision(agent, state)
        agent.execute(nextActivity)
    end for
    nextTimeStep = minimum( all execution endpoints)
    proceed to nextTimeStep
end while

Main Question: Implementation of MakeDecision.
Core: Optimization of the discomfort value:

\[ D(t) = \sum_{k=1}^{n} (f_{target}^k(t) - f_{state}^k(t))^2 \]  \hspace{1cm} (1)

\( n \): the number of targets,
\( f_{target}^k(t) \): target value function,
\( f_{state}^k(t) \): state value function.
C-TAP Decision Model

Core: Optimization of the discomfort value:

\[
D(t) = \sum_{k=1}^{n} \left( f_{\text{target}}^k(t) - f_{\text{state}}^k(t) \right)^2
\]  

(1)

\(n\): the number of targets,
\(f_{\text{target}}^k(t)\): target value function,
\(f_{\text{state}}^k(t)\): state value function.

C-TAP model use mainly the discomfort reduction:

\[
DR(t_{es}, t_{ee}) = D(t_{es}) - D(t_{ee}),
\]

(2)

\(t_{es}\) is the execution starting time \(t_{ee}\) the execution end end time.
C-TAP Decision Model

The decision procedure is subdivided into several steps.

1. maximize the product of $DR(t_{es}, t_{ee}) \cdot LA(t_{ee})$ for every available activity. More precisely, the idea is to find the $t_{ee}$ maximizing the product.

2. multiply with execution time ratio $\frac{t_{ee} - t_{es}}{t_{ee} - t_{ts}}$, where $t_{ts}$ is the starting time of the travel.

3. multiply with an optional random term $(1 + \epsilon)$.
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3. multiply with an optional random term $(1 + \epsilon)$.

4. results in a heuristic function:

$$HF(t_{ts}, t_{es}, t_{ee}) = DR(t_{es}, t_{ee}) \cdot LA(t_{ee}) \cdot \frac{t_{ee} - t_{es}}{t_{ee} - t_{ts}} \cdot (1 + \epsilon).$$

(3)

The agent will now execute the activity, which yields the highest $HF$-value.
Long-Term-C-TAP Decision Model

Default Model:

- heuristic function based on discomfort reduction.
- consider one activity

Model for the long term simulation:

- sum of all discomforts
- consider two or more activities
Long-Term-C-TAP Decision Model

- **Activity 1**
- **Activity 2**
- **not executed Activity**

- **Graph a)**
- **Graph b)**
- **Graph c)**
Long-Term-C-TAP Decision Model

a) Activity 1

b) Activity 2

c) not executed Activity

state
value

time

$\text{travel time}$

$t_1$

t_2$
Optimization Process

Parameters:
Current time $t_0 \rightarrow$ is fixed.
Travel time $t_t \rightarrow$ is constant.
$\Rightarrow$ discomfort depends on $t_1$ and $t_2$.

We fix the first Activity.
$\Rightarrow n$ two-dimensional minimization problems.

Note:
- $n$ is small.
- we assign just the first activity.
Model Validation - Used Data

Data Source:
- Survey from german INVERMO project (Chlond et.al. (2006)).
- 1944 people reporting in total 6593 long distance trips ($\geq 100$km).

Calibration:
For each reported traveling purpose
- a percentage-of-time target (relative time spent),
- a duration target (average duration).

Additionally, we create also for the daily life activity one percentage-of-time target.
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<thead>
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<th>sampled trips</th>
<th>0h-4h</th>
<th>4h - 4d</th>
<th>4d - 14d</th>
<th>14d - 30d</th>
<th>30d+</th>
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</tbody>
</table>
Validation - Average Trip Duration per Purpose

Boxplot of the difference between sampled average trip duration and simulated average trip duration
Validation - Out of House Days (Weekly Pattern)

Relative Distribution of the Trips per Weekday and Purpose

- Work
- Private
- Holidays

Monday  Tuesday  Wednesday  Thursday  Friday  Saturday  Sunday

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Long Term Simulation with C-TAP

10th July 2014
Validation - Out of House Days (Yearly Pattern)

Relative Distribution of the Trips per Calendar Week and Purpose

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## Runtime Results

<table>
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<tr>
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<th>Overall Runtime [h:min:s]</th>
<th>Optimization Steps</th>
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<tr>
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<tr>
<td>Long-Term C-TAP</td>
<td>00:01:14</td>
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Not necessary a hint of a high acceleration, but a hint of an implementation with a much smaller number of parameters needed for a simulation in reasonable runtime.

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Future Work

Short Term:
- Improve Reproduction of Seasonal Effects

Mid Term:
- Location Choice
- Mode Choice
- Budget Restrictions

Long Term:
- Traffic Simulation
Thank You!