Agent-based Modelling of Parking Choice and Search

Rashid A. Waraich

IVT, ETH Zurich

November 2014
Motivation

Parking Policy

- Manage travel demand
- Sometimes alternative to road pricing
- Minimum/maximum parking requirements
- Influence search traffic (average 30%)
- Influence of new infrastructure projects

Recent developments:
- Renting private parking
- Performance based parking prices
- Promote electric vehicles

Figure sources: tournament.co.nz; areahousing.org
Challenges of Current Models

• Mostly aggregated
• Often very coarse time resolution
• Often limited modelling of spatial constraints
• Individual decisions missing or limited
• Integration between parking and traffic model missing etc.
Agent-based Modelling (Example Singapore – MATSim)
How do we Model Travel Demand?

- MATSim (open source)
- Synthetic population: people -> agents
- Individual preferences (based on survey data)
- Initial plans based on census data/travel diaries
- Plans contain activities (work, shopping, education) and trips
- Several transport modes available (car, walk, public transport and bike)
- Optimization of activity and travel demand for whole day
- First step of optimization: simulation
Simulation
MATSim

- simulated plans are scored
- Lower travel time and performing activities gives better score
- The goal of each agent is to maximize its score
- Iterative process, based on idea of evolutionary algorithm
- Replanning (change travel mode, route, times, etc.)
- Co-existence of several plans
  - Bad plans deleted over time, good plans have higher chance of getting selected for execution -> survival of the fittest
  - Iteration continues -> optimal plans ("Nash Equilibrium")
How is Parking Modelled in MATSim

• Parking choice model (very fast)
• Parking search (allows to model missing search traffic)
Parking Choice Algorithm
Parking Choice Algorithm

too far away
Parking Choice Algorithm
Parking Choice Algorithm

not eligible
Parking Choice Algorithm

\[ U_{\text{parking}, i} = U_{\text{P}\downarrow \text{cost}, i} + U_{\text{P}\downarrow \text{searchTime}, i} + U_{\text{P}\downarrow \text{walk}, i} + \ldots + \epsilon_{\downarrow i} \]
Parking Choice Algorithm

\[ U_{\text{parking}, i} = U_{\text{parking cost}, i} + U_{\text{parking search time}, i} + U_{\text{parking walk}, i} + \ldots + \epsilon_{i} \]
Individual Parking Utility Scores

Parking situation: search time = 3 min; walk time = 3 min; parking cost = 4 CHF; activity duration ca. 5 hours.

P1: female, age 20
P2: male, age 80

Income both: 4000 CHF/month
MATSim Scoring

\[ U_{\text{plan}} = \sum U_{\text{travelTime}} + U_{\text{travelCost}} + U_{\text{perFormAct}} + \cdots + U_{\text{parking}} \]
Sample Policy: Reduce Peak Traffic

• Goal: reduce traffic on links with highest traffic volume during evening peak hours (16:00 to 19:00)
• Approach:
  • Identify high volume links (top 10%)
  • Identify agents traveling on these links
  • Identify activity location of previous and next activities
  • Identify clusters of activities
  • Reduce parking capacity in clusters by 30% resp. 100%

• Alternative goal:
  • Select not highest volume, but most congested links during peak hour
Sample Policy: Reduce Peak Traffic
Performance-based Pricing for Zurich

• Currently: High prices for garage parking, low prices for street parking.
Performance-based Pricing for Zurich

- garage parking - initial price
- garage parking - final price
- on-street parking - initial price
- on-street parking - final price

% of parking type

price [CHF/h]
Modelling Parking Search

General Structure of Parking Search Strategies

proactive strategies start operation already before reaching destination

Backup strategy starts operation (mostly random or garage)
Instantiation of Parking Strategy

strategy general description («template»)

200m

?  S  Dest

instantiation

G

Dest

Dest

Dest

Dest
Strategy Group Switches

Strategy switches between groups (10 groups)

a) During initialization (10 iterations) => random switches

b) At 80%MNL (final last 100 iterations)

c) At full MNL (final 100 iterations) => most agents do not change strategy group or switch within same strategy group
Traffic Counts Difference (Missing Parking Search Traffic)
Usage of Garage Parking Strategies
Conclusions & Future Work

• Modelling parking decisions and traffic
  • Disaggregated
  • Equilibrium model
• Various applications/extend models
Questions
Backup Slides
Parking infrastructure supply model

Public Parking

- street parking (49'409)
- garage parking (16'277)

Private Parking

- Indoor (118'531)
- Outdoor (82'781)

[Parking counts from «Statistisches Jahrbuch der Stadt Zürich 2011»]
Comparison: Simulation vs. traffic counts

Link 17560000032125FT, Iteration: 50

![Graph showing comparison between simulation volumes and traffic counts](image-url)
Comparison: Simulation vs. traffic counts (cont.)
Calibration

- measured counts
- iteration 50
- iteration 0