Agent-based Modelling of Parking Choice and Search

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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”)

Diagram:
- Initial demand
  - Simulation (execution)
  - Scoring
  - Analysis
  - Replanning
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

occupied
Parking Choice Algorithm

not eligible
Parking Choice Algorithm

\[ U_{parking,i} = U_{P\text{cost},i} + U_{P\text{searchTime},i} + U_{P\text{walk},i} + \cdots + \epsilon_i \]
Parking Choice Algorithm

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Individual Parking Utility Scores

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

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

Income both: 4000 CHF/month
MATSim Scoring

\[ U_{plan} = \sum U_{travelTime} + U_{travelCost} + U_{performAct} + \cdots + U_{parking} \]
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
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).
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