Preferred citation style for this presentation

Validation results from a multi-agent simulation of coupled travel and social behavior

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Transportation planning fundamentals

Travel is a "price" to pay to go somewhere

Demand for travel periodically exceeds capacity of infrastructure
  → Delays

Adaptive behavior
  → Centralized: pricing of services

  → Decentralized: People adjust their travel and their activities to services, traffic conditions, personal constraints

Almost always: independent utility maximizer
Interactions relevant to travel behavior

Information exchange / choice set
  Knowledge (locations, activities, ideas)

Encounters
  Disease, money, violence, company, etc.

Coordinated travel or activities

Social norms
  Mode choice, trip frequency, total mobility

Altering social relationships due to distance
  Moving house, changing jobs
Problem!

What social interactions are relevant?

- Density and topology of social networks
- Geography
- Biography
- Sociodemographics
- Role of activities / interests
- Identified / Unidentified alters

Lack of data
Basis network generation algorithms

Social Processes
Depend on network/node attributes

Random Processes
Independent of space and network/node attributes

Spatial Processes
Depend on space/geography
Hybrid network generation algorithms

Social Processes
- Preferential attachment
- Triad closure
- Homophily

Nonspatial small-world (Jin, et al. 2001):
- Erdös-Renyi + triangle closure

Random Processes
- Erdös/Renyi
- Mean field models
- Ideal gases

Watts small-world (Watts and Strogatz 1998)
- 1-D Lattice + random rewiring

Spatial Processes
- Crystal lattices
- Geographical boundaries
- Time costs and budgets

Appollonian (Anrade, et al. 2005):
- Preferential attachment + 2D distance

Spatial small-world (Watts 1999)
- Small world + 2D lattice

Spatial small-world (Wong et al. 2006)
- Erdös/Renyi + 2D distance
Evolutionary adaptation of activity-travel

Based on: Rieser, 2008

1 Startup:  initialize social network
            initialize knowledge

2 Iteration Starts:  exchange knowledge
                     spatial meeting

3 Before Mobsim

4 After Mobsim

5 Scoring:  update time window map

6 Iteration Ends:  remove social links
                  output statistics

7 Replanning  use agents' knowledge to alter plans

8 Shutdown
Validation world

100km x 100km ZH

1% population sample
  = 8760 agents

3.4 trips/day
# Validation runs

<table>
<thead>
<tr>
<th>Test</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial social network</td>
<td>None</td>
<td>Dist((-1.5)) Constant z=12</td>
<td>Evolving</td>
</tr>
<tr>
<td>Interactions</td>
<td>None</td>
<td>Exchange 1 location per dyad</td>
<td></td>
</tr>
<tr>
<td>Re-Planning</td>
<td>Time Route Logistic</td>
<td>Time Route Logistic Location</td>
<td></td>
</tr>
<tr>
<td>Social network evolution</td>
<td>None</td>
<td>Make 1 friend, Constant z</td>
<td></td>
</tr>
<tr>
<td>Score</td>
<td>Standard</td>
<td>Standard + Ln(Nfriends)</td>
<td></td>
</tr>
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</table>
Utility of a Day Plan with 3 Activities

Source: David Charypar 2007
## Validation runs

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Social net</th>
<th>Social interact</th>
<th>Score</th>
<th>Replan</th>
<th>Iterations</th>
<th>Runtime</th>
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<td>3.9-4.2GB, 21hours</td>
</tr>
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</table>
Equilibrium?
Equilibrium?
Degree distribution of static and evolved social network

(a) Static network and initialization, Config2, 3, 4
(b) Network which evolved with activity plan optimization, Config6 (Config5 similar)
Euclidean distance between dyad members

Static social network
15.4 km

Evolved social networks
11.7 km

<\textit{d}> = 31 \text{ km} \text{ Dunbar}(1997)
Average Euclidean radius of ego net

Static social network
17.6 km

Evolved social networks
10.4 km
Average Euclidean radius of ego net

Static social network

Evolved social networks
## Other socializing indicators

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Components</th>
<th>Clustering Ratio</th>
<th>Diameter</th>
<th>Last met</th>
<th>Number met at leisure</th>
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<td>155</td>
<td>11</td>
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Spread of knowledge 0
Spread of knowledge 50
Spread of knowledge 100
Spread of knowledge 500
Shifts in distance and duration of trip

![Graph showing shifts in distance and duration of trip](image)
Shifts in time (and congestion)
Summary of effects

Initial social network
   Only one tested

Information exchange
   Highly efficient (location change)

RePlanning
   Location choice raises trip distance, travel time

Social network evolution
   Topology does not evolve dramatically
   Geography does
   Link removal isolates immobile agents (no other social process)

Scoring
   Biggest effect with evolving network
Work to do: validation

Ensemble to discern which effects are significantly different between scenarios

Scaling versus universal phenomena:
   Other initial social networks
   Population/facility density
   World size

Effect of link removal algorithms in evolving networks
Effect of memory of knowledge and criteria for knowledge sharing
Directed social networks?
Work to do: experiments

Utility feedback, e.g.:
\[ U_i = U_i' + U(J), \quad J = \text{ego net} \]
\[ U_i = U_i' + \beta \text{TimeF2F} \]
\[ U_i = U_i' + \beta \text{Num_NotFriends}, \quad \beta < 0 \]

Social process feedbacks, e.g.:
- Triad closure, preferential attachment, homophily index

Constrained relationship contexts, e.g.:
- Average % friendships visited F2F in a day

Households and other social networks

Enforce facility capacities

Ride sharing utility and alternative transportation modes
References: Social geography and Activity Spaces


Bramoullé, Y., H. Djebbari, B. Fortin (2007), Identification of Peer Effects through Social Networks, ...


References: Microsimulation of Social Systems


References: MATSim


Alternatives to Utility-Maximizing

Rule-based decisions:
   If A does this, B does that
   Schelling
Satisficing:
   Strategy OK if utility exceeds average for group
Punishment, Altruism, etc.
   (Could possibly be incorporated into utility maximization)
## Run summaries

<table>
<thead>
<tr>
<th>Avg. Trip Distance</th>
<th>Avg. Best Score</th>
<th>Avg. Friends Score</th>
<th>AvgNFri Score</th>
<th>Score-AvgFriend Score</th>
<th>AvgTripDuration</th>
<th>Trip Speed (km/h)</th>
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