City-Scale Traffic Simulation from Digital Footprints

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Traffic micro-simulation

Activity-based transportation micro-simulation
• a population of agents performing a sequence of activities
• large-scale (millions of vehicles), OSM road geometries
• handles interactions between vehicles, junction crossing, congestion, etc.
• adaptation strategies for route selection and departure time

Traditional data sources

Little/No data
Where do you work?

Home Locations

Work Locations

A sub-sample of 50,000 individuals working in Dublin, Ireland, from the census of population, Central Statistics Office (2006-2011).
Traffic

6 am

10 am – 5 pm

unknown

8 pm
Where else do you go?

National Travel Survey (NTS) includes the following categories:

- school/education
- shopping
- personal business
- sport/leisure
- doctor/medical facility
- visiting family/friends
- social/entertainment

NTS also contains statistics on the variability and relative frequencies of activity chains, 16000 people were asked “what did you do today, and when?”

But where?

- spatial choice models
- geography of social networks
Spatial choice models

We introduced a variation of the radiation model for individual spatial choice

- Theory of intervening opportunities
- Distance decay is replaced with rank-based decay
- Capacities of opportunities matter
- “Individual demand” distribution can be integrated out

\[
P(1|m_i, n_j, s_{ij}) = \int_0^\infty dz P_{m_i}(z) P_{s_{ij}}(<z) P_{n_j}(>z) = \frac{m_i n_j}{(m_i + s_{ij})(m_i + n_j + s_{ij})}
\]

[Simini et al., 2012]
Spatial choice models

$m_i$ – $i^{th}$ individual’s demand threshold to undertake a trip

$n_j$ – capacity of a destination $j$, abilities to satisfy that demand

$s_{ij}$ – sum of intervening capacities

$$P(1|m_i, n_j, s_{ij}) = \frac{m_i n_j}{(m_i + s_{ij})(m_i + n_j + s_{ij})}$$

Fitting the $m$ parameter in the inverse rank cumulative probability plot, log-log scale.

Impact of $m$ parameter on the trip length histogram. X-axis is in $\log_{10}$ scale, km.

Demand parameter can be tuned for each facility/activity type: schools, shopping, medical facilities...
Leisure and social activities on Twitter

Using combined dataset of Twitter and Foursquare check-ins in Ireland, demand parameter was tuned for the set of leisure/sport/social activities

[Pozdnoukhov & Kaiser 2011]
Geography of social networks

Community structure of social network in Ireland from mobile phone data analysis, >10^6 users

Probability of friendship decays with distance/rank

Communities are spatially structured into enclosed contiguous regions

[Walsh&Pozdnoukhov 2011]
Geography of social networks

A social network for the population of agents was generated that reproduces the geographical alignment of community structure, node degree and social tie length distributions of a real social network of 1M people derived from cell phone data.

A histogram of a social tie length (left) and node degree (right) of the simulated social network.
Traffic volumes validation

Weekday M50 Motorway South-Bound (Count Station 2)

Weekday M50 Motorway North-Bound (Count Station 2)

Weekday M4 Motorway In-Bound (Count Station 1)

Weekday M4 Motorway Out-Bound (Count Station 1)

500 more SCATS counters available in the city...
Conclusions

Realistic large-scale traffic micro-simulation accounting for social and leisure trips and validated on road counts.

Mid-day activities are rarely covered by traditional data sources, and we applied:

• social network model from cell phone logs for geography of friendship and destinations of social visits;
• social media to calibrate a radiation-type destination choice model for leisure/shopping journeys.

Now: currently running experiments with > 500,000 agents, inter-city journeys, more realistic volumes, influence of traffic jams on destination location choice, “what-if” scenarios, etc.

Future: Interplay between social ties and mobility is complex, better models needed for that. What about weekends?
Thanks!

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