Activity space: Concept, measurement and first results

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Introduction

Principle question

How may locational choice and the intensity of individual usage of urban space be visualised and measured?

Outline

Variability in travel behaviour and recent data collection
Spatial mobility: Questions and hypotheses
The activity space concept
  Concept
  Measurement
  Results
The Borlänge GPS data - Outlook on further work
Intra-personal level of mobility

**Behavioural variability**

**Inter-personal level**

*Single day*

- Person 1
- Person 2
- Person 3
- Person 4
- Person 5

**Intra-personal level**

- Person X

<table>
<thead>
<tr>
<th>Time</th>
<th>Mo</th>
<th>Tu</th>
<th>We</th>
<th>Th</th>
<th>Fr</th>
<th>Sa</th>
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<tbody>
<tr>
<td>Mean</td>
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</table>

e.g. sum of travel time
Long-term issues in travel behaviour: Mobidrive survey

Temporal phenomena: Behavioural issues over time
  • Stability
  • Regularity / Rhythms
  • Variability
  • Dynamics

New suitable data? - Mobidrive 1999
  • 6-week travel diary
  • Ordinary PAPI design
  • German cities Karlsruhe und Halle
  • 162 households / 361 persons / 52,000 trips

Geocoding of destination addresses (local trips: exact, regional trips: coarse)
Analysis example: Stability in departure time choice* 

* First trips from home, self-employed respondents, interval: 30 minutes
Spatial aspects of mobility: Questions and hypotheses

• Distribution of visited locations in space
• Organisation of activity patterns based on distribution (activity chaining)
• Feedback between spatial opportunities and realised locational choice
• Methodological: Adequate representation of locational choice and measurement of space use

• Equivalent observations to temporal issues: Large degree of routinised behaviour in locational choice
• Travel and activity demand around and between the pegs of daily life (home, work place)
• Necessities, time budgets, travel potentials (e.g. mobility tools) and spatial perception / knowledge determine behaviour
Activity space: Concept (1)

(Micro-geographical) Indicator for individual space use

Geometrical (two-dimensional) form based on distribution of visited activity locations over time \( \Rightarrow \) OBSERVED behaviour

Individual panel data allows physical mapping / listing / enumeration of visited locations and travel demand in-between

Several conceptual studies with focus on travel potentials (e.g. space-time prisms)

But: Few empirical work due to missing data
Activity space: Concept (2)

Objectives (summary)
- verification of hypotheses on individual activity spaces
- help to improve forecasts on locational choice
- reveal interaction between spatial supply and realised demand
Activity space: Measurement approaches (concepts)

Geometrical forms show...

• Probability
  Given an observed locational choice, which further locations are likely?

• Density / intensity
  Which urban space is used intensively according to one’s needs and preferences?

• Perception / memorising
  When moving through nets, which adjacent area is perceived and possibly memorised?
Activity location distribution: Example (1)

Women, 24
Full-time
Single
216 trips / 6 weeks
Activity location distribution: Example (2)

Man, 50
Full-time
1 child
120 trips / 6 weeks
Measurement approaches (1): Confidence ellipse

Concept:
Probability

Smallest possible area of a true value of the population (i.e. activity locations)

Measure: Area

Shows dispersion / concentration
Measurement approaches (2): Kernel densities

Concept: Density of usage

Density surface created by distribution of locations (optional: frequency of visit)

Measure: Area with positive density value or “volume”

Shows clusters, sub-centres
Measurement approaches (3): Minimum spanning tree

Concept: Routes / Area spanned

Smallest geometry based on all O-D-relations observed (e.g. smallest path)

Measure: Length of geometry / area spanned / buffered area

Shows space / network perception
Activity space size variation (1)*

* Local trips only
Activity space size variation (2)*

* “Visited area”, grid cells with positive Kernel densities value [500*500m]
Activity space size variation (3)*

* Minimum network based on observed O-D-relations
Initial results: Determinants of size

No clear picture, but...

+ Amount of mobility (especially kernel densities)
  Number of visited locations

+ Ellipses: Joint effect of household location and intensity car usage

+ Variation within sociodemographic groups differs (minimum spanning trees)

Significant correlation between measures (arrow travel volumes)
Initial results: Determinants of structure

Locational choice stable or variable?

Performing activities at few places:
Combination of activities in “clusters”

Which purposes as cores?
Workplace as centre nonsignificant?

* e.g. radius: 1000m, minimum 10% of all trips, minimum 3 unique locations in total
Measures assessed

- Flexible
- Easy to implement in G.I.S
- Easy to interpret

Ellipses
  - Over-generalisation of activity space size due to rigid geometrical form

Kernel densities
  - Shows proximity between locations, but neglects dispersion and relationships between sub-centres

Minimum spanning trees
  - Shows dispersion and navigation
Directions of work

Principally: Continuous representation of individual space usage / activity space acceptable?

Accessibility of locations, spatial supply of opportunities: Interactions

Internal structure: What ‘happens’ in and between the subcentres? Travel times, activity durations, activity chaining

Activity space and destination choice analysis / modelling: Choice set refinement?
References


Borlänge GPS data: A brief overview

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Background: Rättfart Borlänge

- Background: Traffic safety: Swedish Vision Zero approach
- Objective: Speed-limit control by on-board information systems (GPS)
- Aim: Test of acceptance, dynamic speed adaptation
- Implementation: „Intelligent Speed Adaptation“ (ISA), Vägverket
- Case study: Town of Borlänge (SE), appr. 350 “test drivers”
- Original analysis: Traffic psychology, driving behaviour

Secondary use of logg data for travel behaviour research (IVT/ETHZ and ROSO/DMA EPF Lausanne):
- Regularity of travel - Hazard models
- Activity spaces
- Route choice modelling - especially path size models
Data availability: GPS and auxiliary

Logg data of 260 vehicles: 190 private test driver, 70 commercial
• Data log every 1 (10) second
• 450,000 all trips (including commercial)
• 250,000 private car trips (Minimum 100, maximum 4000 trips per vehicle), ~50,000 mobile days
• Minimum obs. period: 50 days, maximum: 603 days, mean: 1 year

Data attributes used for secondary analysis: Times (dep./arr.), durations, exact positions, (routes)

Additional data: - Regional road network
- Land-use and POI data (Borlänge kommun)
- Debriefing data (sociodemographics)
- Swedish national travel survey (RES)
Data processing requirements

Aim: Create diary-data-like mobility information

Principally: Definition of minimum quality levels for post-processed data attributes (High, acceptable accuracy, approximations, unavoidable missing data)

(Neglect of non-car travel; only local trips)

Fundamental data post-processing tasks:

Detecting additional or redundant trip ends (J. Wolf, Geostats)

Definite identification of...

- the driver
- unique origins and destinations of travel
- trip purposes
Data processing so far

Initial cleaning of raw data
- Thresholds for minimum/maximum durations, distances etc.
- Consider local trips only

Categorisation and filtering
- Weekdays/weekends, trips to parkings etc.

Identification of trip end positions
- Aggregating of observed trip ends to unique destinations

Identification of trip purposes
- Unique home and secondary location where known
- Trips ends ➔ land use / POI
- “Temporal matching”: Trip/activity attributes compared to generic data
Data post-processing example

Spatial clustering

Land use comparison

1 Private business
2 Work related
3 Long-term shopping

1 Private business
2 Work related

1 Leisure
2 Work related
### Data post-processing example

<table>
<thead>
<tr>
<th>Sex</th>
<th>Occupation status</th>
<th>Car availability</th>
<th>Weekday</th>
<th>Activity start time</th>
<th>Activity duration [min]</th>
<th>Most probable activity purpose</th>
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Data processing so far: Initial sample results (1)

28 fulltime workers / 11 retirees (with sufficient debriefing data)
   19 - 208 mobile days
   66 - 1185 trips

Compared with cross-sectional reference data (RES):
   Fairly consistent imputation results (number of trips per day, durations, distances etc.)
   Data confirms earlier findings of Mobidrive (relationship trips-unique locations, variety seeking)

Problems:
   Trip purposes partly mis-assigned
   Missing back-home trips
Data processing so far: Initial sample results (2)

Identified daily patterns (on respondent):

<table>
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<tr>
<th>Activity</th>
<th>Monday-Friday</th>
<th>Sundays</th>
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<tr>
<td>Immobile day</td>
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<td>Serve passenger</td>
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<tr>
<td>Home</td>
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</tbody>
</table>

Activity spaces (Kernel densities):
Data processing - essential next steps

Beforehand detect / remove structural inaccuracy (missing and redundant trips)

Enlarge reference data set

Improve trip purpose assignment to trip ends, i.e. include better land-use / POI data, regularities in travel, combining purpose probabilities (e.g. Bayes) etc.
References
