Collection and Analysis of GPS-Based Travel Data for Understanding and Modeling Activity-Travel Patterns in Time and Space

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GPS Tracking and Time-Geography Applications for Activity Modeling and Microsimulation
Santa Barbara, CA, October 10-11, 2005
Motivation for Time-Space Geography

- Derived nature of travel demand – activities distributed in time and space
- Action “space” governed by modal accessibility and “time” availability
- Representation of time-space continuum offers strong behavioral framework for modeling activity-travel patterns
  - Opportunities and constraints
  - Interactions/interdependencies among agents
- Key distinction between tour-based and activity-based microsimulation model systems
Time Use and Activity Perspectives

- Speed is finite and time is limited
- Individual’s trajectory in time and space confined to Hägerstrand’s prism
- Need to recognize spatio-temporal constraints on individual’s movement
- Time use and activity-based approaches to modeling transport demand emerging
A Time-Space Prism

- A simplified representation of time-space constraints

Diagram:

- Time
- Space
- B
- A
- Work
- Home
- \( v \)
Role of Time-Space Geography

- Prism-Constrained Activity-Travel Simulator (PCATS)
  - Comprehensive activity-based microsimulation model
- Time-space geography plays critical role in:
  - Defining destination choice set by mode availability
  - Defining activity type choice set by destination availability
  - Interdependency among trips with respect to destinations and schedules (timing)
  - Interdependency among individuals – joint activity-travel engagement
Prism-Constrained Activity-Travel Simulator

- Define open and blocked periods for each individual
- PCATS incorporates time-space constraints
  - Mode availability
  - Modal speed
  - Time available
  - Range of destinations
- Structure of PCATS
Sample Distributions:
Origin Vertex – Morning Prism

Percent of Sample

Time

Miami Obs
Miami Vertex
SF Obs
SF Vertex
Sample Distributions:
Obs Travel Time vs Frontier Distributions

- Com Exp ($\mu = 94$ min)
- Com TTB ($\mu = 165$ min)
- Non-Com Exp ($\mu = 95$ min)
- Non-Com TTB ($\mu = 188$ min)
## International Comparisons

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<th>Survey area</th>
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<th>Non-commuters</th>
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<td>India</td>
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GPS Data and Time-Space Geography

- Accurate temporal and spatial attributes for all activities and trips
- Construct time-space paths of activity-travel participation on (actual) modal networks
- Automated geocoding of all activity/trip locations
- Multiday and multiweek data on time-space paths due to reduced survey burden
  - Explore variations and planning time horizons
Collecting GPS Data on Time-Space Paths

- Passive vs. active data collection protocol
  - What does the respondent need to provide?

- Secondary data collection
  - What needs to be collected and how?

- Temporal resolution of data collection

- Sampling issues
  - One person vs. All persons vs. One vehicle vs. All vehicles
  - Sample size: Is a smaller sample size sufficient because of greater accuracy and/or multiday data?

- Understanding limitations of GPS data
Analyzing GPS-based Travel Data

- Management, synthesis, and visualization of data in GIS platforms
- Construction of time-space paths/prisms
- Linking/matching/merging secondary data
  - Land use, network, census, commercial databases
- Route choice behavior and network analysis (supply variables)
- Comparison of actual vs. “optimal” time-space path
  - Develop/refine behavioral paradigm (not utility maximization)
  - Positive utility of travel?
Using GPS Data in Activity-Based Model Development

- Define/identify constraints and opportunities
  - Time-space constraints → Generate choice sets (activity type, destination, mode, time of day)

- Incorporate interactions and interdependencies
  - Household time-space paths → Interperson interactions (vehicle and task allocation, joint activity engagement)
  - Multiday time-space paths → Interday dependency (history dependency and future anticipation/planning)

- Inform model linkages and specification
Challenges and Opportunities

- Tools and resources for collection, analysis, synthesis, and visualization of time-space geography
- Identify wider range of applications
  - ICT, mobility, accessibility, and social equity analysis
  - Network performance assessment (supply analysis) – application to disaster planning
  - Built environment, travel behavior, and physical activity
  - Land use planning – locate activity opportunities within time-space paths
  - Transportation security and safety applications (locations of people and vehicles by time of day)
Challenges and Opportunities (continued)

- Identify wider range of applications (continued)
  - Driver behavior and vehicle acceleration/speed profiles → vehicle emissions analysis
  - Comprehensive microsimulation of land use – travel demand – traffic (network) continuum