Spatio-temporal Approaches to Understanding Human Behavior and Social Organization

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Objective I:

To explore Geo-Information/communication technologies—implications for:

- Individual space-time behavior
- Space-time social ecology of cities & regions
  (i.e., behavioral settings)

Why?

- Geo-ICT influences social consciousness of space, place, & time:
  - Conditioning theoretical perspective & application possibilities
  - Influencing individual decisions & social policies
- Causal reflexivity
  - individuals upon space & place
  - spaces & places (social ecologies) upon individuals
Objective II:

To suggest new information retrieval & display capabilities for:

• Real-time, on-the-fly aggregation
  – Flexible by time and space from individual data
  – Flexible by demography & social attributes from individual data

• Publically accessible, **But:** protective of individual rights to location privacy
Individual Space-time Behavior
Individual paths in time-space — after Hägerstrand
Space-time Perspectives on Individual Activities

• Time-geography — Torsten Hägerstrand
  – Geo-visualization of space-time paths — Mei Po Kwan/Shih-Lung Shaw

• Space-time extensibility — D Janelle/P Adams
Human Space-time Extensibility

• Interaction beyond one’s immediate physical presence

• Projection of authority & presence over space & time

  – Stretching social systems across space & time
Adams on Human Space-time Extensibility

• Paul Adams (2000)
  – People as branching structures

  – Linking micro and macro scales — the role of IT

  – Using CAD with data from personal interviews & detailed records of communication activities
Extensibility Diagram linking Diann’s communications with other survey participants

Paul Adams (2000)
Some New Realities for Individual Behavior

• Techno-enabled **multi-tasking** & **hyper-mobility**

• **Virtual tools** (e.g., wireless Internet) link **mobile objects** (pedestrians, vehicle operators, public transit riders) to broader social systems and networks

• **VGI** volunteered geographic information (M Goodchild) as a new virtual form of human extensibility
Hypotheses about Changing Human Activity Patterns
Helen Couclelis

• Growing **space-time disconnect** between activities & places and between activities & times

• Increasing **fragmentation** of activities & events

• Decreasing reliability of behavioral models for capturing the complexities of human interactions
Discontinuities in Space-time Paths

• Individuals as *agents* can:
  – do more than one thing at a time
  – occupy more than one place at a time (virtually)
  – occupy more than one time at a place (virtually)
  – interact with others independently of their presence

• Individuals as *mobile objects* can be:
  – traced continuously in space & time
  – intercepted in-route
  – redirected along new space-time trajectories
  – archived into long-term surveillance databases

• Individuals as members of *networks* can:
  – be independent of place or dependent on place
  – coalesce into ad hoc groups to meet temporary objectives
  – be stable even though locations of members change
<table>
<thead>
<tr>
<th>Temporal Coincidence Required?</th>
<th>Spatial Coincidence Required?</th>
<th>Yes Transportation Dependent</th>
<th>No Transportation Not Needed</th>
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</thead>
<tbody>
<tr>
<td>Yes Synchronous</td>
<td>Face-to-Face meeting</td>
<td>Telephone (wire, wireless, net), teleconference (audio / audio-visual), Text messaging, radio (CB/HAM,VHF). May need complex coordination</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Requires coordination</td>
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<td>Reduces Costs</td>
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<td>Allows intense, rich, &amp;</td>
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<tr>
<td></td>
<td>personal communication</td>
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<td></td>
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<tr>
<td></td>
<td>Very High Costs</td>
<td></td>
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<tr>
<td>No Asynchronous</td>
<td>Refrigerator notes</td>
<td>Answering machines, voice mail, e-mail, telegrams, telex, fax, computer conferencing, podcasting, printed publications</td>
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<td></td>
<td>Hospital charts, mail</td>
<td>Eliminates coordination</td>
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</tbody>
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Space-time Perspectives on Behavioral Settings

• Time Landscapes – Barbara Adam
  – Time Ecology – Martin Held/Gus Koehler
  – Chronomaps – Sandra Bonfiglioli

• Space-time Social Ecology of Cities
  – D Parkes & N Thrift / M Goodchild & D Janelle
Paths to Space-time Urban Ecological Analysis / Modeling

**1800s** Population Census

**Early 1900s** Time & activity diaries / Social ecology

**1940s – 1950s** Daytime population / Social area analysis

**1960s – 1970s** Census factorial ecology

**1960s** Time geography

**1970s** Space-time diaries / Space-time ecology

**1980s** GIS / Spatial demographics

**1990s** GPS / GIS / Time geography

**2000s** Space-time diaries / GPS / GIS

Time geography / Space-time ecologies

Web 2.0 / Voluntary geographic information (VGI)
Early Interest in Space-time Ecology of Cities

- **Conceptual:**
  - Chicago School of Urban Ecology 1920s–1940s
  - G Engel-Frisch, Temporal Aspects of Human Ecology 1948
  - Amos Harley, Human Ecology 1950

- **Empirical / Enumeration:**
  - F Stuart Chapin, Population Densities Around the Clock 1953
  - Donald Foley, Urban Daytime Populations 1954
  - RC Schmitt, Estimating Daytime Populations 1956

- **Conceptual / Computational / Static:**
  - E Shevky & W Bell, Social Area Analysis 1955
  - R Murdie & others, Factorial Ecology late 1960s/early 1970s

- **Conceptual / Computational / Dynamic:**
  - D Parkes & N Thrift, Factorial-ecology in space & time 1975
Population Densities Around the Clock
F.S. Chapin & P.H. Stewart, *The American City*, Oct 1953

Flint, Michigan
Time Geography of a Canadian City Project
(Janelle & Goodchild)

– Space-time activity survey of Halifax (A. Harvey)
  • Approx 2100 one-day diaries spread over the week
  • 99 activity types
  • Resolution 1-min in time and 100 m in space

– Creating “census-like” data by time of day
  • Based on activities (Who is where when? What are they doing? with whom?)

– 3-mode factor analysis (activities, space, time)
Location Quotients – Concentration of Unmarried Respondents by Time of Day

Space-time measures for subpopulations:
- densities
- segregation indices

From space-time paths:
- activity times & spaces, durations, sequences, fragmentation
- average trip speeds
- activity dispersal, range

Janelle & Goodchild, 1983
Space-time Ecology of Human Activity

Halifax

Janelle, Klinkenberg & Goodchild, 1997
What is the link between individual behavior & urban ecological structure?

Objective II

To suggest new information retrieval & display capabilities

Real-time, on-the-fly aggregation

Individual data
Flexible by time & space
Flexible by demography & social attributes

Publically accessible, But: protective of individual rights to location privacy

The Case for Synoptic Mapping
Synoptic Analysis
(Climatology, meteorology, oceanography)

- Analyzing processes of short & long duration over space
- Fixed & mobile distributed information sensors for continuous real-time coverage
- Integrated data archives for aggregation at any spatial scale or temporal period
- Modeling & visualization tools to describe & analyze changes in patterns & to render results on demand (e.g., weather map; hourly, daily, seasonal forecasts)
Imagine

– Having/using massive amounts of dense tracking data from stationary & mobile sensors for dynamic conversion into mapped synoptic real-time patterns, index measures, & forecasts
– drawing on data archives to analyze trends over any unit of time for different aggregations of space & for different aggregations of people
– **Modeling changing patterns** over space based on refined temporally-sensitive data streams about locations & activities of the population
Possible Dynamic Maps of Urban Social Synoptic Patterns

– Diurnal, weekly, & seasonal shifts in population densities by subpopulations
– Temporal variations in social group integration & spatial concentration by regions/small areas
– Risk exposures to geographically distributed hazards
– Surface representations of average travel speed, congestion, & other indexes of traffic by neighborhood or road segment
Challenges to Dynamic Urban Social Ecology

• Managing & protecting the data
• Demonstrating worthwhile applications, e.g.:
  – Permitting transportation synchronization to changing needs
  – Promoting social capital at neighborhood levels
  – Evaluating time policies on work schedules / services
  – Enhancing responsive emergency services
  – Building space economies from principles of equity, social cohesion, quality of life, & sustainability
• Adding theoretical understanding of process rules / testing hypotheses in a dynamic world
• Designing data capture & display systems that honor the individual’s right to shield identity & protect location privacy
• Avoiding intrusive & unsafe demands on respondents
  – See 2007 NRC report *Putting People on the Map: Protecting confidentiality with linked social-spatial data.*
A Space-time Testbed

• Begin with archive of individual-level data to represent occupants of a hypothetical/real city or region
• Log the hypothetical/real whereabouts, activities & attributes of individuals over their lifetimes, including current real-time information capture
• Create Testbed for Education & Development to:
  – Design & compare approaches to data assembly & aggregation
  – Evaluate trade-offs between location privacy & the scientific benefits of access to individual-level activity archives
  – Develop synoptic index measures & visualizations
  – Assess methods to protect individual confidentiality & guard against malevolent uses
  – Test scientific hypotheses
  – Compare socio-economic or land-use plans & policies at different levels of spatial organization & durations
Conclusions

• Tools are at hand for integrating space-time concepts with the realities of documented dynamic behavior
• A testbed may help in developing new ways to portray the dynamics of ever-emergent social geographies
• Understanding of dynamic social ecologies can yield refined theory & modeling for applied uses
• Entering new territory that will test the ethical bounds of space-time analyses in the social sciences
• Capturing the sense of our dynamic world will set the paradigm that defines the future for more responsive decision making & for better understanding of human social organization
Thank you
References: