Exploring Potential Human Activities in Physical and Virtual Spaces: A Spatio-temporal GIS Approach

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Introduction

- Physical presence vs. tele-presence
  - Information and communication technologies (ICT) have enabled a virtual space.
  - People can participate in activities and interact with others remotely through tele-presence instead of physical presence.

- Time geography (Hägerstrand, 1970)
  - It provides a useful framework to study spatial and temporal aspects of individuals’ activities.
  - Activities in the virtual space are not well addressed.
  - Limited progress is made to develop a GIS-based operational system.

- The main objective of this research is to develop an operational time-geographic GIS for representation, analysis, and visualization of human activities in physical and virtual spaces.
Hägerstrand (1970) proposed a framework to study the relationships between various constraints and human activities in a space-time context.

Three key concepts: space-time path (ST path)
space-time prism (ST prism)
potential path area (PPA)
A Conceptual Model for Physical and Virtual Spaces

- Physical space and virtual space have different rules to control activities within their domains.

- In the meantime, the two spaces also intersect with each other.
  - The physical space provides access channels to the virtual space.
  - The virtual space feeds back information to impact individuals’ activities and travel patterns in the physical space.
Space-time Prisms for Virtual Activities

ST Prism for wired access

ST Prism for wireless access

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Four Types of Communication Modes

- Four types of communication modes have been identified based on their spatial and temporal characteristics (Janelle, 1995; Harvey and Macnab, 2000; Miller, 2003).

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<thead>
<tr>
<th>Temporal</th>
<th>Synchronous</th>
<th>Asynchronous</th>
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<tbody>
<tr>
<td>SP (co-existence)</td>
<td>Face-to-face meeting</td>
<td>AP (co-location in space)</td>
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<td></td>
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<td>▪ Fridge note</td>
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<td>▪ Traditional hospital charts</td>
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<tr>
<td>ST (co-location in time)</td>
<td>Telephone</td>
<td>AT (no co-location in either space or time)</td>
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<td>▪ E-mail</td>
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<td>▪ Web pages</td>
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(Adapted from Miller, 2003)
Spatio-temporal Relationships of Prisms and Potential Human Interactions

Potential SP interactions

Potential AP interactions

Potential ST interactions

Potential AT interactions
Incorporating Time-geographic Concepts in GIS


2. Recently, additional efforts have been made to apply time-geographic concepts in GIS (e.g., Kwan and Hong, 1998; Miller 1999; Miller and Wu, 2000; Weber and Kwan, 2002; Kim and Kwan, 2003; Weber 2003).

3. Representation of space-time paths and prisms in GIS remains a research challenge (Yuan et al., 2004), especially for situations of handling both physical and virtual spaces and analysis of interactions among individuals.
A Spatio-temporal GIS Design for the Extended Time-Geographic Framework

- Three-dimensional spatio-temporal features: 2D space + 1D time
An Explicit Representation of Space-time Prisms

- Forward cone/backward cone: the boundary of a prism
  - Represented as a set of spatio-temporal line features

- Prism
  - Represented as a collection of vertical spatio-temporal line features, which indicate activity opportunities at various locations with explicit time information.
Network based space-time prisms

- **Space-time prism**
- **Potential path area**
- **Origin**
- **Destination**

Forward cone

Backward cone
Space-time life lines for wired access

Space-time life cylinders for wireless access

Extended space-time prism with wired access

Extended space-time prism with wireless access
A case for potential SP interactions

A case for potential AP interactions

A case for potential ST interactions

A case for potential AT interactions
Summary

- Contributions of this study:
  - Extends space-time prism concept to represent potential human activities in both physical and virtual spaces;
  - Develops a spatio-temporal GIS design to accommodate the extended concept by providing functions to compute and visualize space-time prisms in a 3D GIS environment and to support analysis of spatio-temporal relationships among individuals; and
  - Offers an effective approach of dealing with spatio-temporal, individual activity data in a GIS environment.