Visual Analysis of Human Activities

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Human Activities in Space-Time

- Individual movement in space-time is a complex trajectory with many interacting dimensions: location, timing, duration, sequencing and type of activities and/or trips.
- This makes the simultaneous analysis of its many dimensions difficult.
- Past research mainly used multivariate grouping methods to analyze human activity patterns (e.g. pattern recognition algorithms).

Limitations of Conventional Methods

- These methods are not designed to handle real geographical locations of human activities and trips.
- They often involved the use of discretized spatial and temporal variables.
- Sometimes inadequate because of the dimensionality and complexity of the data.

GIS

- Geocomputation and geovisualization can be useful to understand human behavior in space-time
- More complex and realistic representations
- Hybrid activity patterns (Physical and cyberspace)
- Qualitative understanding

Geovisualization and Geocomputation

- Map individual movements through time and space within a set of constraints - **space-time paths**
- These constraints limit people's daily mobility to a set of three dimensional 'prisms' - **space-time prisms**
- Individuals can only occupy the area within these prisms
- Area outside prisms requires mobility beyond that available to them

Interactive 3D Geovisualization

- suitable for dealing with large and complex data sets
- integrate scientific visualization and exploratory spatial data analysis (ESDA)
- can use various **interactive** capabilities (e.g. fly-through, dynamic rotation, etc.)

Development of GIS Methods for the Study of Human Activities in Space-Time

Data Collection

- activity-travel diary data (space-time)
- Activity-internet diary
- global positioning systems (GPS)

Geocomputation

- Space-time accessibility measures

3D Geovisualization

- Space-time activity patterns

Development of GIS Methods for the Study of Human Activities in Space-Time

3D Network Data Models and Algorithms

- Topological data models
- Geometric data models
- 3D shortest path algorithms

Qualitative GIS

- Handle feelings, emotions and perceptions of urban spaces

Portland Data

Activity and Travel Survey (1994-95), Portland, Oregon

- data from 4,451 households with 10,084 individuals
- a total of 128,188 activities and 71,808 trips

Regional Land Information Systems (RLIS)

- 348,580 residential parcels
- 27,749 commercial and industrial parcels

Transport Network

- 130,141 arcs and 104,048 nodes

Activity Density In Geographic Space

Kernel estimation - if $\mathcal{R}$ represents the study area, ***x*** represents a general location in $\mathcal{R}$ and ***x1, x2…. xn*** are the locations of the ***ith*** activities, then the intensity or density, $\lambda(x)$, at ***x*** is estimated by:

$$\lambda_h(\boldsymbol{x}) = \frac{1}{\delta_h(x)} \sum_{i=1}^{n} \frac{w_i}{h^2} k\left(\frac{(\boldsymbol{x} - \boldsymbol{x}_i)}{h}\right), \quad \boldsymbol{x} \in \mathcal{R},$$

where ***k(.)*** is the kernel function, the parameter ***h > 0*** is the bandwidth determining the amount of smoothing, ***wi*** is a weighing factor, and $\delta_h(x)$ is an edge correction factor.

The **quartic kernel function**:

$$k(\boldsymbol{x}) = \begin{cases} 3\pi^{-1}(1 - \boldsymbol{x}^{\mathrm{T}}\boldsymbol{x})^2 & \text{if } \boldsymbol{x}^{\mathrm{T}}\boldsymbol{x} \leqslant 1, \\ 0 & \text{otherwise} \end{cases}$$

described in Silverman (1986) is used for generating space-time activity density surfaces.

In the following examples, this method is implemented with a resolution of 2.89 million cells and a bandwidth of 0.86.

Advantages of Using 3D Geovisualization

- can integrate a large amount of geographic data
- complex and realistic representations
- an interactive environment with navigational capabilities (e.g. “fly-through”)
- increased realism: “virtual reality”
- retain complexity of the original data

3D-VQGIS

3D Visualization and Qualitative Analysis of Geospatial Data

Qualitative Materials

- textual sources, visual/audio sources, interviews, …in qualitative analysis
- Integrated into 3D-VQGIS database for storage and management
- Can be explored separately within database to view available sources
- Can be coded to S-T trajectory and explored interactively in 3D environment

Case Study

- Muslim women in the post 9/11 era
  - A Muslim woman's space-time trajectory in one day.
  - Qualitative sources of the Muslim project
    - Pictures and videos
    - Interview audios and transcripts
- Visualization and exploration in 3D-VQGIS
  - Code for the interviews
  - Qualitative Mapping and Quantification
  - In-depth insights into the person's activities and feelings

Challenges for GIScience

- Mapping location and time
- Context – what is relevant?
- Spatial and temporal resolution – finer the better?
- How to aggregate?
- Scale – multi-scale
- Human experiences
- Privacy issues