Cartographic Visualization

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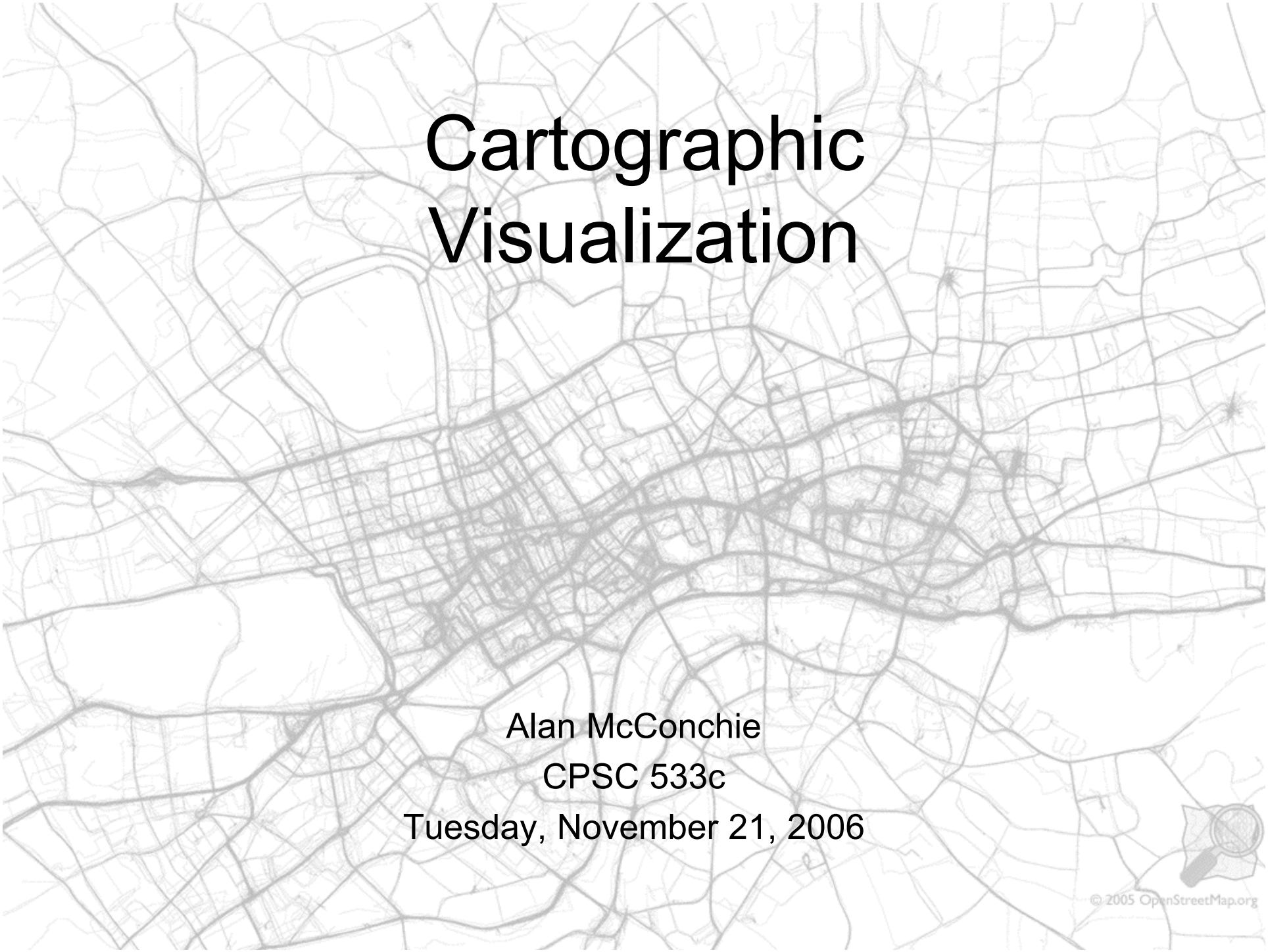
CPSC 533c

Tuesday, November 21, 2006



Papers covered

- **Geographic visualization: designing manipulable maps for exploring temporally varying georeferenced statistics.** MacEachren, A.M. Boscoe, F.P. Haug, D. Pickle, L.W. InfoVis 1998, pp. 87-94.

- **Conditioned Choropleth Maps and Hypothesis Generation.** Carr, D.B., White, D., and MacEachren, A.M., Annals of the Association of American Geographers, 95(1), 2005, pp. 32-53

- **CartoDraw: A Fast Algorithm for Generating Contiguous Cartograms.** Keim, D.A, North, S.C., Panse, C., IEEE Transactions on Visualization and Computer Graphics (TVCG), Vol. 10, No. 1, 2004, pp. 95-110

- **The space-time cube revisited from a geovisualization perspective.** Kraak, M.J., Proceedings of the 21st International Cartographic Conference (ICC), 2003, pp. 1988-96

“Everything is related to everything else, but closer things are more closely related.”

- Waldo Tobler

How does geographic/cartographic visualization relate to the SciVis/InfoVis continuum?

A bridge?

A separate third category?

Designing Manipulable Maps for Exploring Temporally Varying Georeferenced Statistics MacEachren et al. (1998)

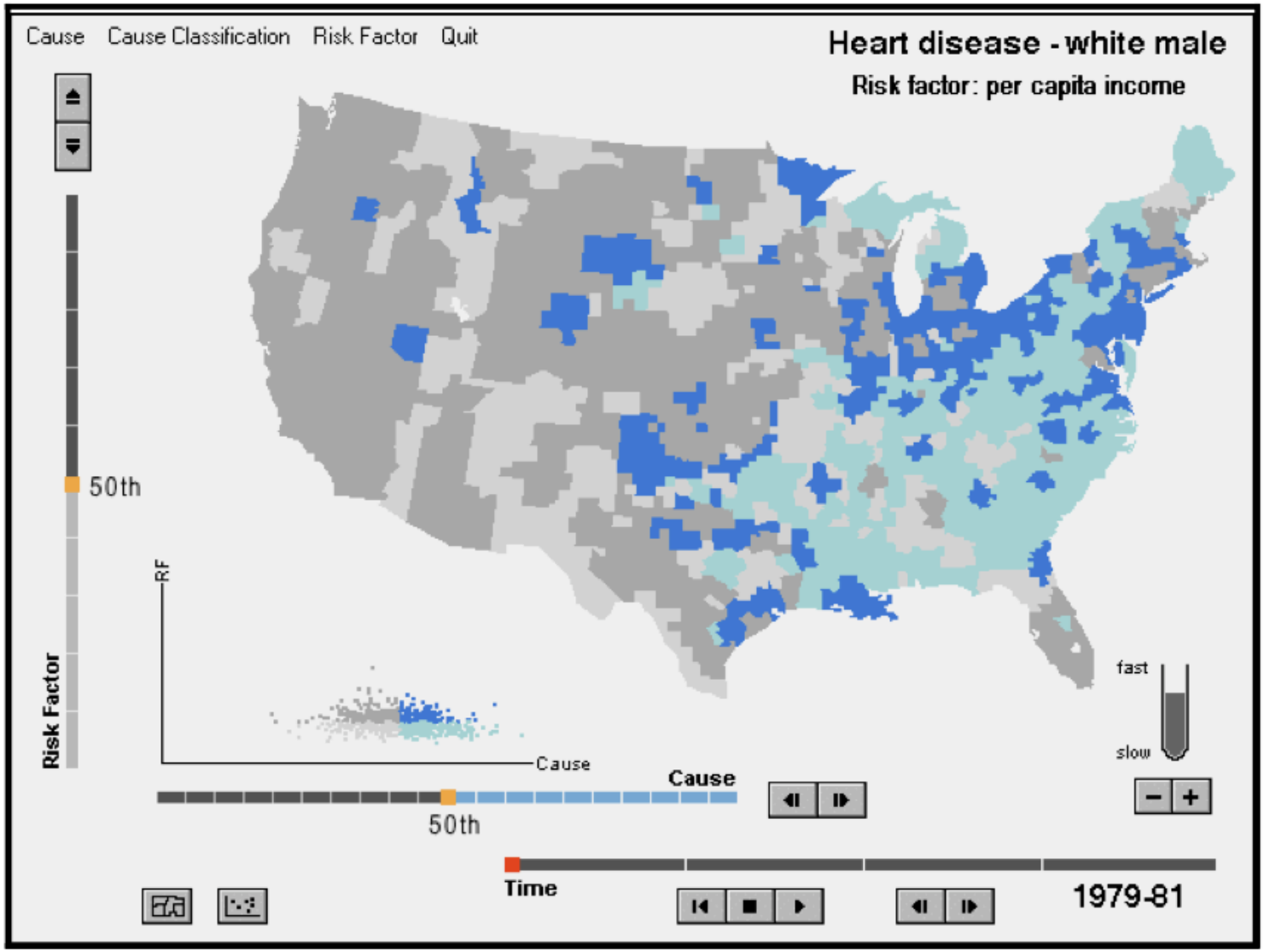
Knowledge construction via Geographic Visualization (GVis)

Four conceptual goals of GVis

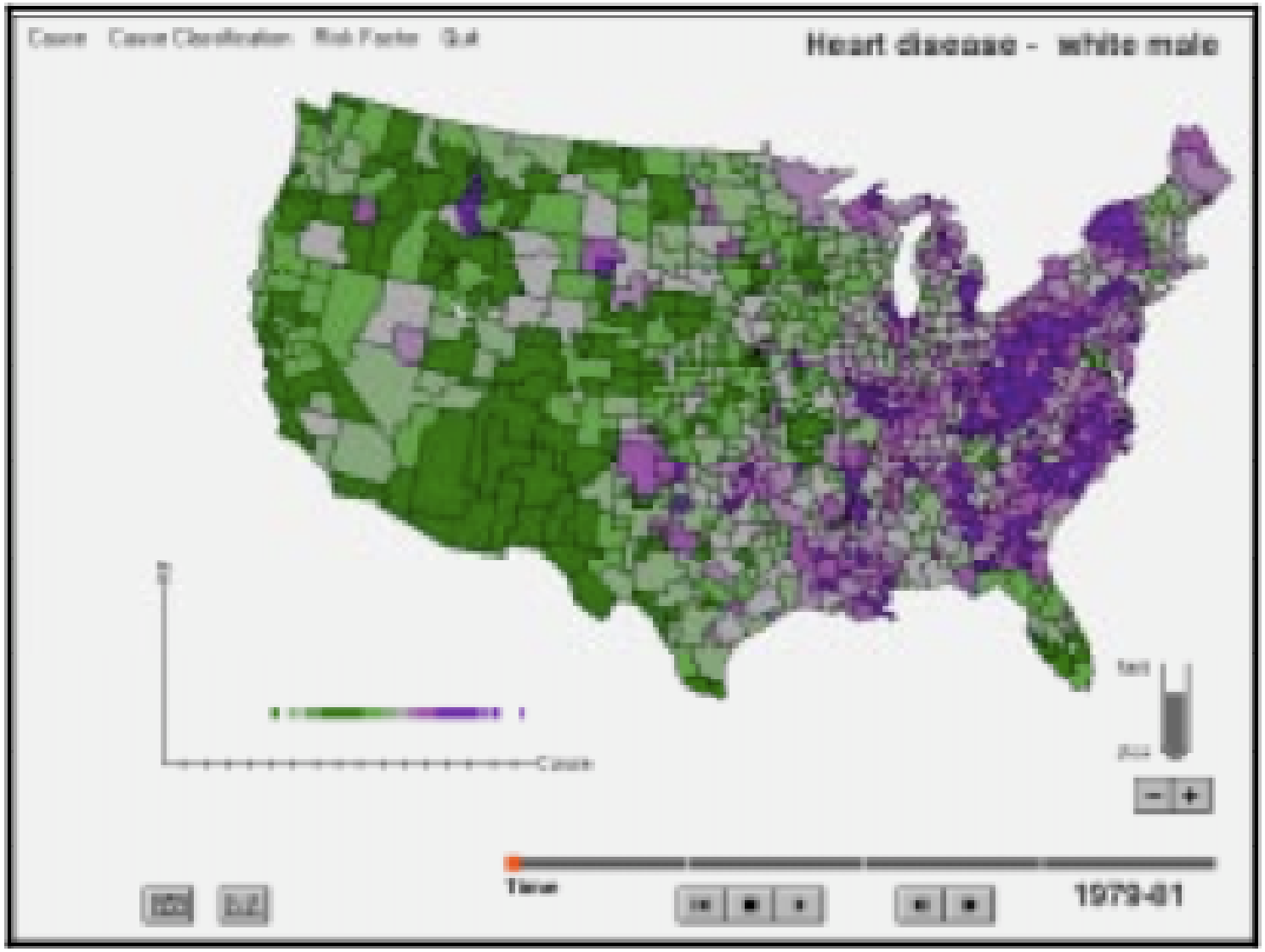
- Exploration
- Analysis
- Synthesis
- Presentation

Foundations

- Map Animation
- Multivariate Representation
- Interactivity

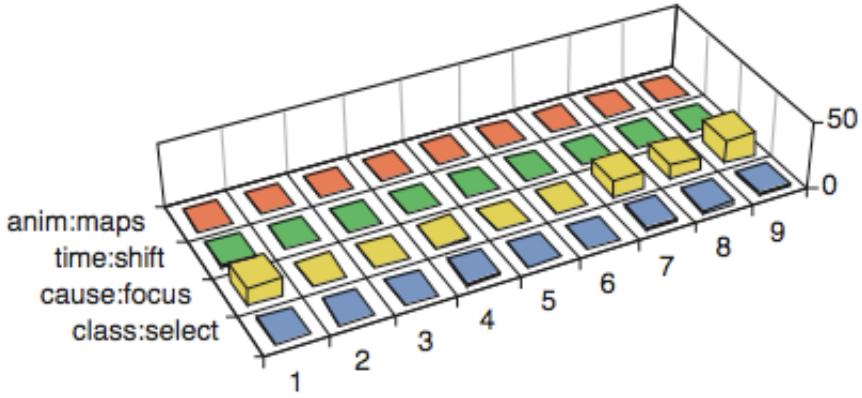


4-class bivariate map (“cross map”)

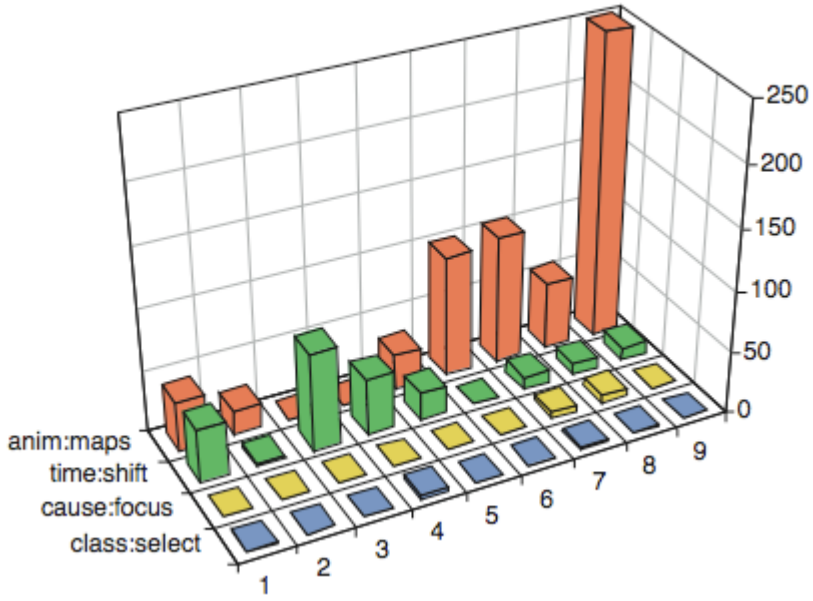


7-class diverging colour scheme

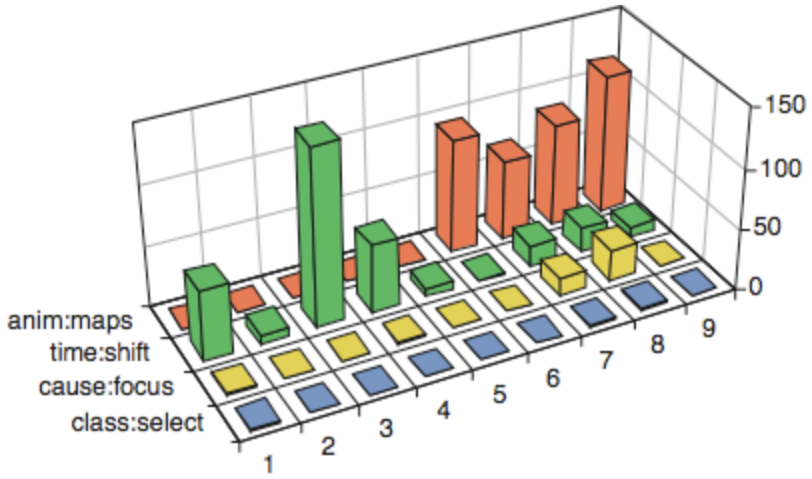
User study: domain experts



1) Find spatial min and max in first time period



2) Find temporal shift in one disease



3) Compare time trend between two diseases

User study: conclusions

- People preferred to use only animation or only time-stepping, few used both.
- Those who used animation spotted more patterns than those who used time-stepping.
- Interactively focusing the cross map is more effective than standard 7-class maps

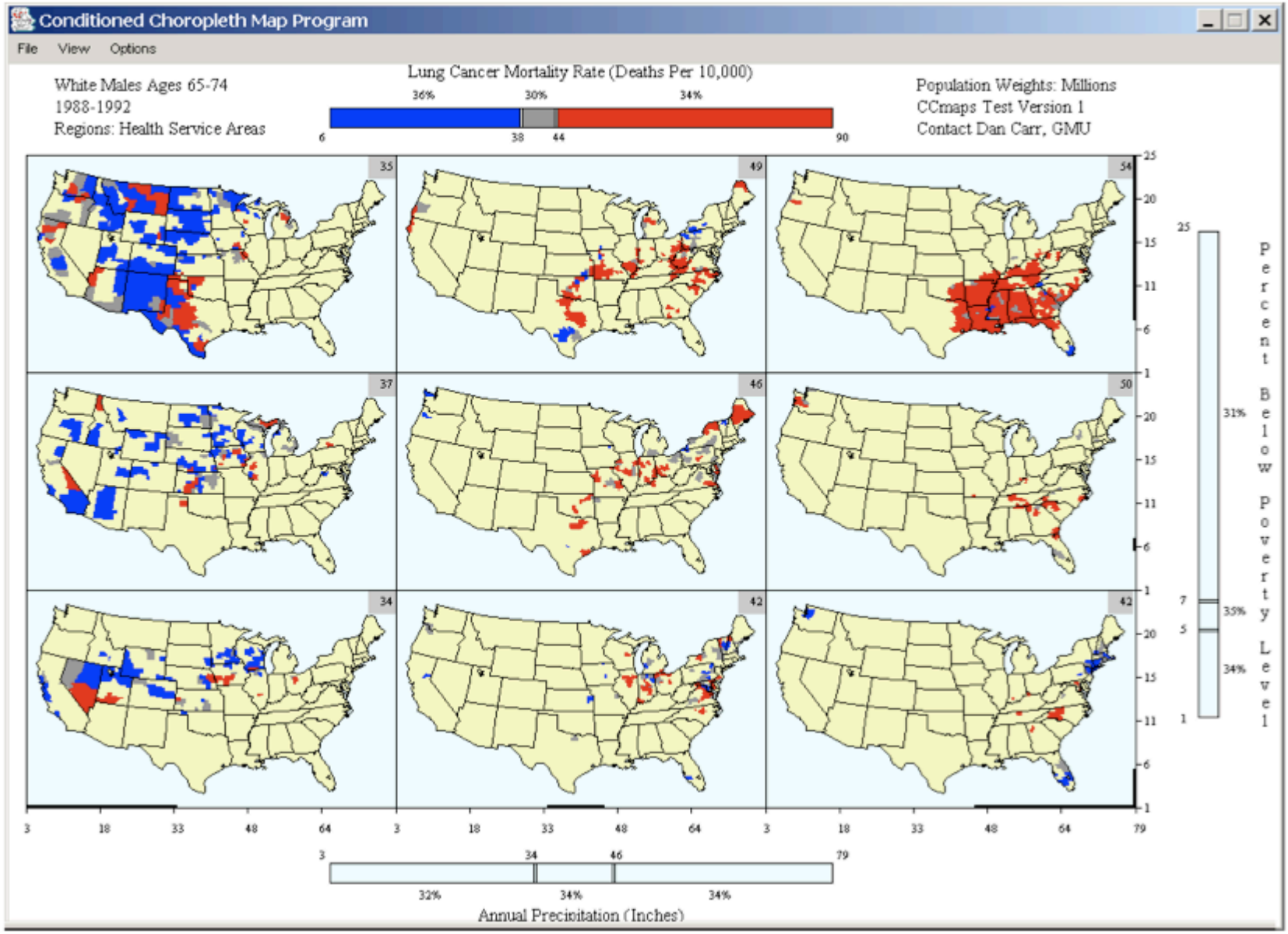
Critique of MacEachren

- Interactive classification solves a major problem in cartography: choosing the best category breaks.
- What if there were more than 4 or 5 time slices?
- Both animation and time-stepping require user to keep patterns in memory.

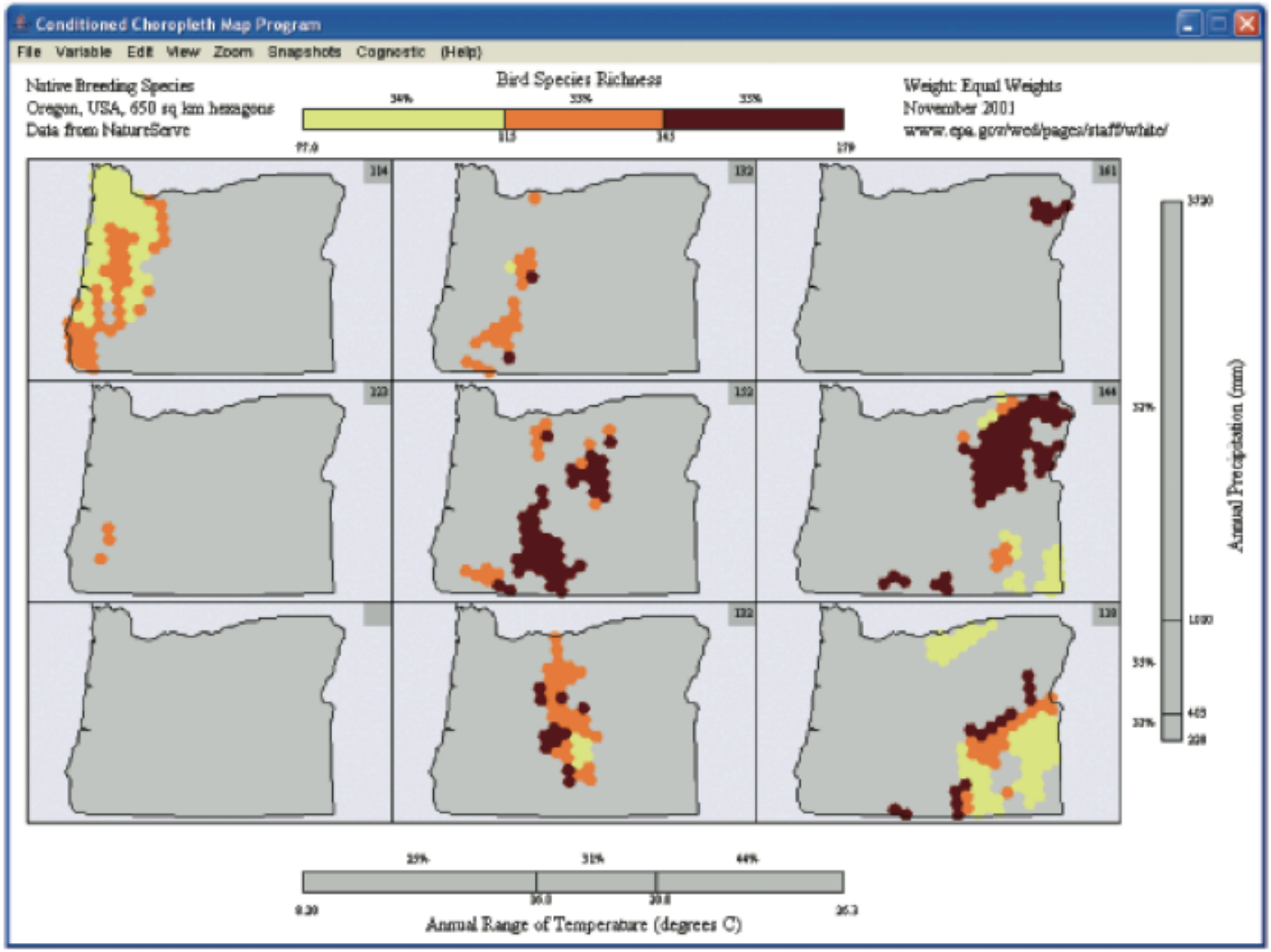
Conditioned Choropleth Maps
Carr, White & MacEachren (2005)

- What is a choropleth map?
  - Statistical data aggregated over previously defined regions
  - Each region is displayed with a uniform value
- What is conditioning?
  - Another variable is used to divide the data.
  - Data satisfying each condition is displayed separately using small multiples

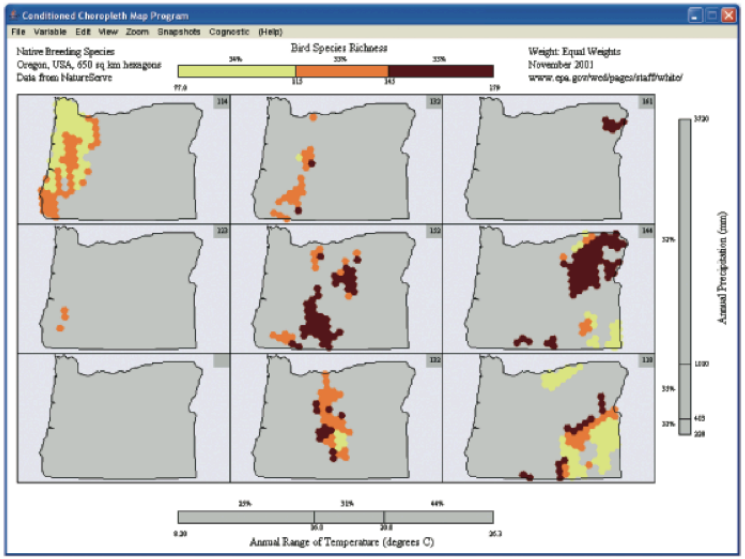
Conditioned Choropleth Maps

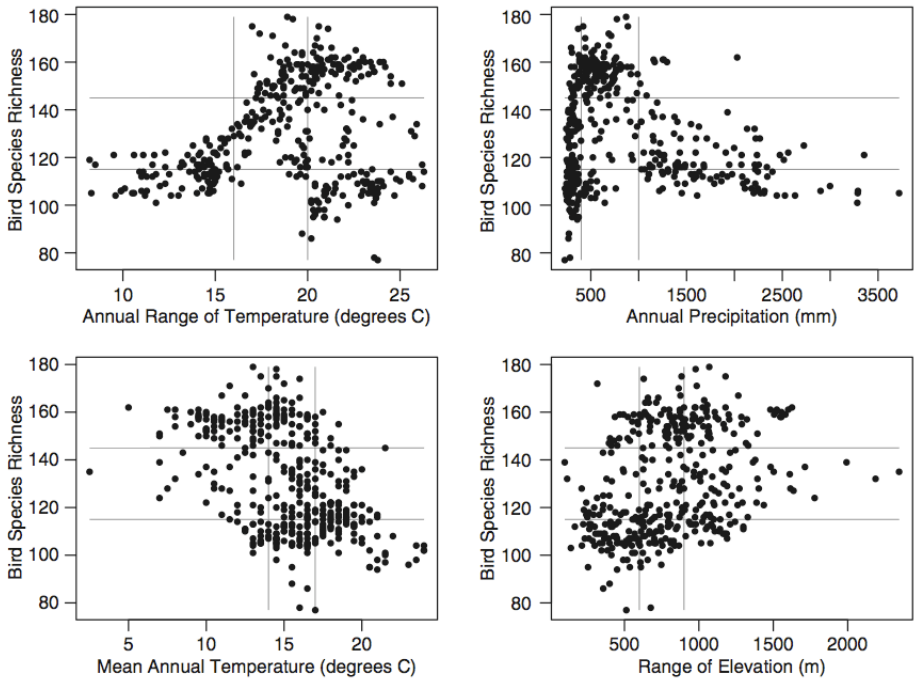


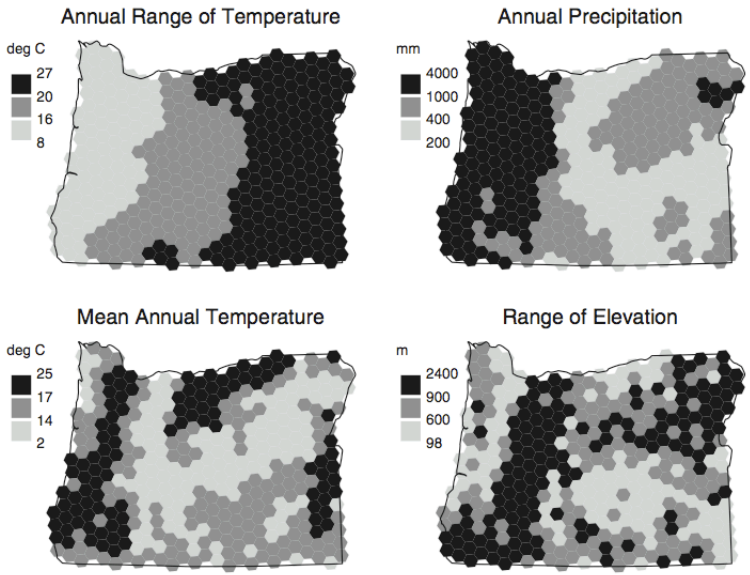
Conditioned Choropleth Maps



Conditioning variables:







Critique of Conditioned Choropleth Maps

- Is all the wasted screen space worth it?
- Use of hexagons is an important step away from pure choropleth maps
  - No longer based on arbitrary regions that may be irrelevant to the analysis
  - However, still aggregate statistics, possibility of patterns being missed that straddle boundaries between areas

CartoDraw: A Fast Algorithm for Generating Contiguous Cartograms
Keim, North & Panse (2004)

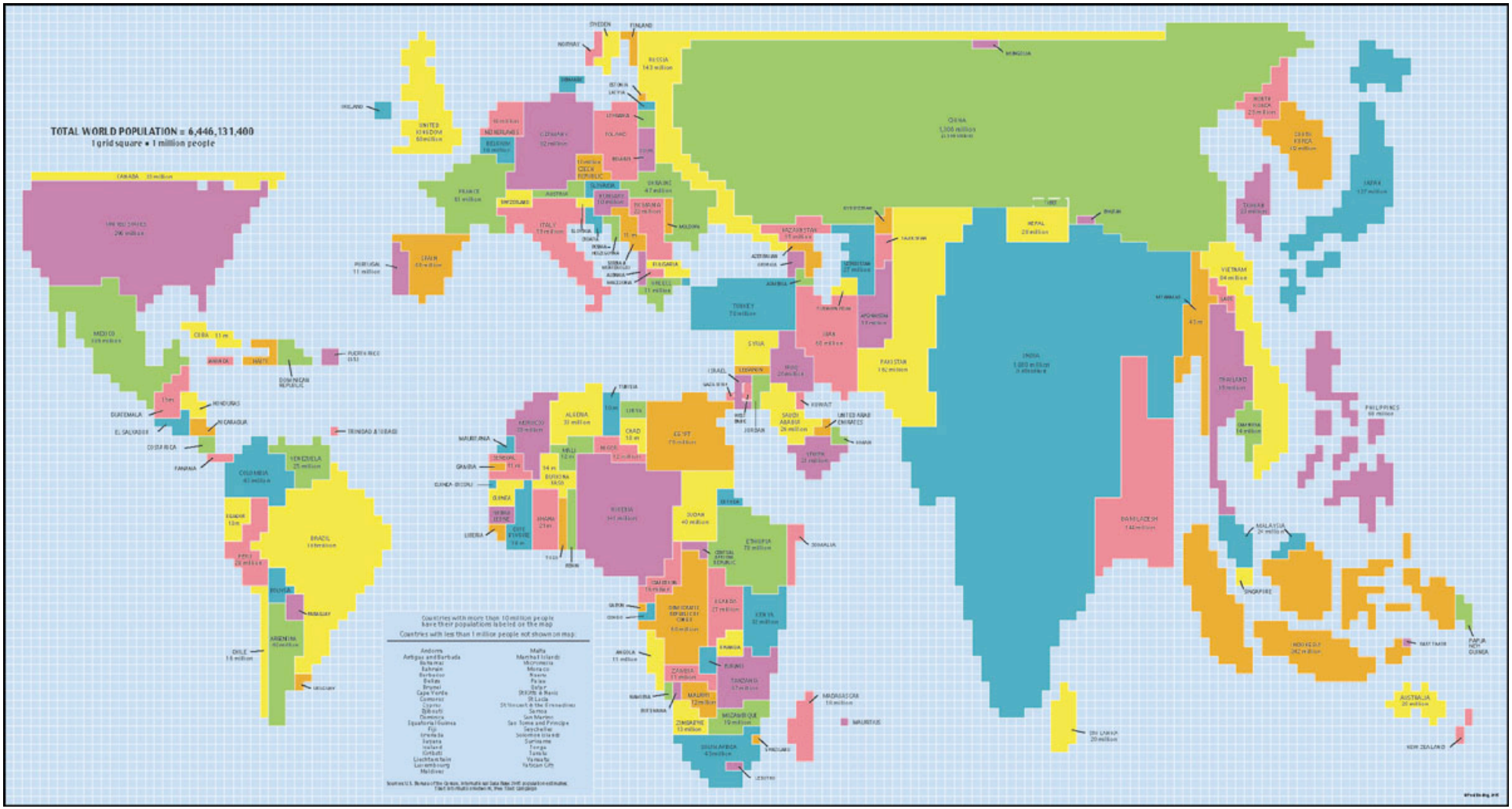
A cartogram is a map where area on the map represents some value other than real-world area

Important trade-off between retaining familiar shapes and representing area accurately (and in a useful way)

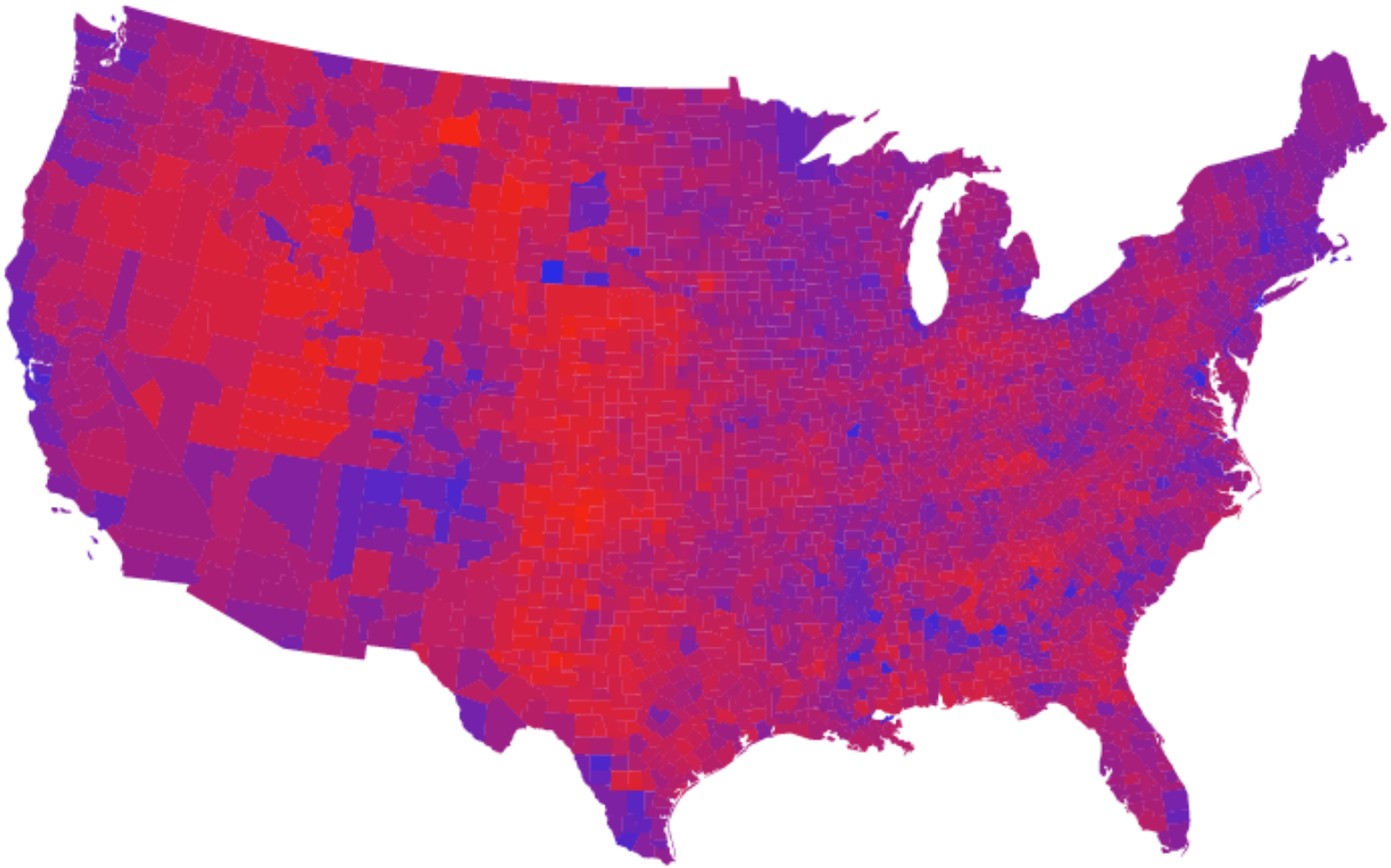
Computer generated cartograms are:

- often not aesthetically pleasing
- computationally intensive

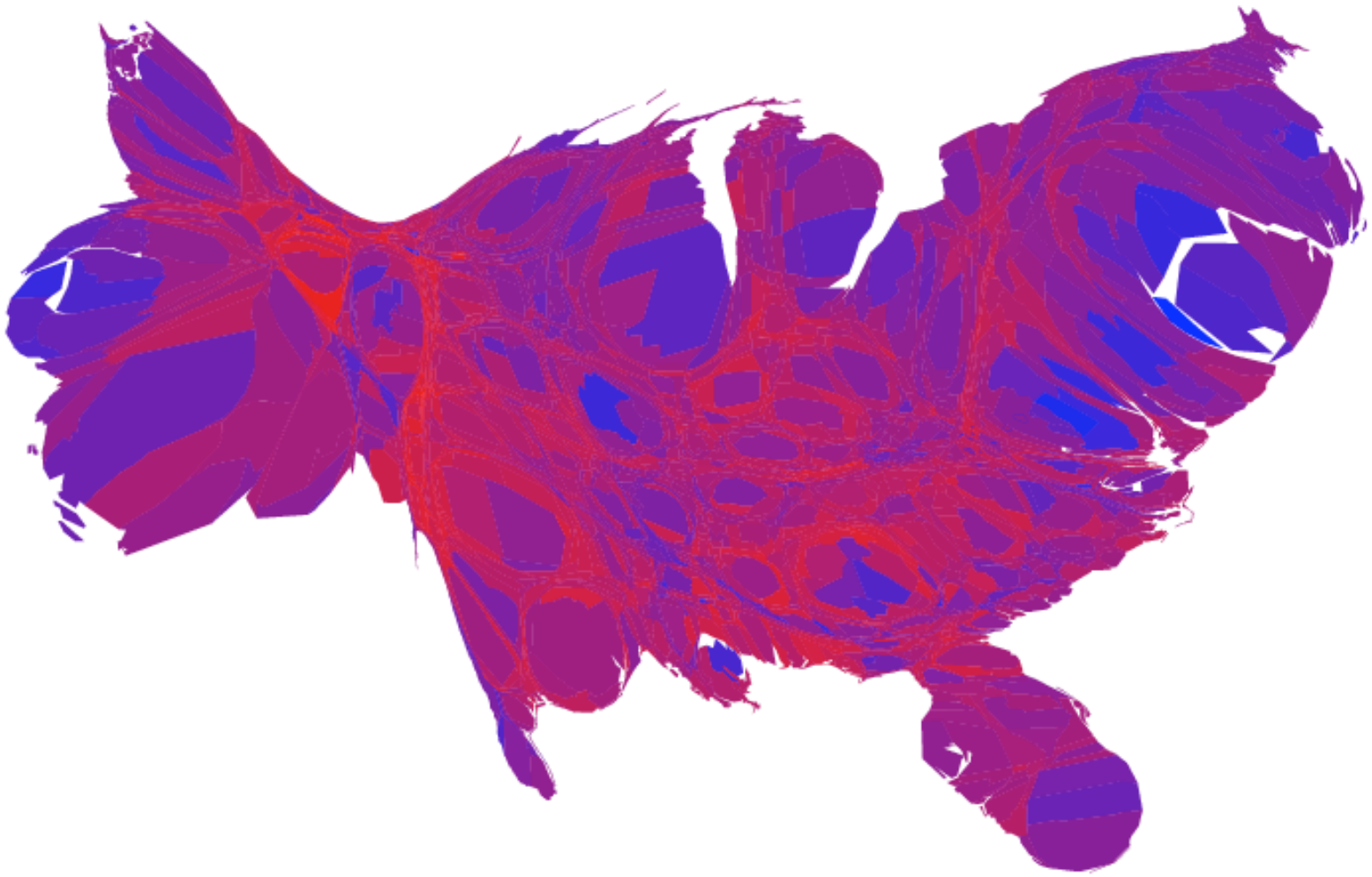
World Population Cartogram



Bush vs Kerry by county

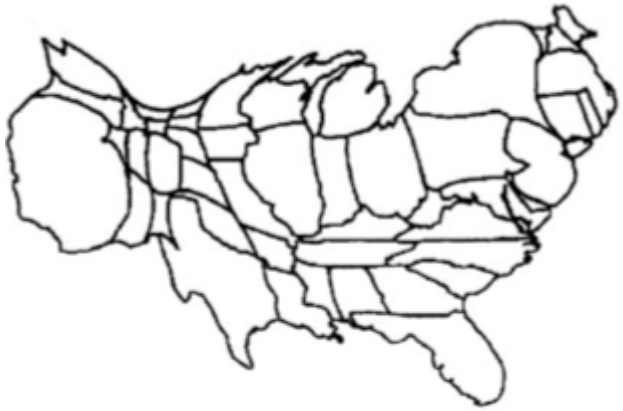


Bush vs Kerry cartogram



Types of contiguous cartograms

Tobler's Pseudo-cartogram



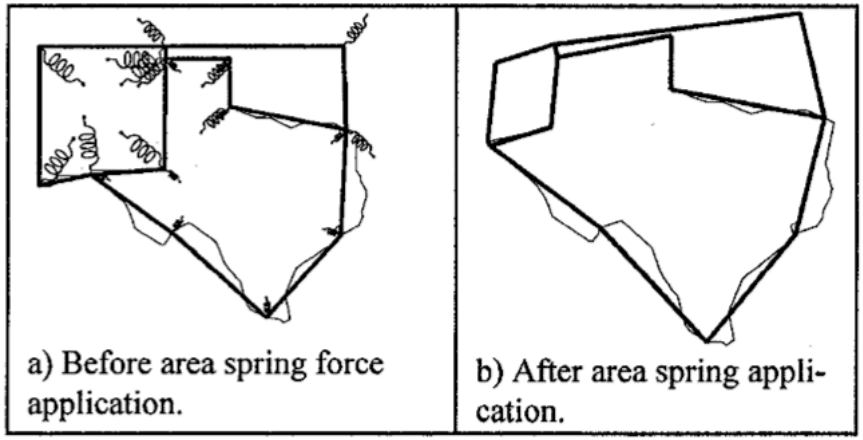
Gusein-Zade & Tikunov's line integral method

(Similar results from Dougenik's force field method and Gastner & Newman's diffusion method)

Kocmoud & House's constraint-based method

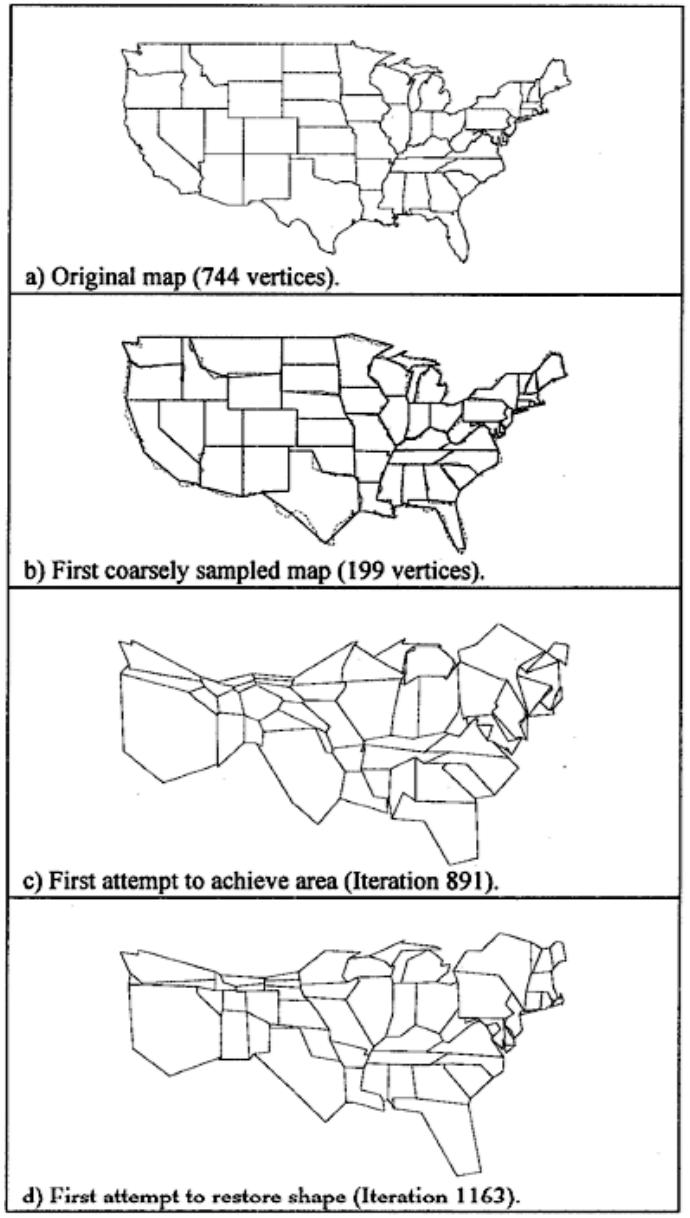
Kocmoud and House:

- Repeated iterations to adjust area
- Vertices have “spring effect” to maintain original orientation



a) Before area spring force application.

b) After area spring application.



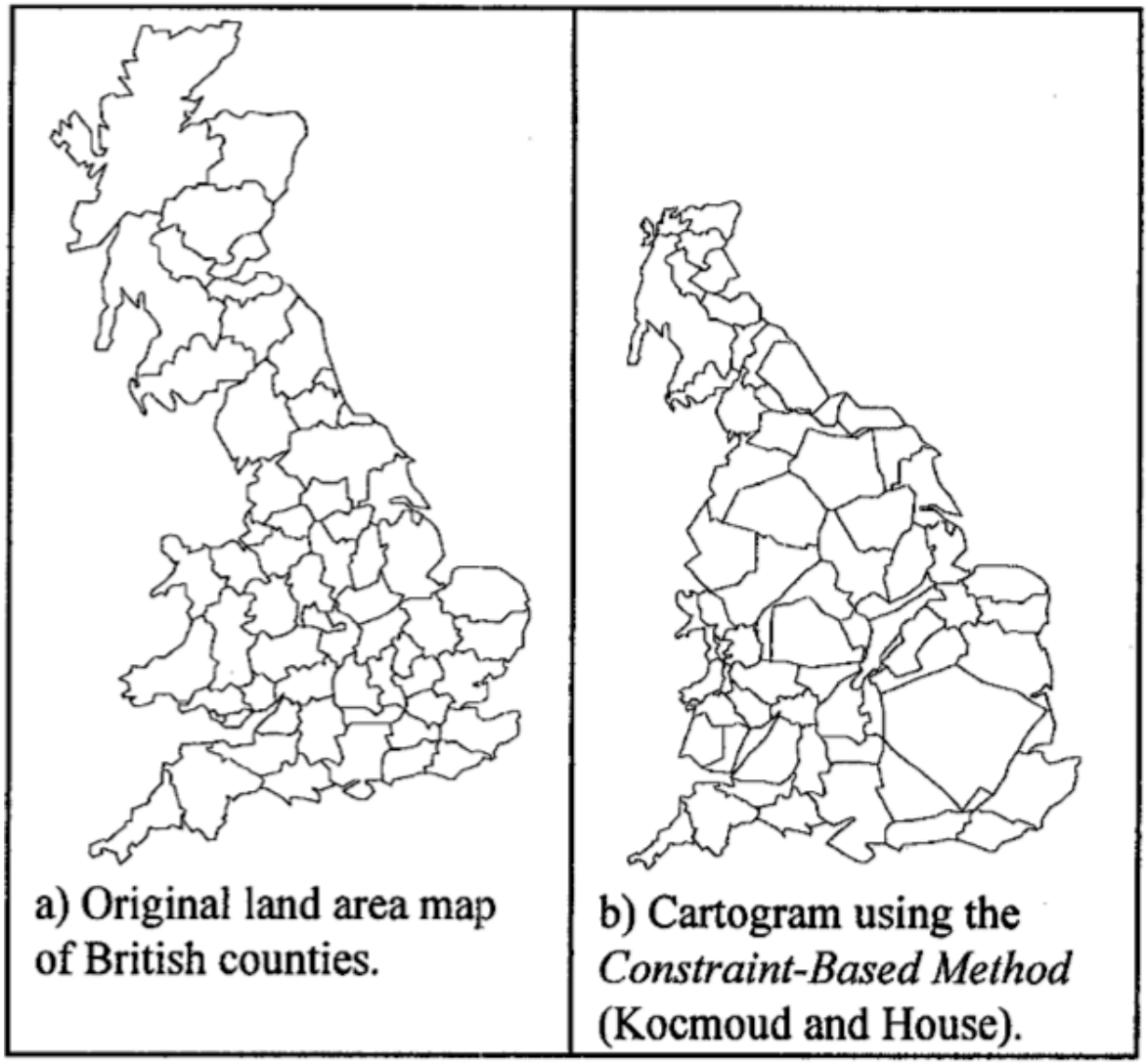
a) Original map (744 vertices).

b) First coarsely sampled map (199 vertices).

c) First attempt to achieve area (Iteration 891).

d) First attempt to restore shape (Iteration 1163).

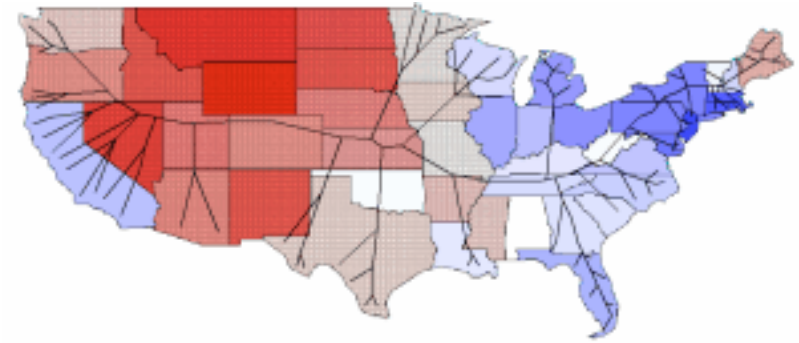
Kocmoud and House:



a) Original land area map of British counties.

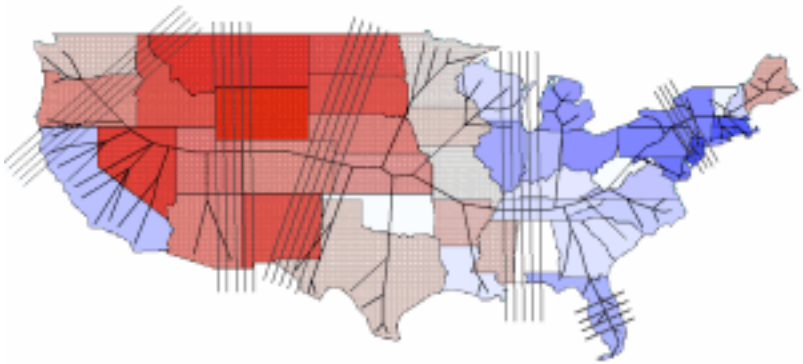
b) Cartogram using the *Constraint-Based Method* (Kocmoud and House).

CartoDraw: Keim, North, Panse



1. Scanlines

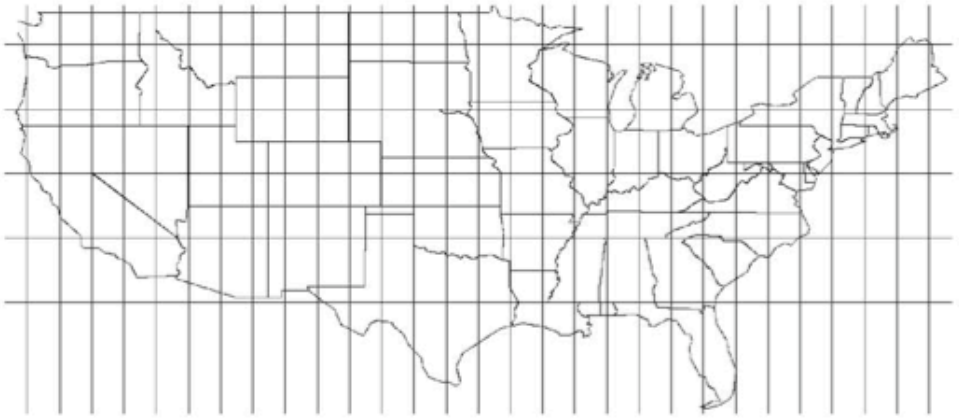
- Make cuts in shape, then add or subtract
- Most of the shape's edge remains intact
- Reduces need to frequently recalculate edges
- Orders of magnitude faster than previous algorithms



2. Cutting Lines

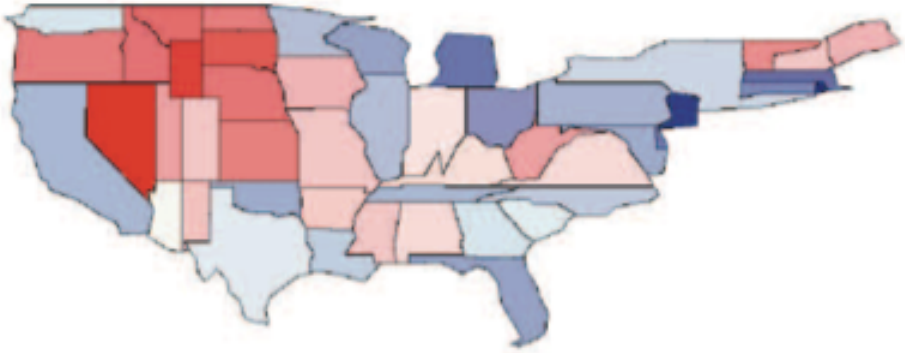
3. Expand or Contract

Scanline placement

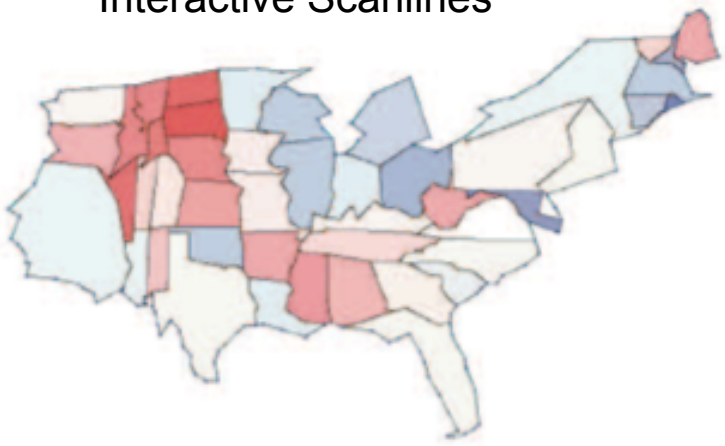


Automatic Scanlines

Interactive Scanlines

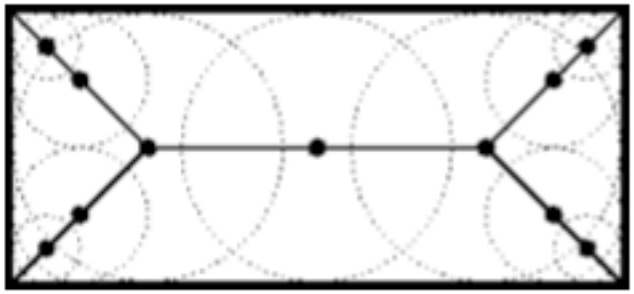


Poor results

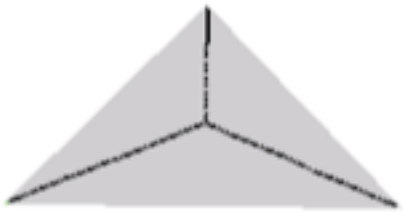


Better results, but requires human intervention

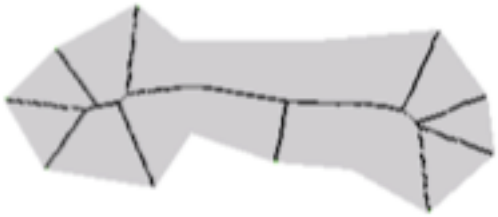
Solution: medial axes



(a) Rectangle with circles

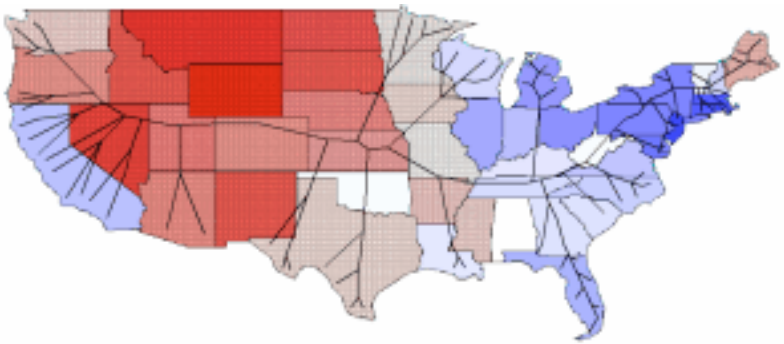


(b) Triangle



(c) Polygon

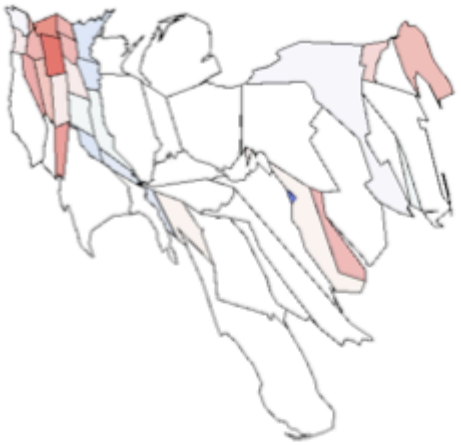
Medial-axes-based scanlines:



Possible use of a fast cartogram algorithm:

Long-distance call volume during one day

(a) 0:00 am (EST)



(b) 6:00am (EST)

(c) 12:00pm (EST)

(d) 6:00pm (EST)

(e) Blue–red colormap used to demonstrate the area error

CartoDraw
Keim, North, Panse

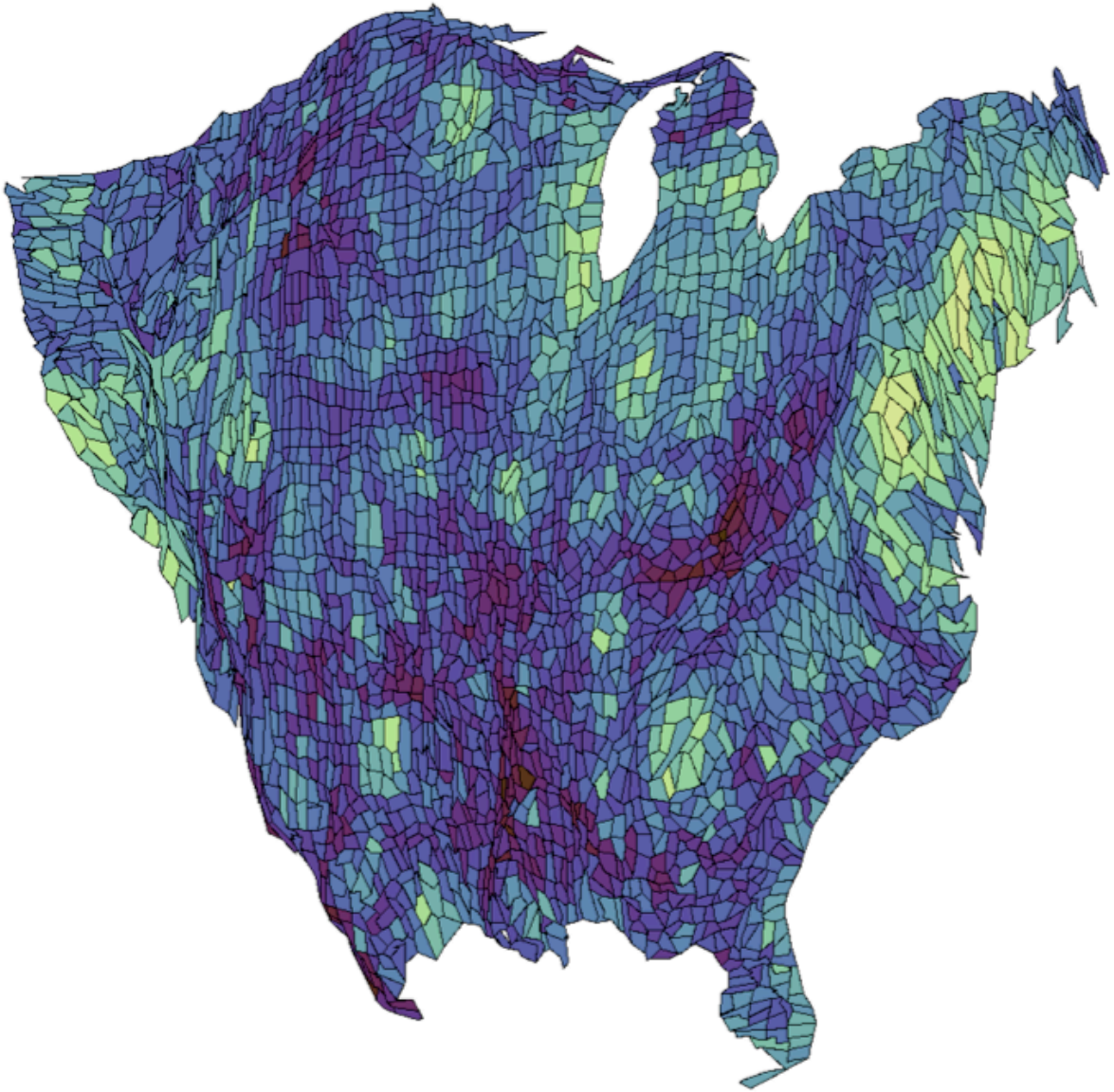
- What is a “good” cartogram?
  - Tradeoff between area error and shape error.
  - Few or no studies have been done to determine what are the most important parts of a map for recognition: Size? Proportion? Edge detail?

- Are cartograms really that useful?
  - Do people remember what the original shapes looked like?
  - Very hard to make fair areal comparisons between irregular shapes.

- Cartograms can easily be used badly.

- Do **not** use cartograms to show average values, per capita values, etc
  - People are not only looking at what’s on the map, but they’re comparing to what’s in their head.

Mean Household Income Cartogram

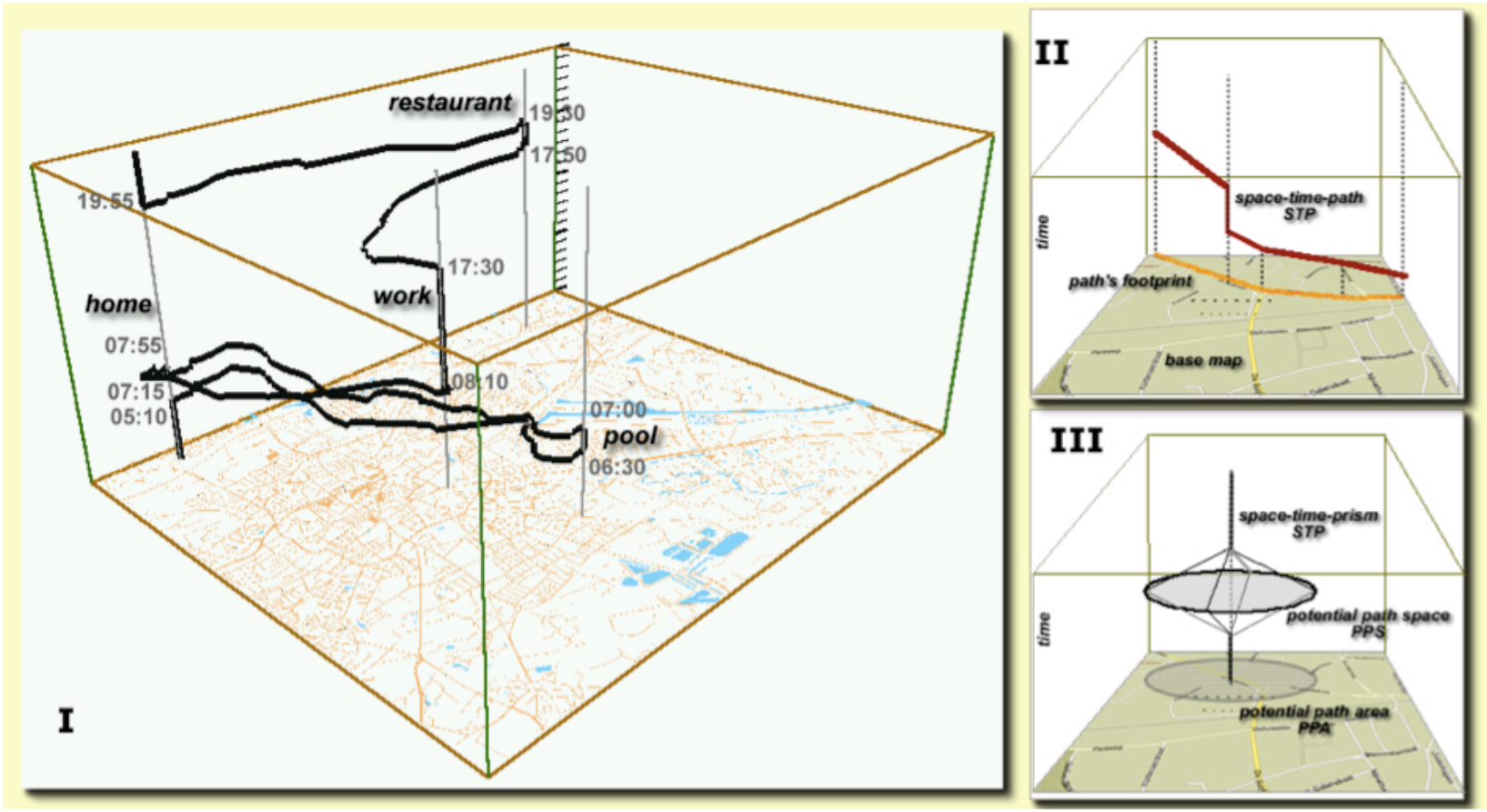


The Space-Time Cube Revisited From a Geovisualization Perspective Kraak (2003)

- Torsten Hägerstrand, “Time geography”, 1970
  - Map daily paths of individuals in space-time
  - 3-dimensional space: x, y and time mapped onto z axis
  - Shifted geographers’ focus onto individual people and experience
  - Disaggregated human behaviour
  - Ideas of “space-time cube” with “paths” and “prisms” within it

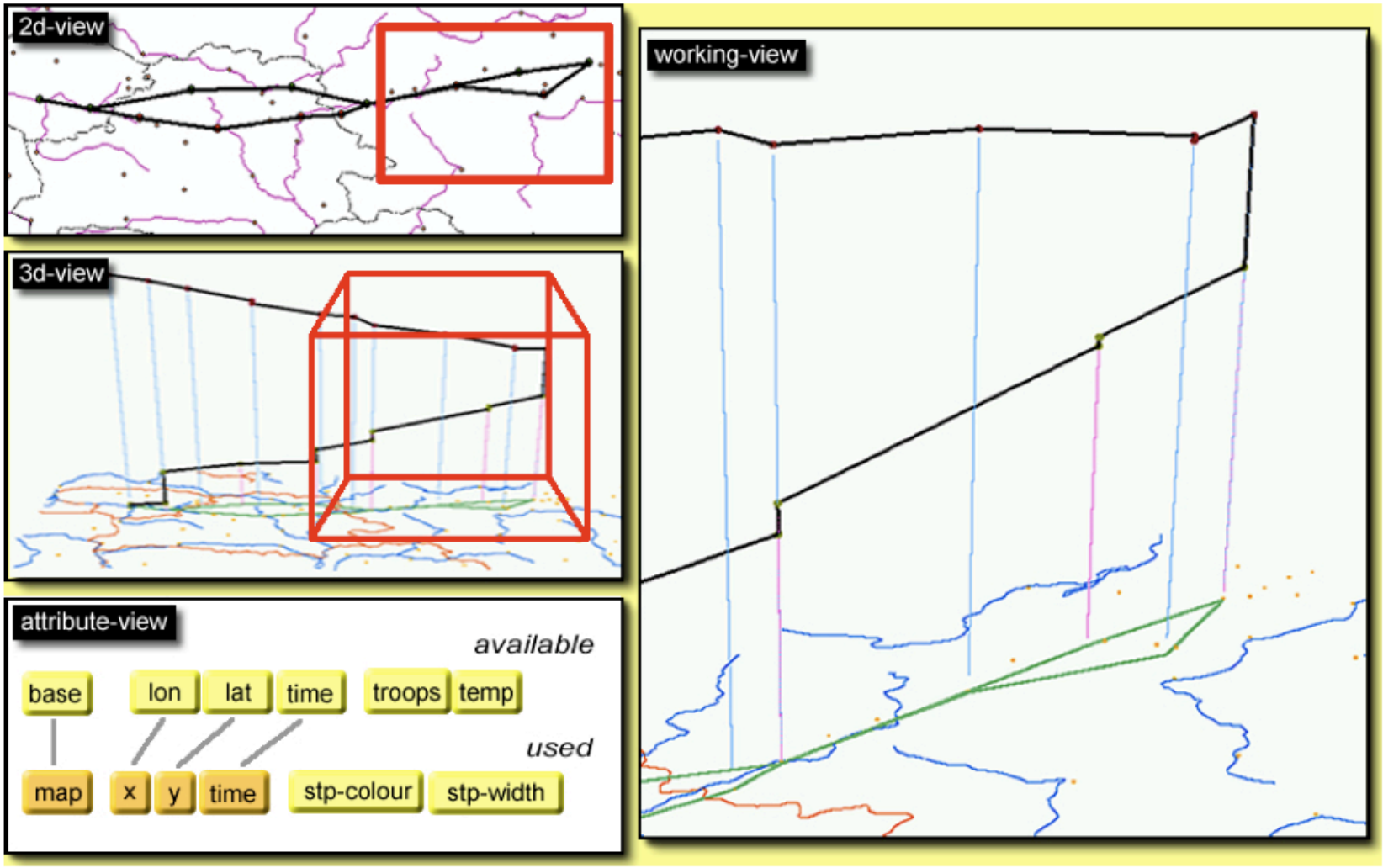
- Kraak’s paper is a survey:
  - How has the space-time cube returned with new visualization tools?
  - Attempt at a classsification of interactions
  - What are possible applications today?

Space-Time Paths



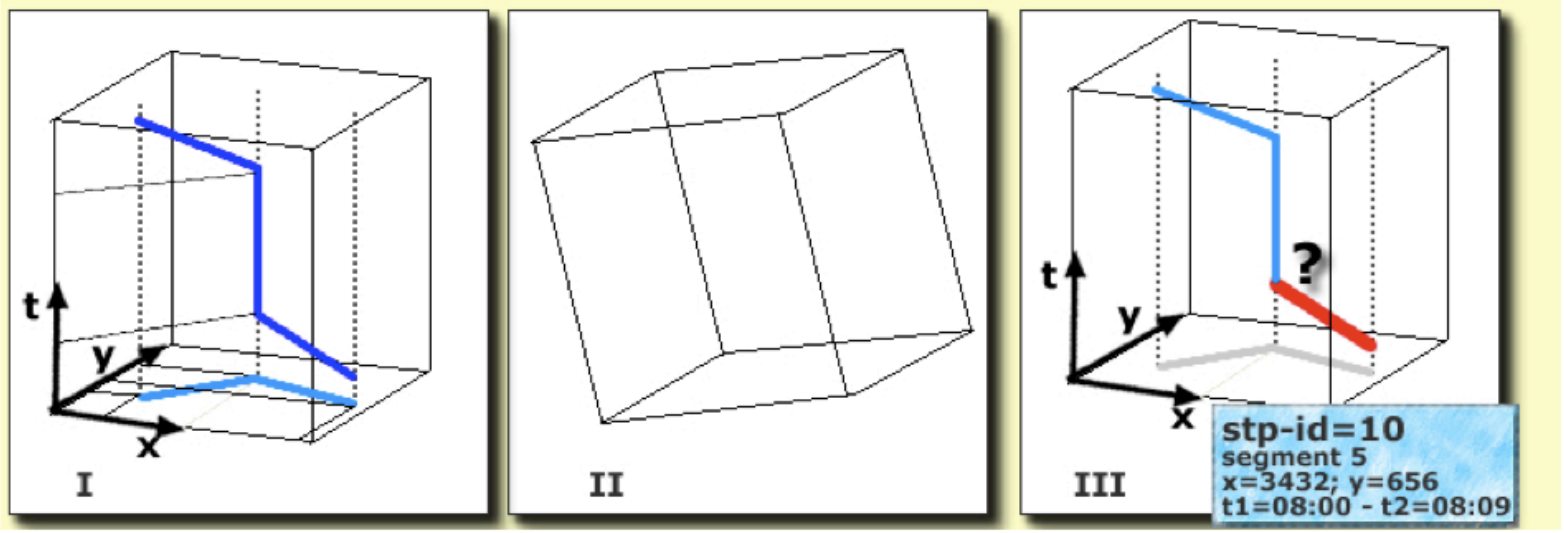
I. Space-time path: movement and “stations”. “Activity bundles” with others.
II. Projection of path’s footprint on base map.
III. Space-time prism of potential path space .

Space-Time Cube in Interactive Environment



Napoleon's march into Russia: building linked views

Space-Time Cube Interactions

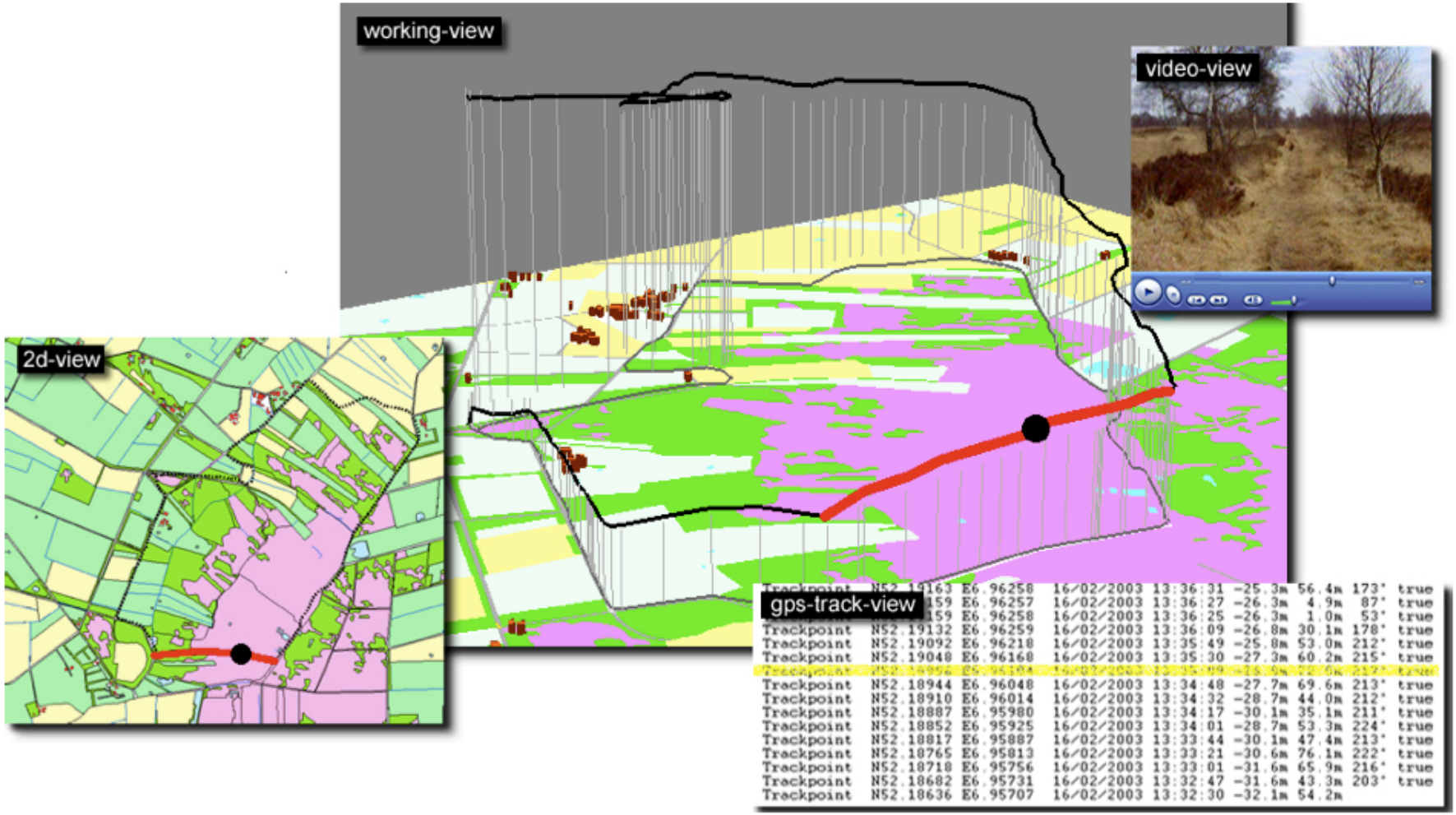


I. Drag axes into cube for measurement

II. Rotate view

III. Select and query

Space-Time Cube with Linked Views



Kraak, Space-Time Cube

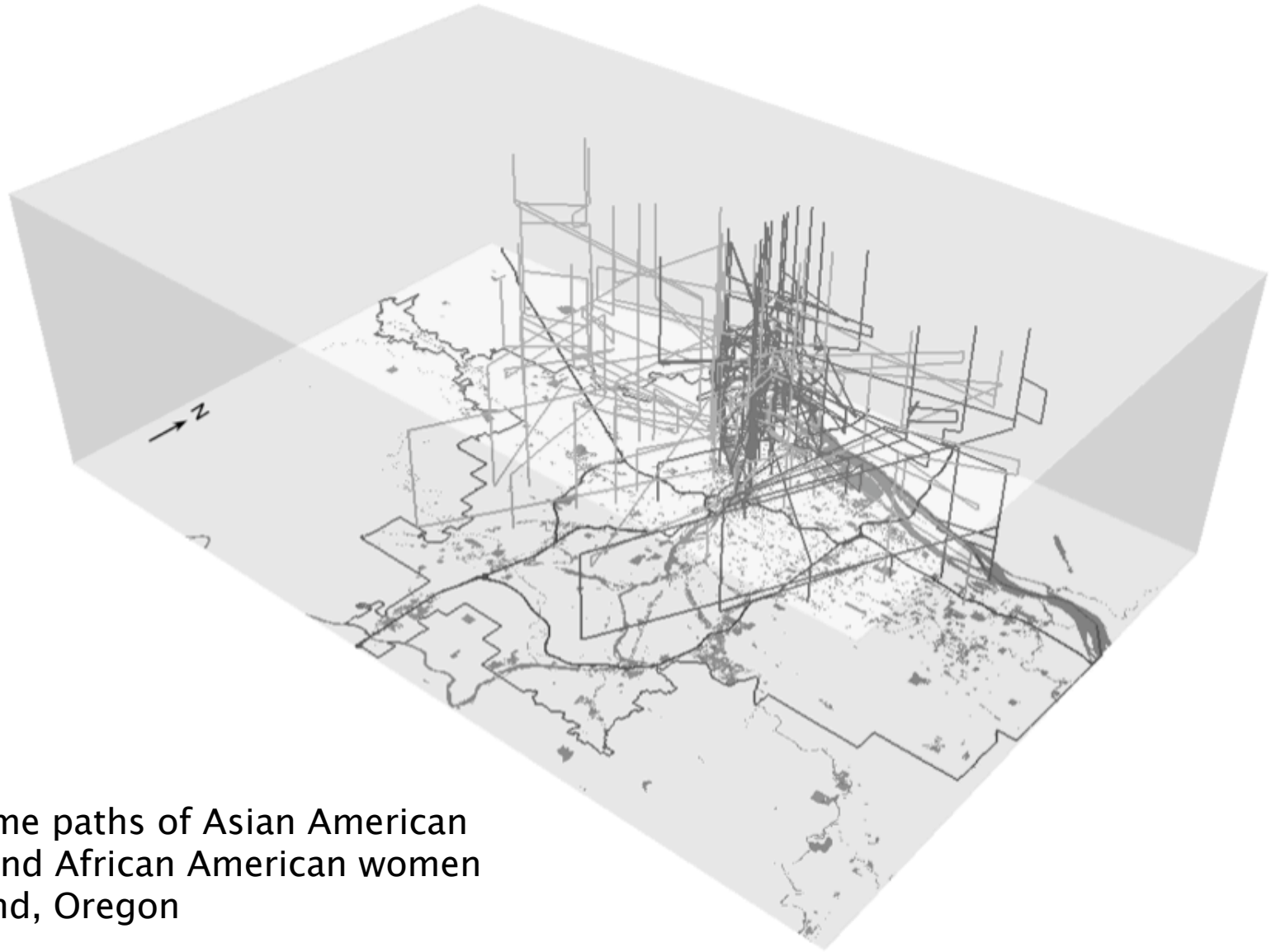
Proposed applications:

- Real-time or retrospective visualization of an orienteering event
- Archaeological finds plotted in S-T cube, showing time uncertainty

Critiques:

- Is this truly useful, or just a toy? Are we learning anything?
- Uninspiring examples. Doesn't show more than one person's path.
- What about objects with higher dimensions than a moving point, such as moving lines or areas?

Space-Time Aquarium, Kwan (2003)



Space-time paths of Asian American women and African American women in Portland, Oregon

The Future of Space-Time Point Data

- Rapidly increasing availability of point-based geodata from GPS systems
- GPS apps that don't use the space-time cube (yet)
  - Geocoded photos: Flickr, Geograph.org.uk
  - Real-time photos and GPS traces and photos: geotracing.com
- Collaborative GPS mapping: openstreetmap.org