Cartographic Visualization

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Outline

- Background
  - Cartography & Cartoviz/Geoviz
- Recent work in Cartoviz/Geoviz
  - An introduction to Geoviz methods
  - Animation for spatiotemporal data exploration
  - Conditioned choropleth maps
  - Cartograms
- Summary
  - Future of Cartoviz/Geoviz

Cartography:

- It is the science or art of mapmaking
- It is a practice that has a long history
- Until the last couple of decades, its primary purpose has been that of communication and the storage of information via static paper maps

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Cartographic Visualization:

- With the introduction of GIS, computerized tools became available making it easier to generate maps and do spatial analysis
- Cartographic (or geographic) visualization is a relatively new development in the field of cartography
- It is the marriage of cartography, information visualization and exploratory data analysis

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Cartographic Visualization:

- Its purpose is to support
  - Data exploration
  - Data analysis
  - Hypothesis generation
  - Knowledge acquisition
- Why? – the "magnitude and complexity of the available geospatial data pose a challenge as to how the data can be transformed into information and ultimately knowledge."

Papers presented

- **Geovisualization illustrated**
  Menno-Jan Kraak, ISPRS Journal of Photogrammetry & Remote Sensing 57(2003), 390-399.
- **Geographic visualization: designing manipulable maps for exploring temporally varying georeferenced statistics**
  A. M. MacEachren, F. P. Boscoe, D. Haug, and L. W. Pickle. Proc. InfoVis '98, 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


Geovisualization Illustrated

Goal of paper:

To increase awareness within the geographic community of the geovisualization approach and its benefits.

Author's approach :

- Show how alternative graphic representations can stimulate & support visual thinking about spatial patterns, relationships, & trends
- Applies the geoviz approach to one of the most well-known maps in the history of cartography
  "Napoleon's March on Moscow" (Minard)
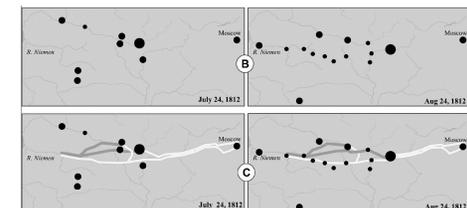

Napoleon's March on Moscow (Minard):
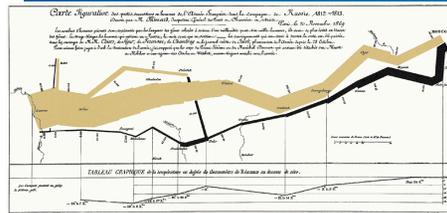
Napoleon's 1812 Russian campaign:
- Troop movement shown in a single flow; size of army encoded in width of bands.
- Time inherently illustrated.
- Temperature diagram linked to the retreat path.

Minard's Map:

- How can we take an alternative look at this map and its data to improve our understanding about this event?
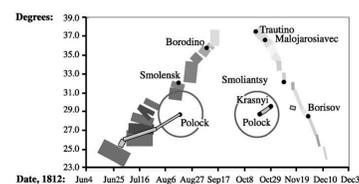

Small multiples for time series:

Change perceived by succession of maps depicting the successive events.
B=position of troops
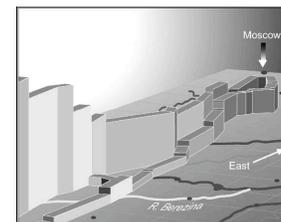C=adds overview of campaign up to date

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Animation to represent time:

- Variations introduced to represent an event are deduced from real movement on the map
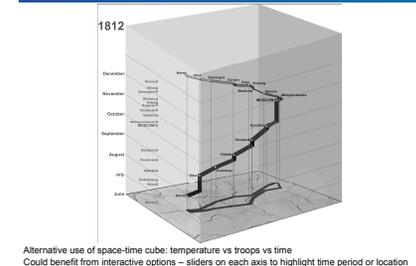- Animated map provided on author's website
  http://www.itc.nl/personal/kraak/1812

2-d chart:

Example of visualization not influenced by traditional cartographic rules:
- Reveals info not shown in original map: (1) 2 battles took at Pollock (2) Napoleon stayed in Moscow for a month before returning west

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3D view of the size of Napoleon's army:

Column height = # of troops (colour could be added to represent temperature as well)
Interactivity necessary to look at 3-d map from different views (to deal with occlusion)

Space-time cube of Napoleon's march:

Alternative use of space-time cube: temperature vs troops vs time
Could benefit from interactive options – sliders on each axis to highlight time period or location

Critique:

➡ Light intro to the geoviz – basic techniques
➡ Stresses that new & different views can reveal new insights
➡ No in depth description of techniques
➡ No discussion of pros/cons
➡ Could have made better use of small multiples

Geographic visualization: designing manipulable maps for exploring temporally varying georeferenced statistics

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The Project:

● Presents the 2nd part of a 2-part project
● **Overall project goal**: to understand the cognitive aspects of map use & to develop appropriate geoviz tools with an emphasis on *data exploration*.
● Project:
  ● Part 1: spatial pattern analysis
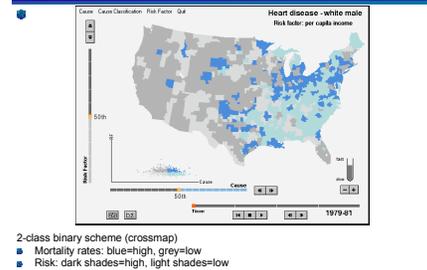 ● Part 2: spatiotemporal analysis

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Goal of paper:

(1) To present a geoviz interface prototype to support domain experts in the exploration of time series multivariate spatial health data
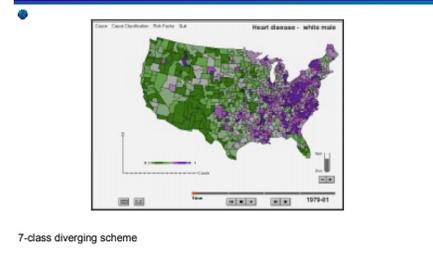(2) To understand the cognitive aspects of map use

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HealthVisB Interface:

● Provides spatiotemporal analysis methods
● Single integrated manipulable map
● 1 or 2 variables:
  ➢ Mortality cause
  ➢ (Risk factor)
● Data classification schemes:
  ➢ 5-class diverging scheme
  ➢ 7-class diverging scheme
  ➢ 2-variable binary scheme – with focusing
● Can step through time or can use animation (VCR controls)

HealthVisB Interface Prototype:

2-class binary scheme (crossmap)
■ Mortality rates: blue=high, grey=low
■ Risk: dark shades=high, light shades=low

HealthVisB Interface Prototype:
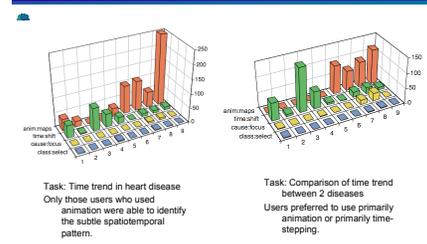

7-class diverging scheme

HealthVisB :

● Authors use a single integrated display with animation or discrete time steps
● Acknowledge that small multiples could also be used but they don't use it as:
  ➢ Disaggregation of info & small map size needed to fit many views on a page may make comparison of variables difficult

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Usability Study :

● **Purpose**: to investigate how spatial data exploration is facilitated (if at all) by the geoviz tools (animation, time stepping, focusing).
● **Method**: observation with think-aloud protocol & system-generated logs
● **Participants**: 9 domain experts (doing research on analysis of health-related data)
● **Tasks**: users were asked to look for spatial trends over time

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Usability Study Results:

Task: Time trend in heart disease
Only those users who used animation were able to identify the subtle spatiotemporal pattern.

Task: Comparison of time trend between 2 diseases
Users preferred to use primarily animation or primarily time-stepping.

Critique:

➡ In-depth usability study of spatial data exploration by domain experts
➡ Good description of usability study protocol
➡ Not very flexible in data classification (2, 5 or 7 classes only)
➡ Analysis would have been stronger if had also compared animation to small multiples
➡ No support for standardizing data
➡ Somewhat unclear in their discussion of results

Conditioned Choropleth Maps

Conditioned Choropleth Maps (CCMaps):

What is a choropleth map?:
● A map in which data collection units are shaded with an intensity proportional to the data values associated with those units.

What is conditioning?
● It partitions data for a variable of interest into subsets to control the spatial variation of this variable that can be attributed to explanatory (or conditioning) variables

What is a CCMap?
● A choropleth map with conditioning

Purpose of CCMaps:

To support the generation of hypotheses to explain the spatial variation of a variable; a common and important task for geographers.

  ➢ E.g., What causes the spatial variation of lung cancer mortality across the United States?

Motivation for conditioning:

● In many cases, we already know some of the factors contributing to the spatial variability of a variable.
● What we really want to figure out is what else might be contributing to its spatial pattern?
● To get at this underlying spatial pattern, we need a way to remove or "control for" known variation.
● Why? - our visual-cognitive system cannot do it for us. We can't mentally remove known components of variation and envision the underlying patterns.


CCMaps:

● Dependent variable: coarsely partitioned into 3 classes
  ➢ Region's class indicated by colour: red=high, gray=medium, blue=low
● 2 conditioning variables: also coarsely partitioned into 3 classes (low, med, high)
  ➢ Region's class indicated by its location in a 3-by-3 matrix of panels
  ➢ Initial classification done using equal intervals (33% of regions included in each class)

Cognostics?:

- Cognostics mentioned briefly as a possible way for choosing where to locate partitioning sliders
- But they don't really describe how their cognostic ranks different possible partitions
- They indicate that this is an area for future work

CCMaps Interface - Demo:
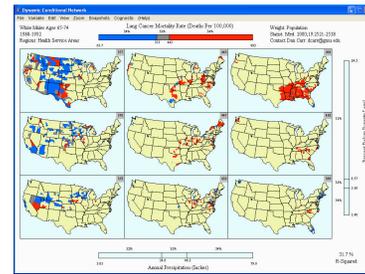
Critique:

- Helps support the explanation of variability in spatial patterns
- Dynamic and interactive
- Good default colour scheme
- Also provides traditional statistical views
- Limited to two explanatory variables
- No flexibility in the classification of variables
- No guidance for choosing conditioning variables
- No support for dynamic data standardization
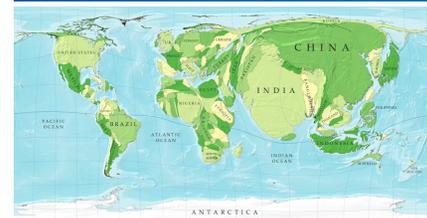

CartoDraw

What is a cartogram?:

- Conventional maps only **show data in relation to land area**, not population or some other variable of interest.
- By intentionally distorting individual map regions so that their **areas are proportional to some other input parameter** this alternative information can be communicated more effectively.
- Maps transformed in this way are called **CARTOGRAMS**.
- Typical applications: social, political, & epidemiological.
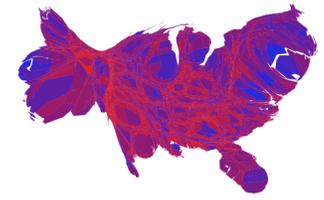

Key property of a cartogram:

To be effective, a cartogram must be **recognizable**. That is, a viewer must be able to quickly determine the geographic area that is being presented!

Cartogram Example – World Population:

An example of an effective cartogram.

Cartogram Example – US Election results:

An example of a less effective cartogram. Still somewhat recognizable as the USA.

Motivation behind CartoDraw:

- Drawing cartograms by hand is a laborious task
- Previous computer-aided techniques:
  - Are prohibitively slow
    - E.g., Kocmoud & House report a time of 18 hours for a medium-sized map (744 vertices)
  - Produce significant deformation of global shape
- General technique for "trading off shape and area adjustments" – wider applicability than just geoviz.
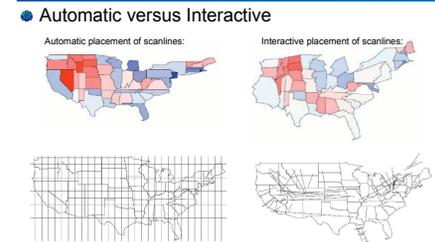

Goal of CartoDraw:

The goal of the authors is to produce a dynamic "on the fly" cartogram drawing method that preserves global shape to create a recognizable cartogram.
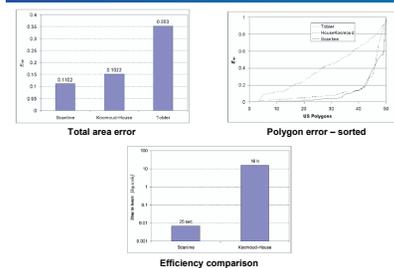

CartoDraw Method:

- Step 1: intelligent decimation of vertices
  - Vertices with no noticeable effect on polygon shape & that don't belong to multiple polygons removed
- Step 2: heuristic, scanline-based incremental repositioning of vertices (global 1st, then interior)
  - Heuristic: area error function and shape error function
  - For each scanline, the repositioned vertices produced are only accepted if the area error and shape error are below the specified thresholds
- Step 3: fitting undecimated polygons to the decimated mesh to get the output cartogram

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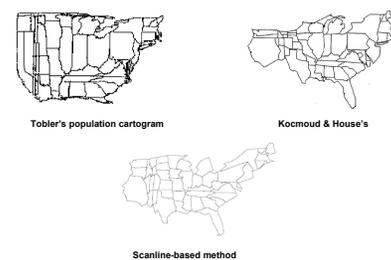
Scanline placement:

- Automatic versus Interactive

Comparison: efficiency and area error

Total area error

Polygon error – sorted

Efficiency comparison

Comparison: population cartograms

Tobler's population cartogram

Kocmoud & House's

Scanline-based method

Critique:

- Dynamic generation of cartogram
  - 2 seconds for US population data
  - 19 sec for 90,000 polygons
- Minimizes error in global shape to promote recognition
- Highly sensitive to scanline placement – user defined scanlines better
- Not much guidance provided to the user for placing scanlines appropriately

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Future of Geovisualization:

- The demand for geovisualization techniques will continue to increase as the sheer volume of geospatial data continues to grow exponentially and the popularity of spatial information increases due to tools such as Google Maps.