Lectures 5-6:
Spatial Data, Color

Tamara Munzner
Department of Computer Science
University of British Columbia

DSCI 531: Data Visualization I
Lecture 5: 29 November 2016
Lecture 6: 5 December 2016

https://github.ubc.ca/ubc-mds-2016/DSCI_531_viz-1_students
Spatial Data
VAD Chap 8: Arrange spatial data

- **Use Given**
  - Geometry
    - Geographic
    - Other Derived

- **Spatial Fields**
  - Scalar Fields (one value per cell)
    - Isocontours
    - Direct Volume Rendering
  - Vector and Tensor Fields (many values per cell)
Idiom: choropleth map

• use given spatial data
  – when central task is understanding spatial relationships

• data
  – geographic geometry
  – table with 1 quant attribute per region

• encoding
  – use given geometry for area mark boundaries
  – sequential segmented colormaps

• trickiness
  – small regions are less visually salient

http://bl.ocks.org/mbostock/4060606
Population maps trickiness

• beware!
• absolute vs relative again
  • population density vs per capita
• investigate with Ben Jones Tableau Public demo
  • http://public.tableau.com/profile/ben.jones#!/vizhome/PopVsFin/PopVsFin

Are Maps of Financial Variables just Population Maps?
• yes, unless you look at per capita (relative) numbers

[https://xkcd.com/1138]
Idiom: **topographic map**

- **data**
  - geographic geometry
  - scalar spatial field
    - 1 quant attribute per grid cell
- **derived data**
  - isoline geometry
    - isocontours computed for specific levels of scalar values

*Land Information New Zealand Data Service*
Idiom: **isosurfaces**

- **data**
  - scalar spatial field
    - 1 quant attribute per grid cell
- **derived data**
  - isosurface geometry
    - isocontours computed for specific levels of scalar values
- **task**
  - spatial relationships

Vector and tensor fields

• data
  – many attrs per cell

• idiom families
  – flow glyphs
    • purely local
  – geometric flow
    • derived data from tracing particle trajectories
    • sparse set of seed points
  – texture flow
    • derived data, dense seeds
  – feature flow
    • global computation to detect features
      – encoded with one of methods above


Vector fields

• empirical study tasks
  – finding critical points, identifying their types
  – identifying what type of critical point is at a specific location
  – predicting where a particle starting at a specified point will end up (advection)
Idiom: similarity-clustered streamlines

• data
  – 3D vector field

• derived data (from field)
  – streamlines: trajectory particle will follow

• derived data (per streamline)
  – curvature, torsion, tortuosity
  – signature: complex weighted combination
  – compute cluster hierarchy across all signatures
  – encode: color and opacity by cluster

• tasks
  – find features, query shape

• scalability
  – millions of samples, hundreds of streamlines

Color
Idiom design choices: Encode

Why?
How?
What?

Map
from *categorical* and *ordered* attributes

- **Color**
  - *Hue* [red, yellow, blue]
  - *Saturation* [gray, white, black]
  - *Luminance* [green, blue, yellow]

- **Size, Angle, Curvature, ...**
  - ![Size, Angle, Curvature, ...](image)

- **Shape**
  - ![Shape](image)

- **Motion**
  - *Direction, Rate, Frequency, ...* [image]
Categorical vs ordered color

Color: Luminance, saturation, hue

- 3 channels
  - identity for categorical
    - hue
  - magnitude for ordered
    - luminance
    - saturation

- RGB: poor for encoding
- HSL: better, but beware
  - lightness ≠ luminance

Luminance
Saturation
Hue

Corners of the RGB color cube
L from HLS
All the same
Luminance values
Spectral sensitivity

& three cone types

Small but important separation
Opponent color and color deficiency

• 3 cones processed before optic nerve
  – one achromatic luminance channel L
  – edge detection through luminance contrast
  – two chroma channels, R-G and Y-B axis

• “color blind” if one axis has degraded acuity
  – 8% of men are red/green color deficient
  – blue/yellow is rare

Designing for color deficiency: Check with simulator

Normal vision  Deuteranope  Protanope  Tritanope

http://rehue.net

Designing for color deficiency: Avoid encoding by hue alone

- redundantly encode
  - vary luminance
  - change shape

Deuteranope simulation

Color deficiency: Reduces color to 2 dimensions

Normal

Protanope

Deuteranope

Tritanope

Designing for color deficiency: Blue-Orange is safe
Color/Lightness constancy: Illumination conditions

Image courtesy of John McCann
Color/Lightness constancy: Illumination conditions

Image courtesy of John McCann
Bezold Effect: Outlines matter

• color constancy: simultaneous contrast effect
Colormaps

- Categorical
- Ordered
  - Sequential
  - Diverging
- Diverging

Colormaps

- Categorical
- Ordered
  - Sequential
  - Diverging
- Bivariate

---

Colormaps

- Categorical
  - Ordered
    - Sequential
  - Diverging
- Bivariate

use with care!

• color channel interactions
  – size heavily affects salience
    • small regions need high saturation
    • large need low saturation
  – saturation & luminance: 3-4 bins max
    • also not separable from transparency

ColorBrewer

- http://www.colorbrewer2.org
- saturation and area example: size affects salience!
Categorical color: Discriminability constraints

- noncontiguous small regions of color: only 6-12 bins

[Cinteny: flexible analysis and visualization of synteny and genome rearrangements in multiple organisms. Sinha and Meller. BMC Bioinformatics, 8:82, 2007.]
Ordered color: Rainbow is poor default

• problems
  − perceptually unordered
  − perceptually nonlinear

• benefits
  − fine-grained structure visible and nameable


Ordered color: Rainbow is poor default

• problems
  – perceptually unordered
  – perceptually nonlinear

• benefits
  – fine-grained structure visible and nameable

• alternatives
  – large-scale structure: fewer hues


Ordered color: Rainbow is poor default

• problems
  – perceptually unordered
  – perceptually nonlinear

• benefits
  – fine-grained structure visible and nameable

• alternatives
  – large-scale structure: fewer hues
  – fine structure: multiple hues with monotonically increasing luminance [eg viridis R/python]


Viridis

• colorful, perceptually uniform, colorblind-safe, monotonically increasing luminance

https://cran.r-project.org/web/packages/viridis/vignettes/intro-to-viridis.html
Ordered color: Rainbow is poor default

• problems
  – perceptually unordered
  – perceptually nonlinear

• benefits
  – fine-grained structure visible and nameable

• alternatives
  – large-scale structure: fewer hues
  – fine structure: multiple hues with monotonically increasing luminance [eg viridis R/python]
  – segmented rainbows for binned or categorical
Map other channels

- **size**
  - length accurate, 2D area ok, 3D volume poor

- **angle**
  - nonlinear accuracy
    - horizontal, vertical, exact diagonal

- **shape**
  - complex combination of lower-level primitives
    - many bins

- **motion**
  - highly separable against static
    - binary: great for highlighting
  - use with care to avoid irritation
Angle

Sequential ordered line mark or arrow glyph

Diverging ordered arrow glyph

Cyclic ordered arrow glyph