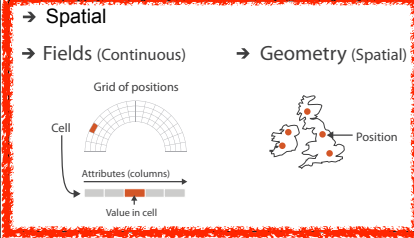
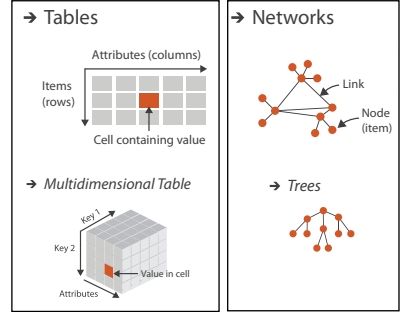


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Focus on Spatial

Dataset Types



2

How?

Encode	Manipulate	Facet	Reduce
<ul style="list-style-type: none"> Arrange Express Order Use 	<ul style="list-style-type: none"> Change Select Navigate 	<ul style="list-style-type: none"> Juxtapose Partition Superimpose 	<ul style="list-style-type: none"> Filter Aggregate Embed

Map from categorical and ordered attributes

Color: Hue, Saturation, Luminance

Size, Angle, Curvature, ...

Shape: Square, Circle, Triangle

Motion: Direction, Rate, Frequency, ...

What? Why? How?

3

How?

Encode	Manipulate	Facet	Reduce
<ul style="list-style-type: none"> Arrange Express Order Use 	<ul style="list-style-type: none"> Change Select Navigate 	<ul style="list-style-type: none"> Juxtapose Partition Superimpose 	<ul style="list-style-type: none"> Filter Aggregate Embed

Map from categorical and ordered attributes

Color: Hue, Saturation, Luminance

Size, Angle, Curvature, ...

Shape: Square, Circle, Triangle

Motion: Direction, Rate, Frequency, ...

What? Why? How?

4

Spatial data

- use given spatial position
- when?
 - dataset contains spatial attributes and they have primary importance
 - central tasks revolve around understanding spatial relationships
- examples
 - geographical/cartographic data
 - sensor/simulation data

Geographic Maps

Geographic Map



Interlocking marks

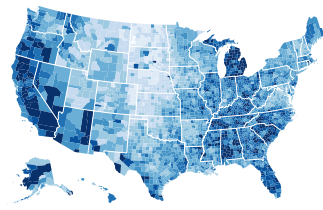
- shape coded
 - area coded
 - position coded
- cannot encode another attribute with these channels, they're "taken"

Thematic maps

- show spatial variability of attribute ("theme")
 - combine geographic / reference map with (simple, flat) tabular data
 - join together
 - region: interlocking area marks (provinces, countries with outline shapes)
 - also could have point marks (cities, locations with 2D lat/lon coords)
 - region: categorical key attribute in table
 - use to look up value attributes
- major idioms
 - choropleth
 - symbol maps
 - cartograms
 - dot density maps

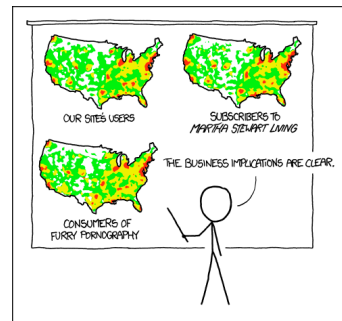
Idiom: choropleth map

- use given spatial data
 - when central task is understanding spatial relationships
- data
 - geographic geometry
 - table with 1 quant attribute per region
- encoding
 - position: use given geometry for area mark boundaries
 - color: sequential segmented colormap



<http://bl.ocks.org/mbostock/4060606>

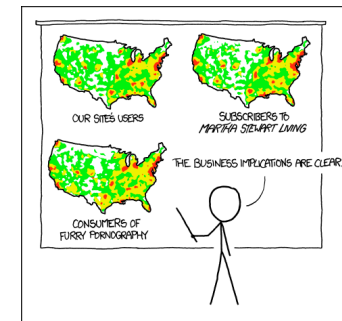
Beware: Population maps trickiness!



PET PEEVE #208: GEOGRAPHIC PROFILE MAPS WHICH ARE BASICALLY JUST POPULATION MAPS
 [<https://xkcd.com/1138>]

Beware: Population maps trickiness!

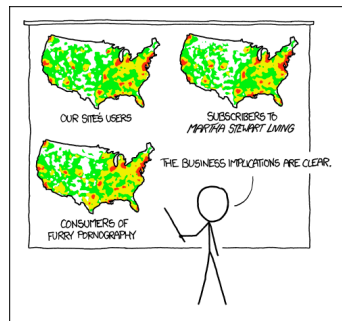
- spurious correlations: most attributes just show where people live



PET PEEVE #208: GEOGRAPHIC PROFILE MAPS WHICH ARE BASICALLY JUST POPULATION MAPS
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Beware: Population maps trickiness!

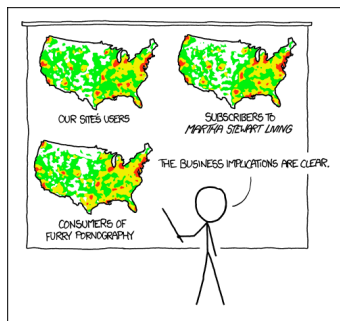
- spurious correlations: most attributes just show where people live
- consider when to normalize by population density
 - encode raw data values
 - tied to underlying population
 - but should use normalized values
 - unemployed people per 100 citizens, mean family income



PET PEEVE #208: GEOGRAPHIC PROFILE MAPS WHICH ARE BASICALLY JUST POPULATION MAPS
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Beware: Population maps trickiness!

- spurious correlations: most attributes just show where people live
- consider when to normalize by population density
 - encode raw data values
 - tied to underlying population
 - but should use normalized values
 - unemployed people per 100 citizens, mean family income
- general issue
 - absolute counts vs relative/normalized data
 - failure to normalize is common error



PET PEEVE #208: GEOGRAPHIC PROFILE MAPS WHICH ARE BASICALLY JUST POPULATION MAPS
 [<https://xkcd.com/1138>]

Choropleth maps: Recommendations

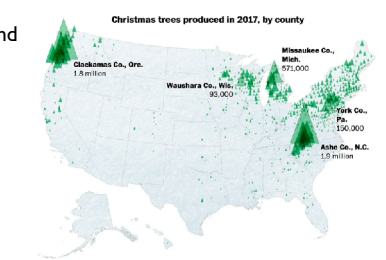
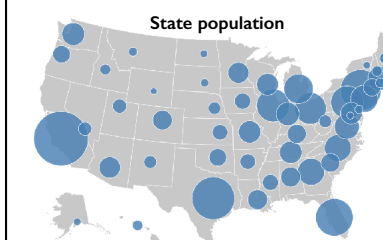
- only use when central task is understanding spatial relationships
- show only one variable at a time
- normalize when appropriate
- be careful when choosing colors & bins
- best case: regions are roughly equal sized

Choropleth map: Pros & cons

- pros
 - easy to read and understand
 - well established visualization (no learning curve)
 - data is often collected and aggregated by geographical regions
- cons
 - most effective visual variable used for geographic location
 - visual salience depends on region size, not true importance wrt attribute value
 - large regions appear more important than small ones
 - color palette choice has a huge influence on the result

Idiom: Symbol maps

- symbol is used to represent aggregated data (mark or glyph)
 - allows use of size and shape and color channels
 - aka proportional symbol maps, graduated symbol maps
- keep original spatial geometry in the background
- often a good alternative to choropleth maps



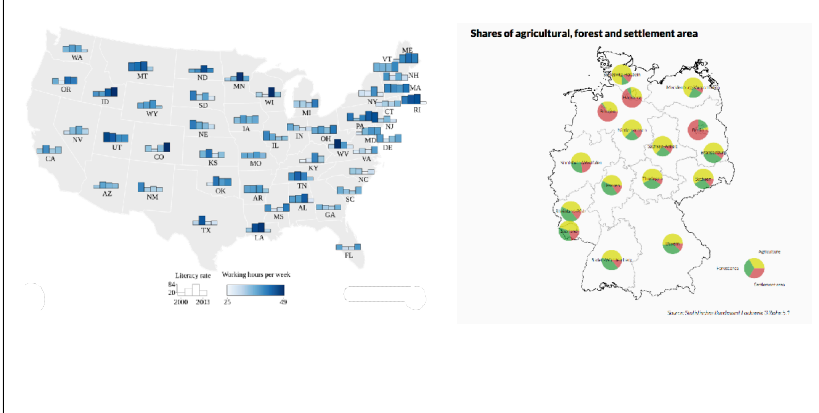
13

14

15

16

Symbol maps with glyphs

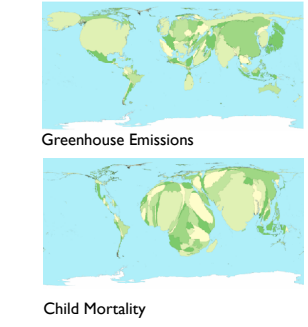


Symbol map: Pros & cons

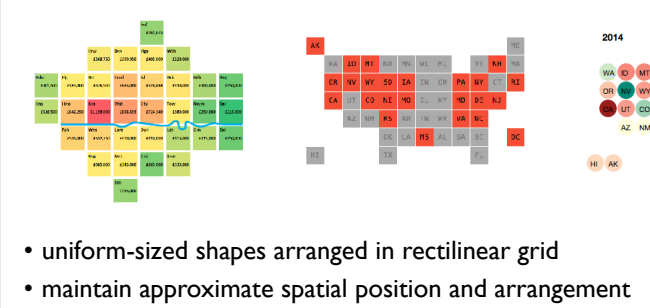
- pros
 - somewhat intuitive to read and understand
 - mitigate problems with region size vs data salience
 - marks: symbol size follows attribute value
 - glyphs: symbol size can be uniform
- cons
 - possible occlusion / overlap
 - symbols could overlap each other
 - symbols could occlude region boundaries
 - complex glyphs may require explanation / training

Idiom: Contiguous cartogram

- interlocking marks:
 - shape, area, and position coded
- derive new interlocking marks
 - based on combination of original interlocking marks and new quantitative attribute
- algorithm to create new marks
 - input: target size
 - goal: shape as close to the original as possible
 - requirement: maintain constraints
 - relative position
 - contiguous boundaries with their neighbours



Idiom: Grid Cartogram



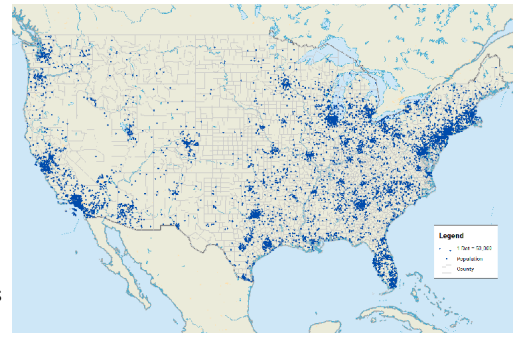
- uniform-sized shapes arranged in rectilinear grid
- maintain approximate spatial position and arrangement

Cartogram: Pros & cons

- pros
 - can be intriguing and engaging
 - best case: strong and surprising size disparities
 - non-contiguous cartograms often easier to understand
- cons
 - require substantial familiarity with original dataset & use of memory
 - compare distorted marks to memory of original marks
 - mitigation strategies: transitions or side by side views
 - major distortion is problematic
 - may be aesthetically displeasing
 - may result in unrecognizable marks
 - difficult to extract exact quantities

Idiom: Dot density maps

- visualize distribution of a phenomenon by placing dots
- one symbol represents a constant number of items
 - dots have uniform size & shape
 - allows use of color channel
- task:
 - show spatial patterns, clusters

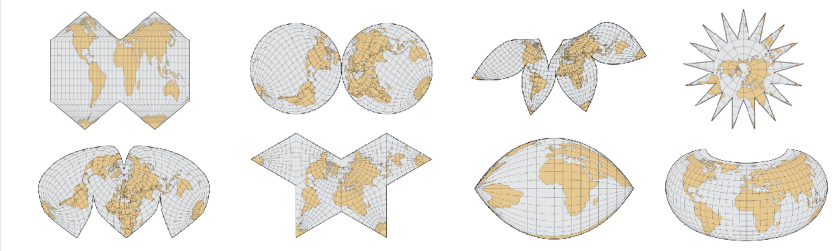


Dot density maps: Pros and cons

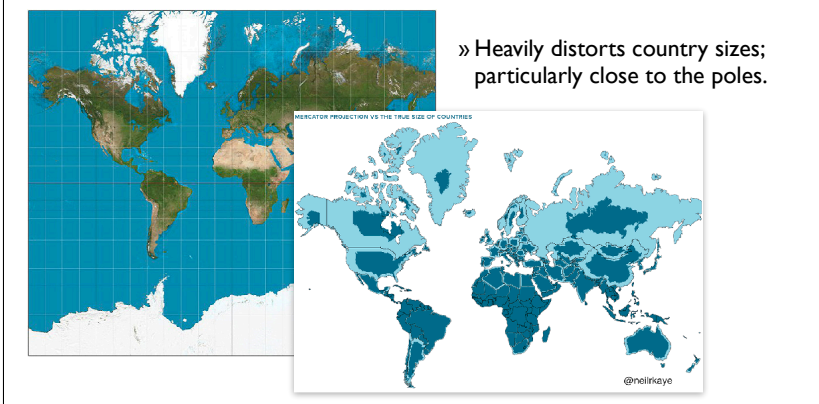
- pros
 - straightforward to understand
 - avoids choropleth non-uniform region size problems
- cons
 - challenge: normalization, just like choropleths
 - show population density (correlated with attribute), not effect of interest
 - perceptual disadvantage:
 - difficult to extract quantities
 - performance disadvantage:
 - rendering many dots can be slow

Map Projections

- mathematical functions that map 3D surface geometry of the Earth to 2D maps
- all projections of sphere on plane necessarily distort surface in some way
- interactive: philogb.github.io/page/myriahedral/ and jasondavies.com/maps/



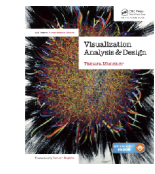
Mercator Projection



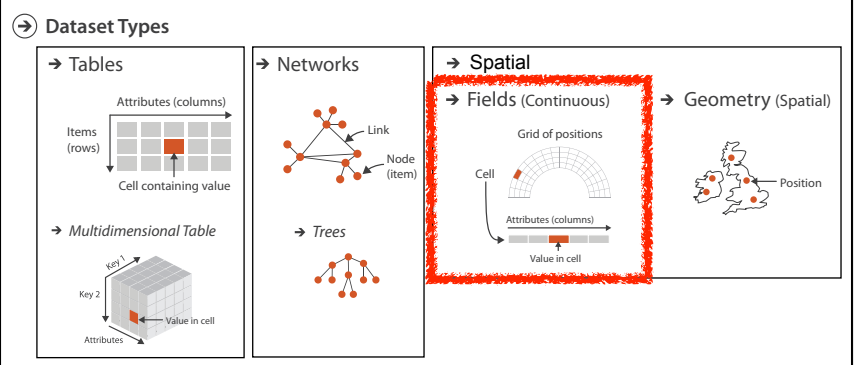
Visualization Analysis & Design

Spatial Data (Ch 9) II

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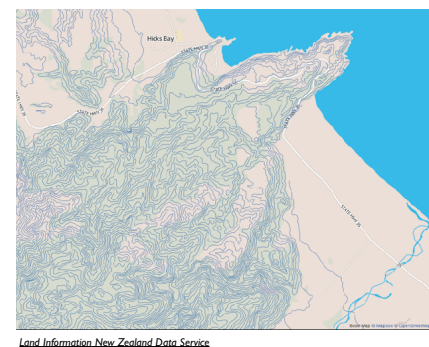
Focus on Spatial



Spatial Fields

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
- task
 - understanding terrain shape
 - densely lined regions = steep
- pros
 - use only 2D position, avoid 3D challenges
 - color channel available for other attributes
- cons
 - significant clutter from additional lines



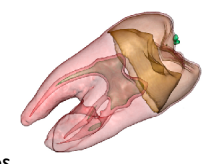
Idioms: isosurfaces, direct volume rendering

- data
 - scalar spatial field (3D volume)
 - 1 quant attribute per grid cell
- task
 - shape understanding, spatial relationships

[Interactive Volume Rendering Techniques. Kniss. Master's thesis, University of Utah Computer Science, 2002.]
 [Multidimensional Transfer Functions for Volume Rendering. Kniss, Kindlmann, and Hansen. In The Visualization Handbook, edited by Charles Hansen and Christopher Johnson, pp. 189–210. Elsevier, 2005.]

Idioms: isosurfaces, direct volume rendering

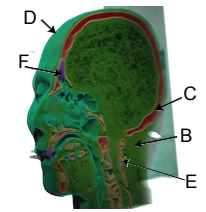
- data
 - scalar spatial field (3D volume)
 - 1 quant attribute per grid cell
- task
 - shape understanding, spatial relationships
- isosurface
 - derived data: isocontours computed for specific levels of scalar values



[Interactive Volume Rendering Techniques. Kniss. Master's thesis, University of Utah Computer Science, 2002.]
 [Multidimensional Transfer Functions for Volume Rendering. Kniss, Kindlmann, and Hansen. In The Visualization Handbook, edited by Charles Hansen and Christopher Johnson, pp. 189–210. Elsevier, 2005.]

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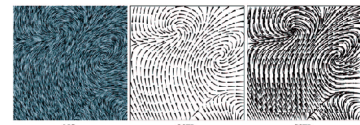
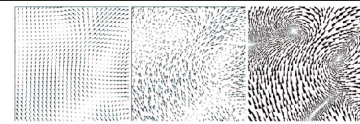
- data
 - scalar spatial field (3D volume)
 - 1 quant attribute per grid cell
- task
 - shape understanding, spatial relationships
- isosurface
 - derived data: isocontours computed for specific levels of scalar values
- direct volume rendering
 - transfer function maps scalar values to color, opacity
 - no derived geometry



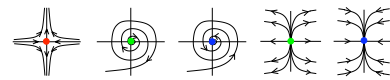
[Interactive Volume Rendering Techniques. Kniss. Master's thesis, University of Utah Computer Science, 2002.]
 [Multidimensional Transfer Functions for Volume Rendering. Kniss, Kindlmann, and Hansen. In The Visualization Handbook, edited by Charles Hansen and Christopher Johnson, pp. 189–210. Elsevier, 2005.]

Vector and tensor fields

- data
 - multiple attribs per cell (vector: 2)
- 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



[Comparing 2D vector field visualization methods: A user study. Laidlaw et al. IEEE Trans. Visualization and Computer Graphics (TVCG) 11:1 (2005), 59–70.]

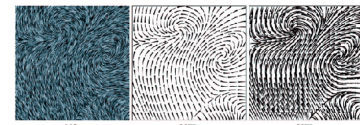
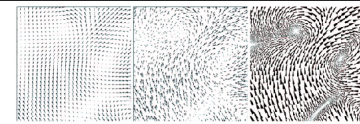


[Topology tracking for the visualization of time-dependent two-dimensional flows. Tricoche, Wischgoll, Scheuermann, and Hagen. Computers & Graphics 26:2 (2002), 249–257.]

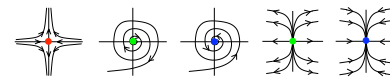
33

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)



[Comparing 2D vector field visualization methods: A user study. Laidlaw et al. IEEE Trans. Visualization and Computer Graphics (TVCG) 11:1 (2005), 59–70.]

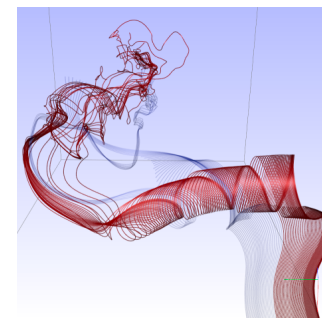


[Topology tracking for the visualization of time-dependent two-dimensional flows. Tricoche, Wischgoll, Scheuermann, and Hagen. Computers & Graphics 26:2 (2002), 249–257.]

34

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

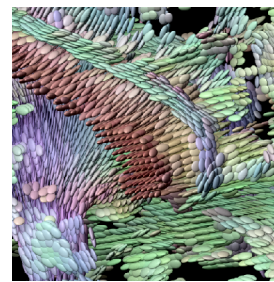


[Similarity Measures for Enhancing Interactive Streamline Seeding. McLaughlin, Jones, Laramee, Malki, Masters, and Hosten. IEEE Trans. Visualization and Computer Graphics 19:8 (2013), 1342–1353.]

35

Idiom: Ellipsoid Tensor Glyphs

- data
 - tensor field: multiple attributes at each cell (entire matrix)
 - stress, conductivity, curvature, diffusivity...
 - derived data:
 - shape (eigenvalues)
 - orientation (eigenvectors)
- visual encoding
 - glyph: 3D ellipsoid



[Superquadric Tensor Glyphs. Kindlmann. Proc. VisSym04, p147-154, 2004.]

36

Arrange spatial data

- ⊕ Use Given
 - Geometry
 - Geographic
- Spatial Fields
 - Scalar Fields (one value per cell)
 - Isocontours
 - Direct Volume Rendering
 - Vector and Tensor Fields (many values per cell)
 - Flow Glyphs (local)
 - Geometric (sparse seeds)
 - Textures (dense seeds)
 - Features (globally derived)



37