Week 4:
Manipulate, Facet, Reduce

Tamara Munzner
Department of Computer Science
University of British Columbia

JRNL 520H, Special Topics in Contemporary Journalism: Data Visualization
Week 4: 4 October 2016

http://www.cs.ubc.ca/~tmm/courses/journ16

Whereabouts

- Caitlin on travel this week and next week
  - don't expect email answers until she returns; email Tamara instead!
- Tamara on travel Thu Oct 6 - Mon Oct 10
  - in Portland Fri/Sat to give another keynote, will still be answering email
  - short office hours in Sing Tao next week: 12:30-1:30pm

News

- Assign 2 marks not out yet
  - stay tuned, just got back from Stanford late last night
- Today's format
  - interleave foundations & demos
    - Tamara will walk through Tableau demos
    - you follow along step by step on your own laptop
    - Tamara will take breaks to rove the room to help out folks who get stuck

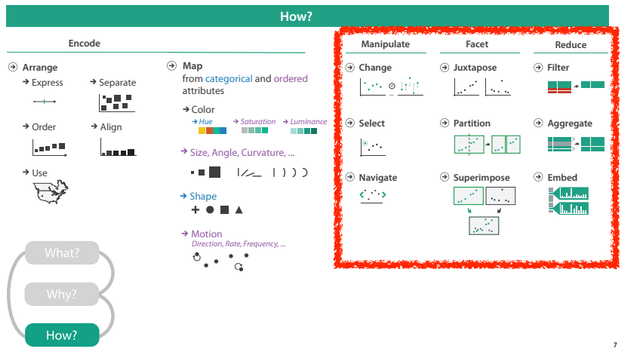
Last Time

Demo 1: Stone Color Workbook

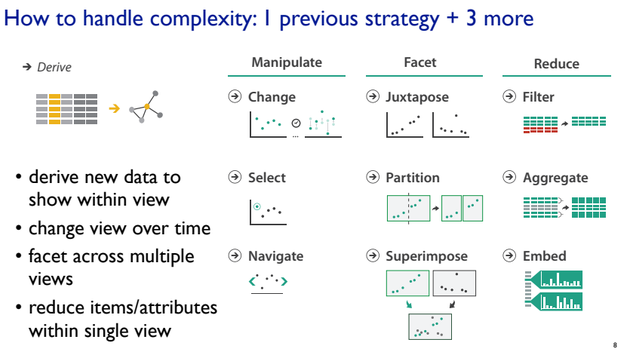
- Credit: Maureen Stone, Tableau Research
  - designer of Tableau color defaults, author of *A Field Guide to Digital Color*
  - workbook from Tableau Customer Conference 2014 talk
    Seriously Colorful: Advanced Color Principles & Practices
- Tableau Lessons
  - more visual encoding practice
  - color palettes, univariate & bivariate
  - discrete (categorical) vs continuous (quantitative)
- Big Ideas
  - Tableau has many built-in features to get color right, but care still needed

Demo 2: Intro to Maps

- Tableau Lessons
  - handling spatial data
  - multiple data sources
  - paths on maps
  - more on handling missing data: filtering
- Big Ideas
  - integrating visual encoding design choices with given spatial data

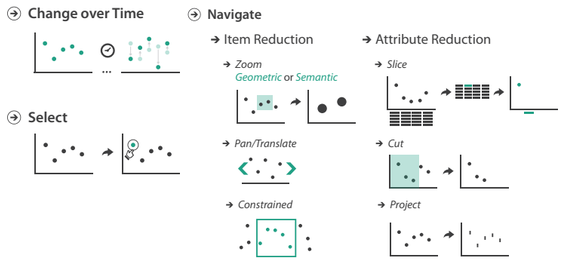


How to handle complexity: 1 previous strategy + 3 more



- derive new data to show within view
- change view over time
- facet across multiple views
- reduce items/attributes within single view

Manipulate



Change over time

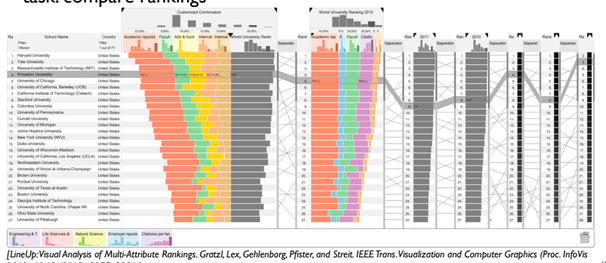
- change any of the other choices
  - encoding itself
  - parameters
  - arrange: rearrange, reorder
  - aggregation level, what is filtered...
  - interaction entails change

Idiom: **Re-encode** System: **Tableau**

made using Tableau, http://tableausoftware.com

Idiom: **Reorder** System: **LineUp**

- data: tables with many attributes
- task: compare rankings



[LineUp: Visual Analysis of Multi-Attribute Rankings. Gratzl, Lex, Gehlenborg, Pfister, and Streit. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2013) 19:12 (2013), 2277–2286.]

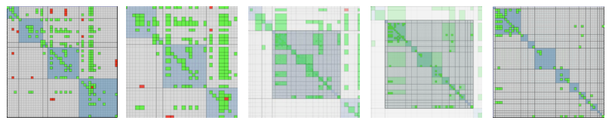
Idiom: **Realign** System: **LineUp**

- stacked bars
  - easy to compare
    - first segment
    - total bar
- align to different segment
  - supports flexible comparison

[LineUp: Visual Analysis of Multi-Attribute Rankings. Gratzl, Lex, Gehlenborg, Pfister, and Streit. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2013) 19:12 (2013), 2277–2286.]

Idiom: **Animated transitions**

- smooth transition from one state to another
  - alternative to jump cuts
  - support for item tracking when amount of change is limited
- example: multilevel matrix views
- example: animated transitions in statistical data graphics
  - https://vimeo.com/19278444



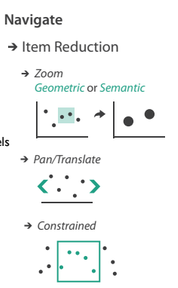
[Using Multilevel Call Matrices in Large Software Projects. van Ham. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 227–232, 2003.]

Select and highlight

- selection: basic operation for most interaction
- design choices
  - how many selection types?
    - click vs hover: heavyweight, lightweight
    - primary vs secondary: semantics (eg source/target)
- highlight: change visual encoding for selection targets
  - color
    - limitation: existing color coding hidden
  - other channels (eg motion)
  - add explicit connection marks between items

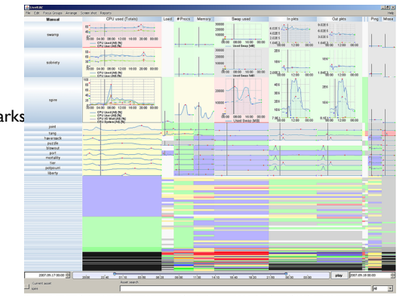
Navigate: Changing item visibility

- change viewpoint
  - changes which items are visible within view
  - camera metaphor
    - zoom
      - geometric zoom: familiar semantics
      - semantic zoom: adapt object representation based on available pixels
        - » dramatic change, or more subtle one
    - pan/translate
    - rotate
      - especially in 3D
  - constrained navigation
    - often with animated transitions
    - often based on selection set



Idiom: **Semantic zooming** System: **LiveRAC**

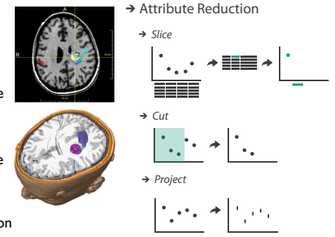
- visual encoding change
  - –colored box
  - –sparkline
  - –simple line chart
  - –full chart: axes and tickmarks



[LiveRAC - Interactive Visual Exploration of System Management Time-Series Data. McLachlan, Munzner, Koutsofios, and North. Proc. ACM Conf. Human Factors in Computing Systems (CHI), pp. 1483–1492, 2008.]

Navigate: Reducing attributes

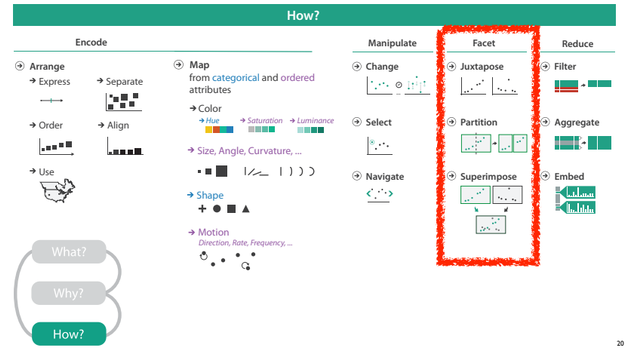
- continuation of camera metaphor
  - –slice
    - show only items matching specific value for given attribute: slicing plane
    - axis aligned, or arbitrary alignment
  - –cut
    - show only items on far slide of plane from camera
  - –project
    - change mathematics of image creation
      - – orthographic
      - – perspective
      - – many others: Mercator, cabinet, ...



[Interactive Visualization of Multimodal Volume Data for Neurosurgical Tumor Treatment. Rieder, Ritter, Raspe, and Peitgen. Computer Graphics Forum (Proc. EuroVis 2008) 27:3 (2008), 1055–1062.]

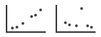
Previous Demos

- Tableau Lessons
  - –changing visual encoding
  - –changing ordering (sorting)
  - –navigation
    - zoom/translate in maps



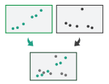
Facet

Juxtapose



Partition

Superimpose



Juxtapose and coordinate views

Share Encoding: Same/Different

Linked Highlighting

Share Data: All/Subset/None

Share Navigation

Idiom: **Linked highlighting** System: **EDV**

- see how regions contiguous in one view are distributed within another
  - –powerful and pervasive interaction idiom
- encoding: different
  - –***multiform***
- data: all shared

[Visual Exploration of Large Structured Datasets. Wills. Proc. New Techniques and Trends in Statistics (NTTS), pp. 237–246. IOS Press, 1995.]

Demo 1: Seattle Construction

- Credit: Ben Jones
- Tableau Lessons
  - –linking views with actions: highlight on hover
  - –global filtering
- Big Ideas
  - –linking views possible but somewhat clunky in Tableau

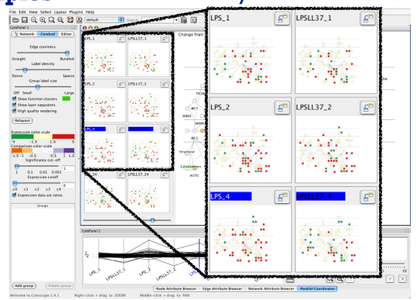
Idiom: **bird's-eye maps** System: **Google Maps**

- encoding: same
- data: subset shared
- navigation: shared
  - –bidirectional linking
- differences
  - –viewpoint
  - –(size)
- ***overview-detail***

[A Review of Overview+Detail, Zooming, and Focus+Context Interfaces. Cockburn, Karlson, and Bederson. ACM Computing Surveys 41:1 (2008), 1–31.]

Idiom: **small multiples** System: **Cerebral**

- encoding: same
- data: none shared
  - –different attributes for node colors
  - –(same network layout)
- navigation: shared



[Cerebral: Visualizing Multiple Experimental Conditions on a Graph with Biological Context. Barsky, Munzner, Gardy, and Kincaid. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2008) 14:6 (2008), 1253–1260.]

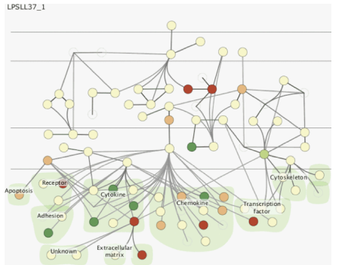
Coordinate views: Design choice interaction

Encoding	Data: All	Data: Subset	Data: None
Same	Redundant	Overview/ Detail	Small Multiples
Different	Multiform	Multiform, Overview/ Detail	No Linkage

- why juxtapose views?
  - –benefits: eyes vs memory
    - lower cognitive load to move eyes between 2 views than remembering previous state with single changing view
  - –costs: display area, 2 views side by side each have only half the area of one view

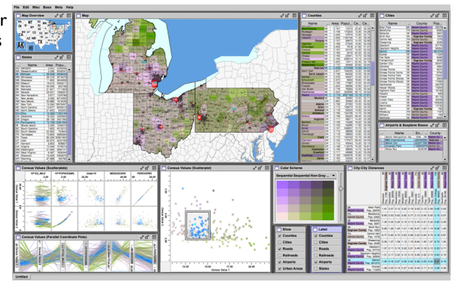
Why not animation?

- disparate frames and regions: comparison difficult
  - –vs contiguous frames
  - –vs small region
  - –vs coherent motion of group
- safe special case
  - –animated transitions



System: **Improvise**

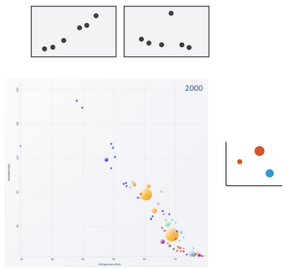
- investigate power of multiple views
  - –pushing limits on view count, interaction complexity
  - –how many is ok?
    - open research question
  - –reorderable lists
    - easy lookup
    - useful when linked to other encodings



[Building Highly-Coordinated Visualizations In Improvise. Weaver. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 159–166, 2004.]

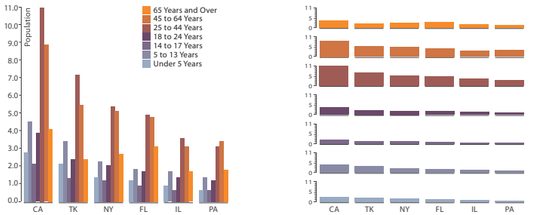
Partition into views

- how to divide data between views → Partition into Side-by-Side Views
  - –split into regions by attributes
  - –encodes association between items using spatial proximity
  - –order of splits has major implications for what patterns are visible
- no strict dividing line
  - –***view:*** *big/detailed*
    - contiguous region in which visually encoded data is shown on the display
  - –***glyph:*** *small/iconic*
    - object with internal structure that arises from multiple marks



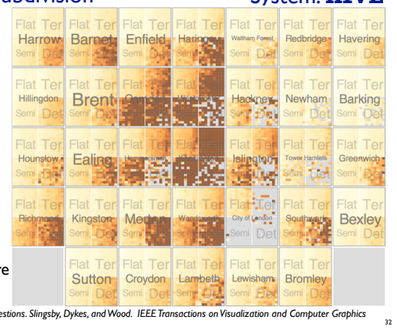
Partitioning: List alignment

- single bar chart with grouped bars
  - –split by state into regions
    - complex glyph within each region showing all ages
  - –compare: easy within state, hard across ages
- small-multiple bar charts
  - –split by age into regions
    - one chart per region
  - –compare: easy within age, harder across states



Partitioning: Recursive subdivision System: **HIVE**

- split by neighborhood
- then by type
- then time
  - –years as rows
  - –months as columns
- color by price
- neighborhood patterns
  - –where it's expensive
  - –where you pay much more for detached type



[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

Partitioning: Recursive subdivision

System: **HIVE**

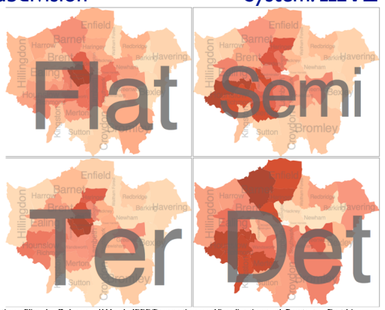
- switch order of splits
  - –type then neighborhood
- switch color
  - –by price variation
- type patterns
  - –within specific type, which neighborhoods inconsistent

[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

Partitioning: Recursive subdivision

System: **HIVE**

- different encoding for second-level regions
  - –choropleth maps



[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

Partitioning: Recursive subdivision

System: **HIVE**

- size regions by sale counts
  - –not uniformly
- result: treemap

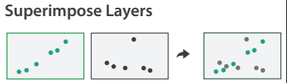
[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

Previous Demos

- Tableau Lessons
  - –partitioning: drag multiple pills into Row or Column
  - –disaggregation: drag field into Detail/Color
    - aggregation is automatic and aggressive in Tableau

Superimpose layers

- *layer*: set of objects spread out over region
  - –each set is visually distinguishable group
  - –extent: whole view
- design choices
  - –how many layers, how to distinguish?
    - encode with different, nonoverlapping channels
    - two layers achieveable, three with careful design
  - –small static set, or dynamic from many possible?



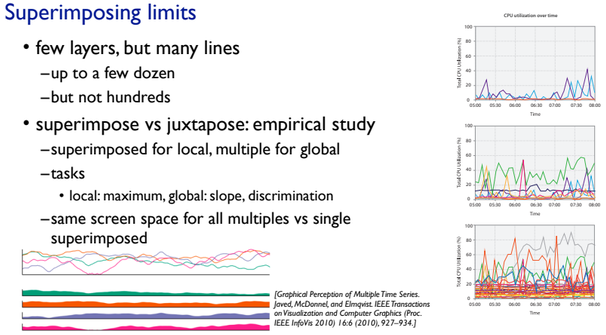
Static visual layering

- foreground layer: roads
  - –hue, size distinguishing main from minor
  - –high luminance contrast from background
- background layer: regions
  - –desaturated colors for water, parks, land areas
- user can selectively focus attention
- "get it right in black and white"
  - –check luminance contrast with greyscale view

[Get it right in black and white. Stone. 2010. http://www.stonesc.com/wordpress/2010/03/get-it-right-in-black-and-white]

Superimposing limits

- few layers, but many lines
  - –up to a few dozen
  - –but not hundreds
- superimpose vs juxtapose: empirical study
  - –superimposed for local, multiple for global
  - –tasks
    - local: maximum, global: slope, discrimination
  - –same screen space for all multiples vs single superimposed

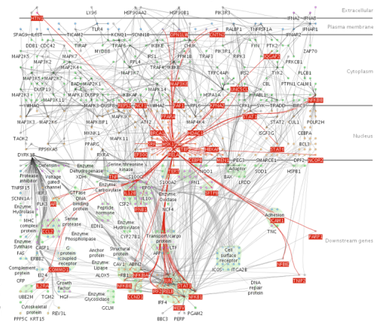


[Graphical Perception of Multiple Time Series. Javed, McDonnel, and Elmqvist. IEEE Transactions on Visualization and Computer Graphics (Proc. IEEE InfoVis 2010) 16:6 (2010), 927–934.]

Dynamic visual layering

System: **Cerebral**

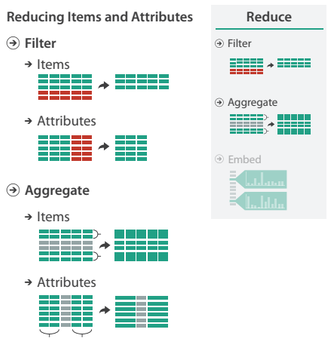
- interactive, from selection
  - –lightweight: click
  - –very lightweight: hover
- ex: 1-hop neighbors



[Cerebral: a Cytoscape plugin for layout of and interaction with biological networks using subcellular localization annotation. Barsky, Gardy, Hancock, and Munzner. Bioinformatics 23:8 (2007), 1040–1042.]

Reduce items and attributes

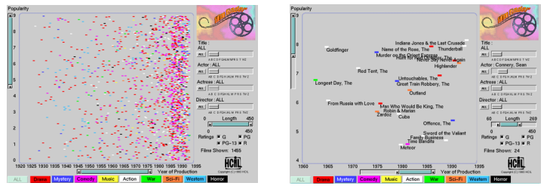
- reduce/increase: inverses
- filter
  - –pro: straightforward and intuitive
    - to understand and compute
  - –con: out of sight, out of mind
- aggregation
  - –pro: inform about whole set
  - –con: difficult to avoid losing signal
- not mutually exclusive
  - –combine filter, aggregate
  - –combine reduce, change, facet



Idiom: **dynamic filtering**

System: **FilmFinder**

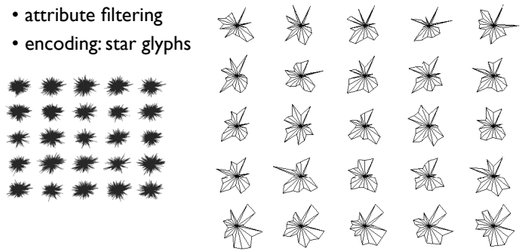
- item filtering
- browse through tightly coupled interaction
  - –alternative to queries that might return far too many or too few



[Visual information seeking: Tight coupling of dynamic query filters with starfield displays. Ahlberg and Shneiderman. Proc. ACM Conf. on Human Factors in Computing Systems (CHI), pp. 313–317, 1994.]

Idiom: **DOSFA**

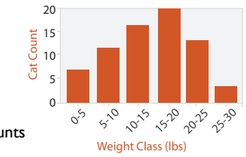
- attribute filtering
- encoding: star glyphs



[Interactive Hierarchical Dimension Ordering, Spacing and Filtering for Exploration Of High Dimensional Datasets. Yang, Peng, Ward, and. Rundensteiner. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 105–112, 2003.]

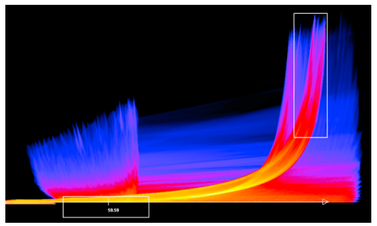
Idiom: **histogram**

- static item aggregation
- task: find distribution
- data: table
- derived data
  - –new table: keys are bins, values are counts
- bin size crucial
  - –pattern can change dramatically depending on discretization
  - –opportunity for interaction: control bin size on the fly



Continuous scatterplot

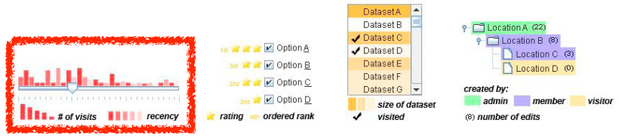
- static item aggregation
- data: table
- derived data: table
  - – key attribs x,y for pixels
  - – quant attrib: overplot density
- dense space-filling 2D matrix
- color: sequential categorical hue + ordered luminance colormap



[Continuous Scatterplots. Bachthaler and Weiskopf. IEEE TVCG (Proc. Vis 08) 14:6 (2008), 1428–1435. 2008.]

Idiom: **scented widgets**

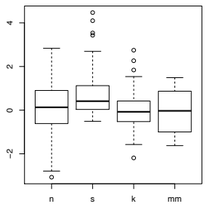
- augment widgets for filtering to show ***information scent***
  - –cues to show whether value in drilling down further vs looking elsewhere
- concise, in part of screen normally considered control panel



[Scented Widgets: Improving Navigation Cues with Embedded Visualizations. Willett, Heer, and Agrawala. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2007) 13:6 (2007), 1129–1136.]

Idiom: **boxplot**

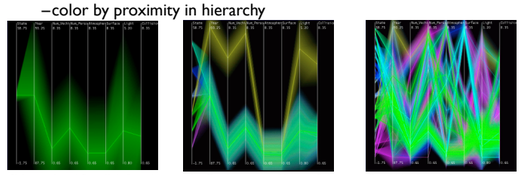
- static item aggregation
- task: find distribution
- data: table
- derived data
  - –5 quant attribs
    - median: central line
    - lower and upper quartile: boxes
    - lower upper fences: whiskers
      - –values beyond which items are outliers
  - –outliers beyond fence cutoffs explicitly shown



[40 years of boxplots. Wickham and Stryjewski. 2012. had.co.nz]

Idiom: **Hierarchical parallel coordinates**

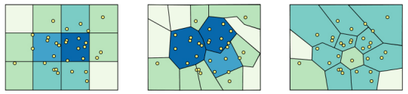
- dynamic item aggregation
- derived data: ***hierarchical clustering***
- encoding:
  - –cluster band with variable transparency, line at mean, width by min/max values
  - –color by proximity in hierarchy



[Hierarchical Parallel Coordinates for Exploration of Large Datasets. Fua, Ward, and Rundensteiner. Proc. IEEE Visualization Conference (Vis '99), pp. 43– 50, 1999.]

Spatial aggregation

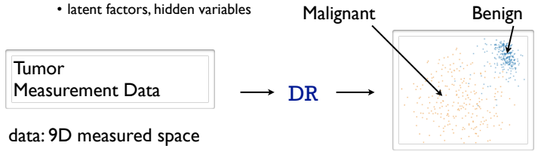
- MAUP: Modifiable Areal Unit Problem
  - gerrymandering (manipulating voting district boundaries) is one example!



[http://www.e-education.psu.edu/geog486/l4_p7.html, Fig 4.cg.6]

Dimensionality reduction

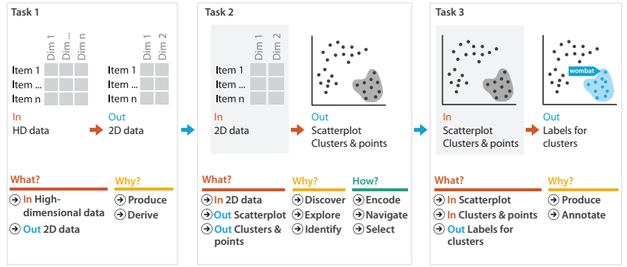
- attribute aggregation
  - derive low-dimensional target space from high-dimensional measured space
  - use when you can't directly measure what you care about
    - true dimensionality of dataset conjectured to be smaller than dimensionality of measurements
    - latent factors, hidden variables



data: 9D measured space

derived data: 2D target space

Idiom: **Dimensionality reduction for documents**



Demo 2: Internet Use

- Credit: Ben Jones

- Tableau Lessons
  - more maps, dual axes
  - linked views (apply filter to selected worksheets)
  - actions: highlight/hover

- Big Ideas
  - Tableau interactivity defaults not necessarily what you want

Demo 3: House Price Index

- Credit: Robert Kosara, from TCC 2014 talk Recreating News Visualizations in Tableau

- Tableau Lessons
  - more calculated field practice
  - create parameter
  - reference lines
  - interactive sliders

- Big Ideas
  - calculated fields plus interactivity gives you a lot of power and flexibility

Assignment 4

- finish/review House Price Index workbook
- add interactivity to last week's story
  - update workbook
  - upload to Tableau Public
  - revise story to include embedded interactive
- final project proposal