Visualization Analysis & Design

Reduce: Aggregation & Filtering (Ch 13)

Tamara Munzner
Department of Computer Science
University of British Columbia
@tamaramunzner

How to handle complexity: 3 previous strategies

- derive new data to show within view
- change view over time
- facet across multiple views

Manipulate
- Change
- Select
- Navigate

Facet
- Juxtapose
- Partition
- Superimpose

How to handle complexity: 3 previous strategies + 1 more

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

Manipulate
- Change
- Select
- Navigate

Facet
- Juxtapose
- Partition
- Superimpose

Reduce
- Filter
- Aggregate
- Embed

Reduce items and attributes

- reduce/increase: inverses
- filter
  - pro: straightforward and intuitive
    - to understand and compute
  - con: out of sight, out of mind

Reducing Items and Attributes
- Filter
  - Items
  - Attributes

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

Reducing Items and Attributes
- Filter
  - Items
  - Attributes
- Aggregate
  - Items
  - Attributes

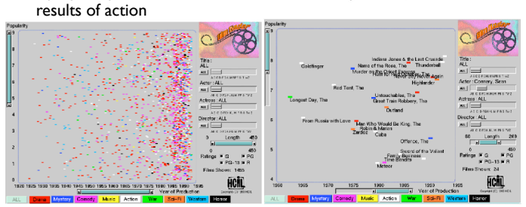
Filter

- eliminate some elements
  - either items or attributes
- according to what?
  - any possible function that partitions dataset into two sets
    - attribute values bigger/smaller than x
    - noise/signal
- filters vs queries
  - query: start with nothing, add in elements
  - filters: start with everything, remove elements
  - best approach depends on dataset size

Reducing Items and Attributes
- Filter
  - Items
  - Attributes

Idiom: **FilmFinder**

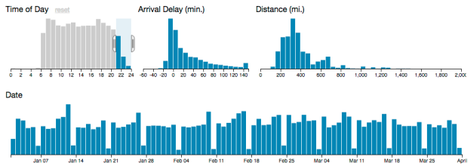
- dynamic queries/filters for items
  - tightly coupled interaction and visual encoding idioms, so user can immediately see results of action



[Ahlberg & Shneiderman, Visual Information Seeking: Tight Coupling of Dynamic Query Filters with Starfield Displays. CHI 1994.]

Idiom: **cross filtering** System: **Crossfilter**

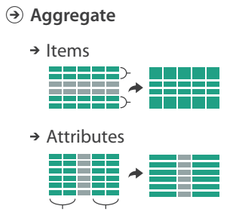
- item filtering
- coordinated views/controls combined
  - all scented histogram bisliders update when any ranges change



http://square.github.io/crossfilter/
https://observablehq.com/@uwdata/interaction

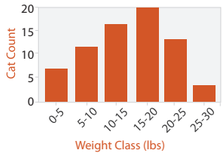
Aggregate

- a group of elements is represented by a smaller number of derived elements



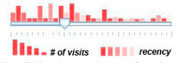
Idiom: **histogram**

- 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



Idiom: **scented widgets**

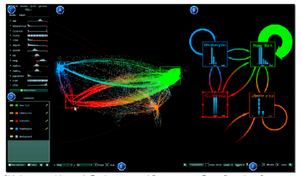
- augmented widgets show *information scent*
  - better cues for *information foraging*: show whether value in drilling down further vs looking elsewhere
- concise use of space: histogram on slider



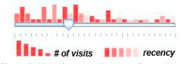
[Scented Widgets: Improving Navigation Cues with Embedded Visualizations. Willett, Heer, and Agrawala. IEEE TVCG (Proc. InfoVis 2007) 13:6 (2007), 1129–1136.]

Idiom: **scented widgets**

- augmented widgets show *information scent*
  - better cues for *information foraging*: show whether value in drilling down further vs looking elsewhere
- concise use of space: histogram on slider



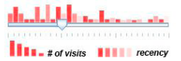
[Multivariate Network Exploration and Presentation: From Detail to Overview via Selections and Aggregations. van den Elzen, van Wijk, IEEE TVCG 20(12): 2014 (Proc. InfoVis 2014).]



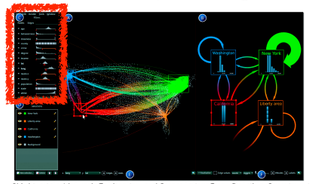
[Scented Widgets: Improving Navigation Cues with Embedded Visualizations. Willett, Heer, and Agrawala. IEEE TVCG (Proc. InfoVis 2007) 13:6 (2007), 1129–1136.]

Idiom: **scented widgets**

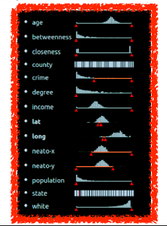
- augmented widgets show *information scent*
  - better cues for *information foraging*: show whether value in drilling down further vs looking elsewhere
- concise use of space: histogram on slider



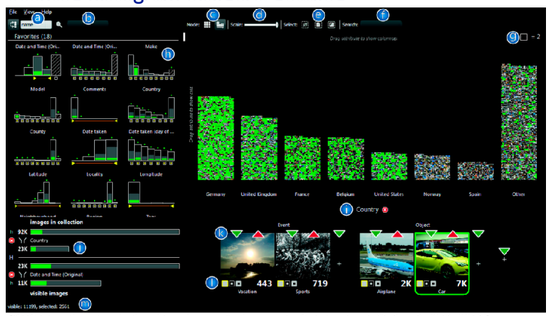
[Scented Widgets: Improving Navigation Cues with Embedded Visualizations. Willett, Heer, and Agrawala. IEEE TVCG (Proc. InfoVis 2007) 13:6 (2007), 1129–1136.]



[Multivariate Network Exploration and Presentation: From Detail to Overview via Selections and Aggregations. van den Elzen, van Wijk, IEEE TVCG 20(12): 2014 (Proc. InfoVis 2014).]



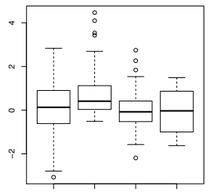
Scented histogram bisliders: detailed



[ICLIC: Interactive categorization of large image collections. van der Corput and van Wijk. Proc. PacificVis 2016.]

Idiom: **boxplot**

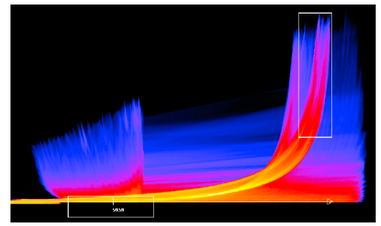
- static item aggregation
- task: find distribution
- data: table
- derived data
  - 5 quant attribs
    - median: central line
    - lower and upper quartile: boxes
    - lower upper fences: whiskers
      - values beyond which items are outliers
  - outliers beyond fence cutoffs explicitly shown
-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



[40 years of boxplots. Wickham and Stryjewski. 2012]

Idiom: **Continuous scatterplot**

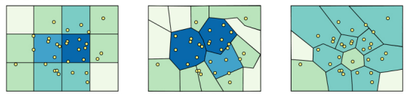
- static item aggregation
- data: table
- derived data: table
  - key attribs x,y for pixels
  - quant attrib: overplot density
- dense space-filling 2D matrix
- color: sequential categorical hue + ordered luminance colormap
- scalability
  - no limits on overplotting: millions of items



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

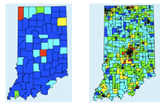
Spatial aggregation

- MAUP: Modifiable Areal Unit Problem
  - changing boundaries of cartographic regions can yield dramatically different results
  - zone effects



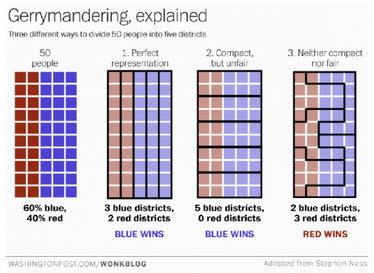
[http://www.e-education.psu/edu/geog486/l4_p7.html, Fig 4.cg.6]

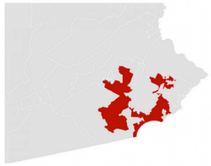
  - scale effects



https://blog.cartographica.com/blog/2011/5/19/the-modifiable-areal-unit-problem-in-gis.html

Gerrymandering: MAUP for political gain





A real district in Pennsylvania: Democrats won 51% of the vote but only 5 out of 18 house seats

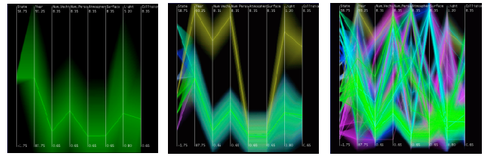
https://www.washingtonpost.com/news/wonk/wp/2015/03/01/this-is-the-best-explanation-of-gerrymandering-you-will-ever-see/

Dynamic aggregation: Clustering

- clustering: classification of items into similar bins
  - based on similiarity measure
  - hierarchical algorithms produce "similarity tree": cluster hierarchy
    - agglomerative clustering: start w/ each node as own cluster, then iteratively merge
- cluster hierarchy: derived data used w/ many dynamic aggregation idioms
  - cluster more homogeneous than whole dataset
    - statistical measures & distribution more meaningful

Idiom: **Hierarchical parallel coordinates**

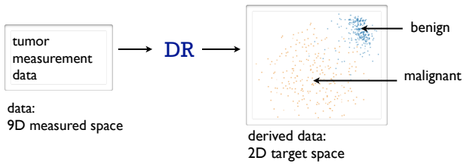
- dynamic item aggregation
- derived data: **cluster hierarchy**
- encoding:
  - cluster band with variable transparency, line at mean, width by min/max values
  - color by proximity in hierarchy



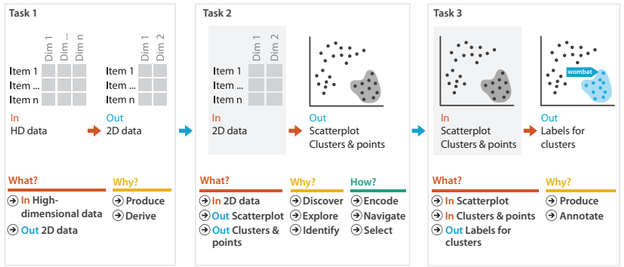
[Hierarchical Parallel Coordinates for Exploration of Large Datasets. Fua, Ward, and Rundensteiner. Proc. IEEE Visualization Conference (Vis '99), pp. 43– 50, 1999.]

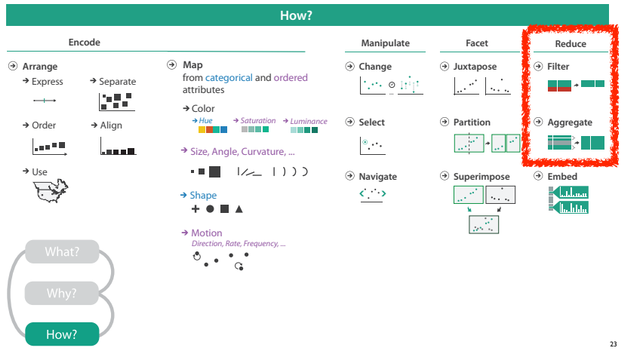
Attribute aggregation: Dimensionality reduction

- attribute aggregation
  - derive low-dimensional target space from high-dimensional measured space
    - capture most of variance with minimal error
  - 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



Idiom: **Dimensionality reduction for documents**



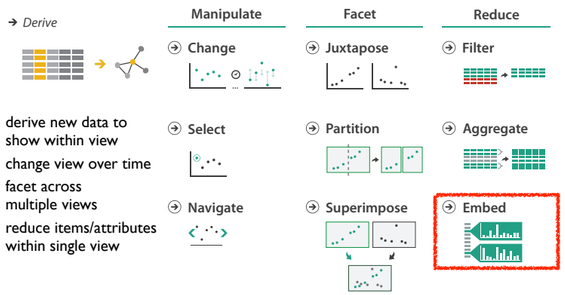


Visualization Analysis & Design

Embed: Focus+Context (Ch 14)

Tamara Munzner
Department of Computer Science
University of British Columbia
@tamaramunzner

How to handle complexity: 4 strategies



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

Embed: Focus+Context

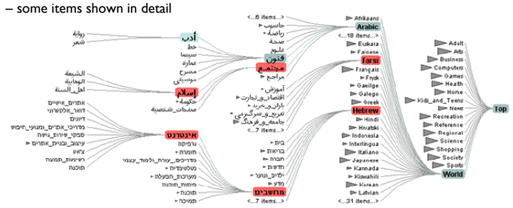
- combine focus + context info within single view
  - vs standard navigation within view
  - vs multiple views

Embed: Focus+Context

- combine focus + context info within single view
  - vs standard navigation within view
  - vs multiple views
- elide data
  - selectively filter and aggregate

Idiom: **DOITrees Revisited**

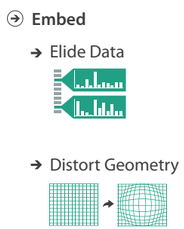
- focus+context choice: elide
  - some items dynamically filtered out
  - some items dynamically aggregated together
  - some items shown in detail



[DOITrees Revisited: Scalable, Space-Constrained Visualization of Hierarchical Data. Heer and Card. Proc. Advanced Visual Interfaces (AVI), pp. 421–424, 2004.]

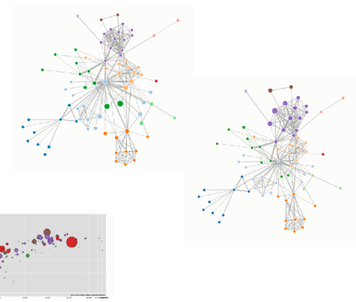
Embed: Focus+Context

- combine focus + context info within single view
  - vs standard navigation within view
  - vs multiple views
- elide data
  - selectively filter and aggregate
- distort geometry
  - carefully chosen to integrate F+C



Idiom: **Fisheye Lens**

- F+C choice: distort geometry
  - shape: radial
  - focus: single extent
  - extent: local
  - metaphor: draggable lens
- variant: Cartesian distortion
  - shape: rectilinear



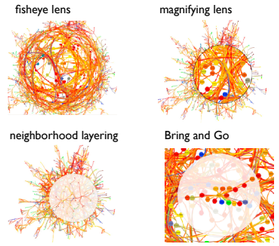
[D3 Fisheye Lens] https://bost.ocks.org/mike/fisheye/

Embed: Focus+Context

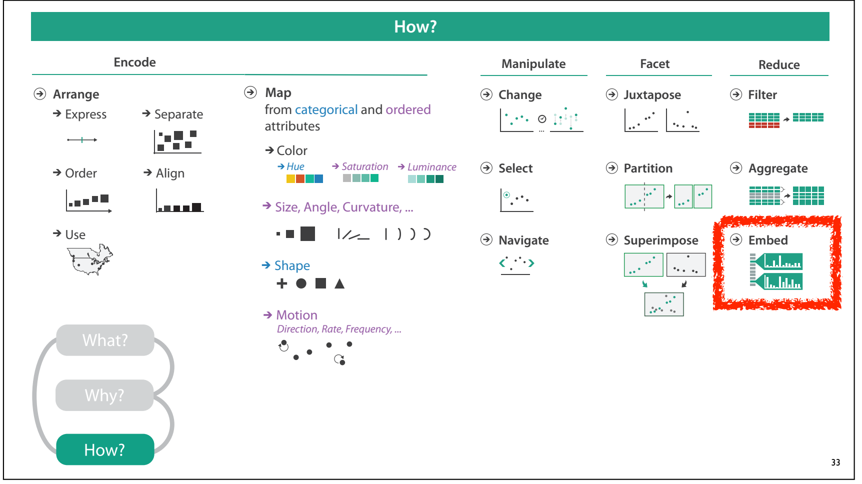
- combine focus + context info within single view
  - vs standard navigation within view
  - vs multiple views
- elide data
  - selectively filter and aggregate
- distort geometry: design choices
  - region shape: radial, rectilinear, complex
  - how many regions: one, many
  - region extent: local, global
  - interaction metaphor

Distortion costs and benefits

- benefits
  - combine focus and context information in single view
- costs
  - length comparisons impaired
    - topology comparisons unaffected: connection, containment
  - effects of distortion unclear if original structure unfamiliar
  - object constancy/tracking may be impaired



[Living Flows: Enhanced Exploration of Edge-Bundled Graphs Based on GPU-Intensive Edge Rendering. Lambert, Auber, and Melançon. Proc. Intl. Conf. Information Visualisation (IV), pp. 523–530, 2010.]



How?
Encode
Manipulate
Facet
Reduce
Arrange
Express
Separate
Order
Align
Use
Map
from categorical and ordered attributes
Color
Hue
Saturation
Luminance
Size, Angle, Curvature, ...
Shape
Motion
Direction, Rate, Frequency, ...
Change
Select
Navigate
Juxtapose
Partition
Superimpose
Filter
Aggregate
Embed
What?
Why?
How?
33