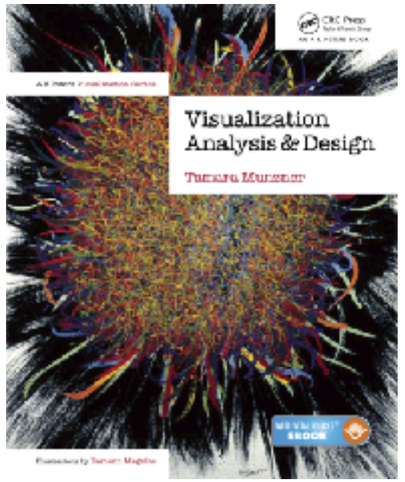
Visualization Analysis & Design



Reduce: Aggregation & Filtering (Ch 13)

Tamara Munzner
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@tamaramunzner

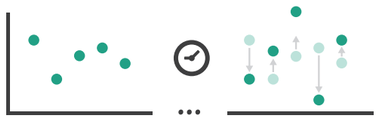
How to handle complexity: 3 previous strategies

➔ *Derive*

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

Manipulate

➔ Change



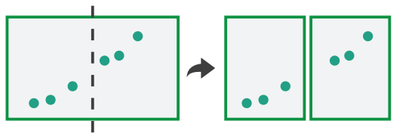
➔ Select

➔ Navigate

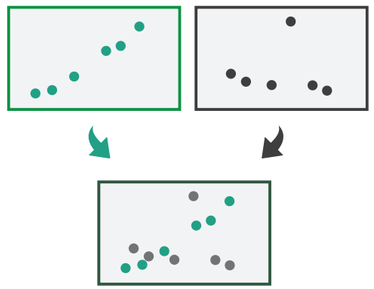
Facet

➔ Juxtapose

➔ Partition



➔ Superimpose



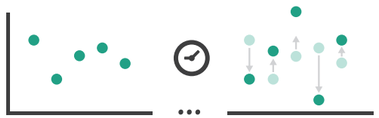
How to handle complexity: 3 previous strategies + 1 more

→ *Derive*

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

Manipulate

→ Change



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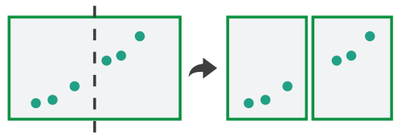
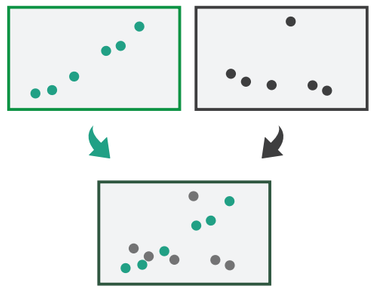


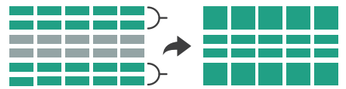
→ Superimpose



Reduce

→ Filter

→ Aggregate



→ Embed

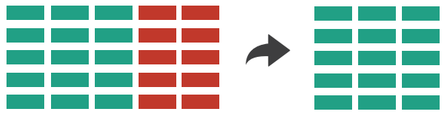
Reduce items and attributes

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

Reducing Items and Attributes

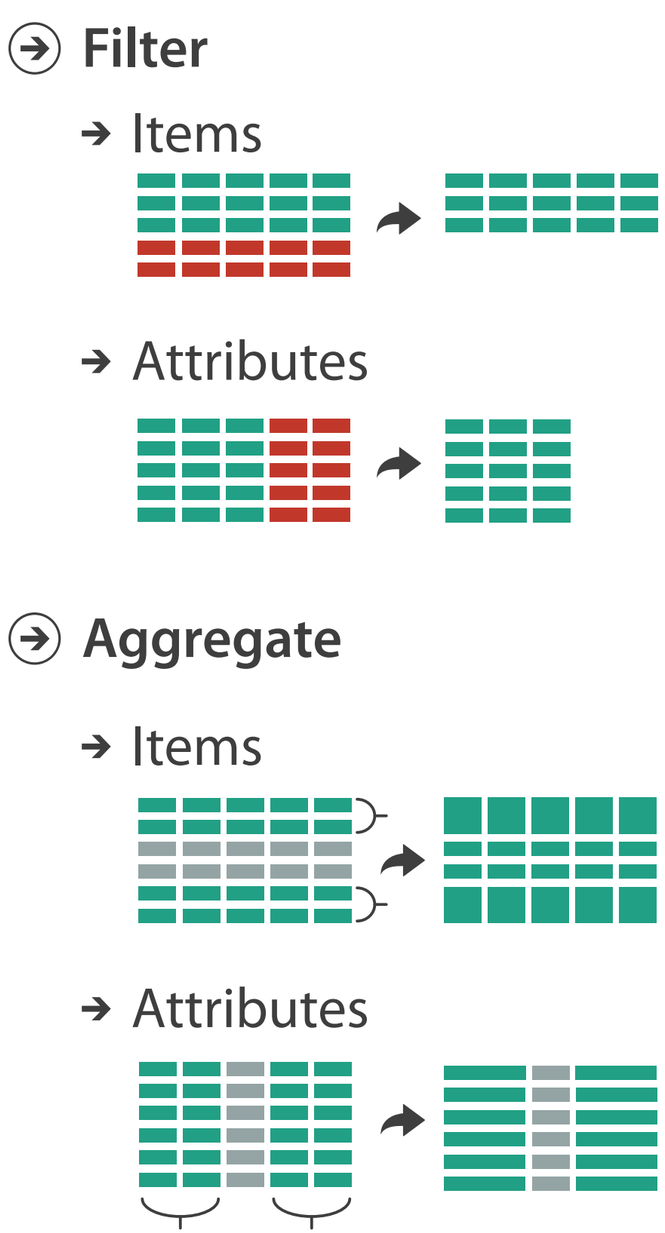
- **Filter**
  - Items

  - Attributes



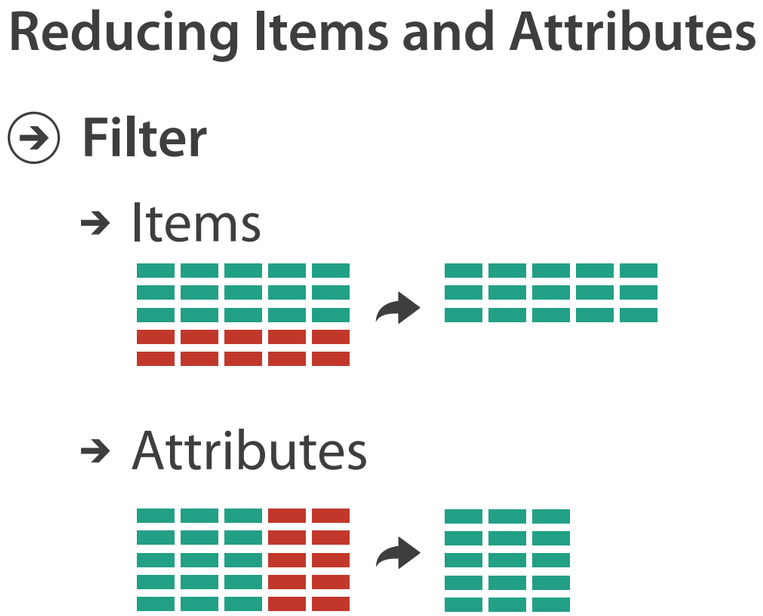
Reduce items and attributes

- 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



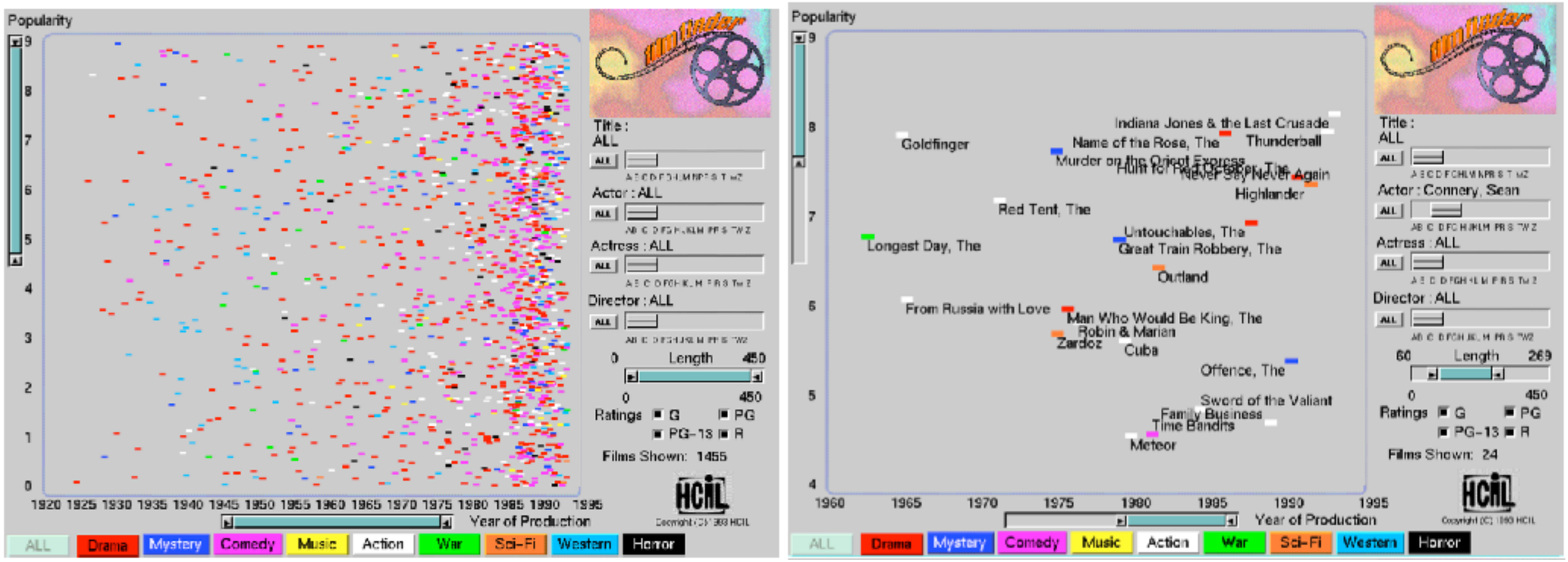
Filter

- 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



Idiom: **FilmFinder**

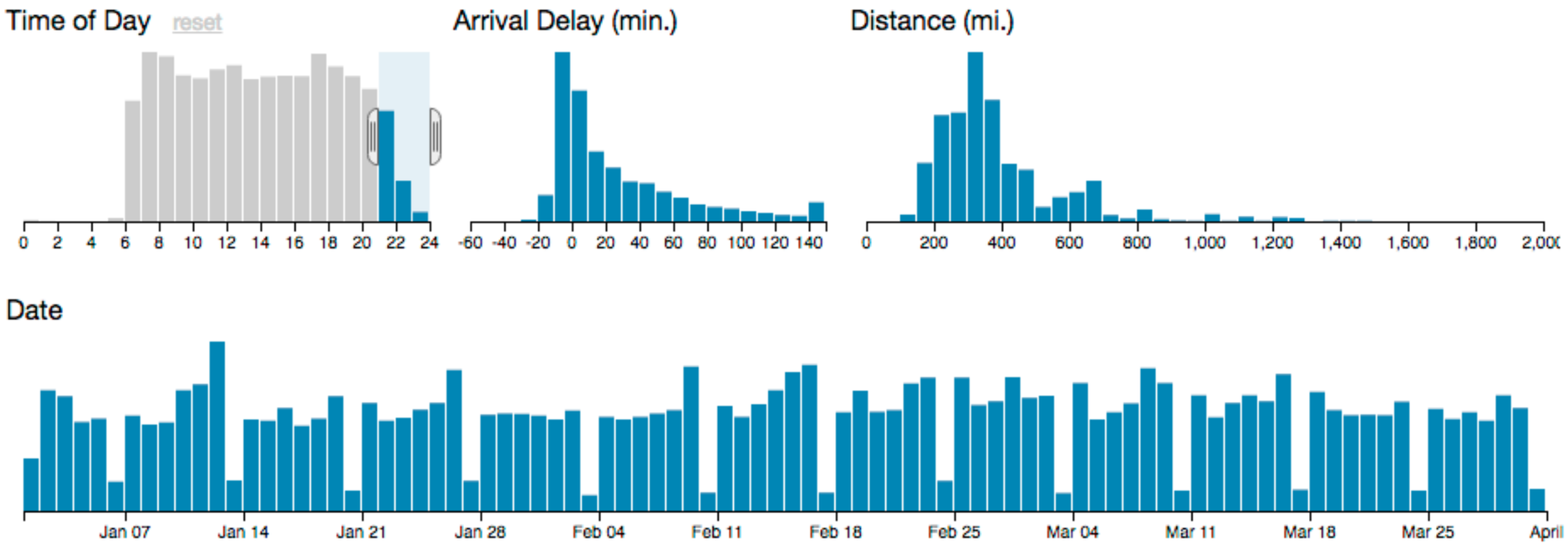
- dynamic queries/filters for items
  - tightly coupled interaction and visual encoding idioms, so user can immediately see results of action



[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

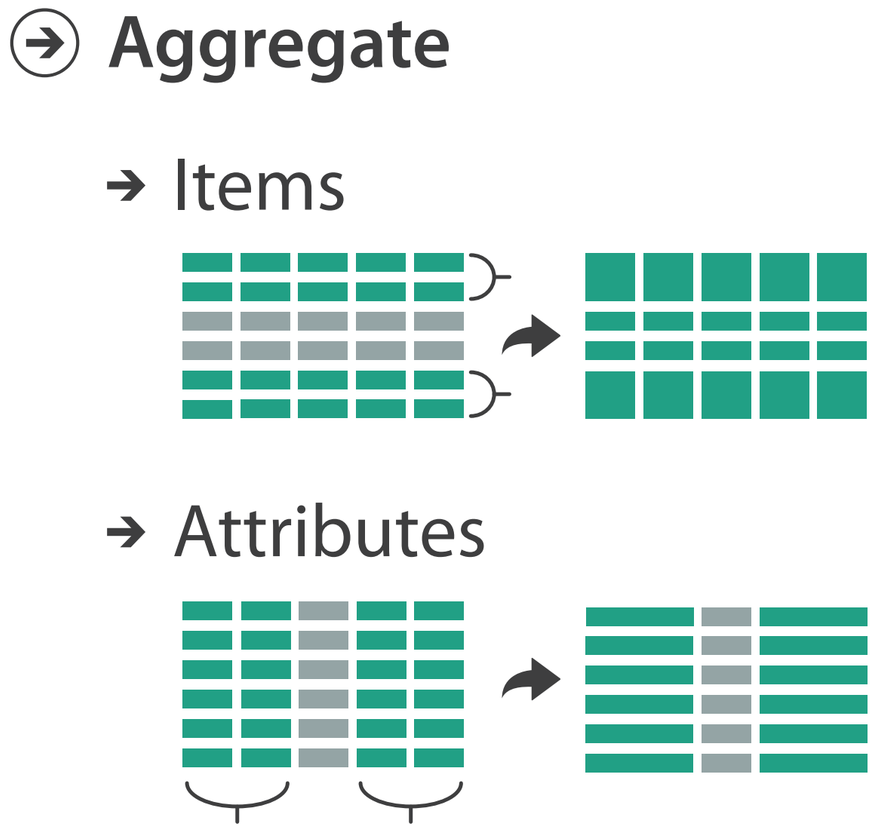


http://square.github.io/crossfilter/

https://observablehq.com/@uwdata/interaction

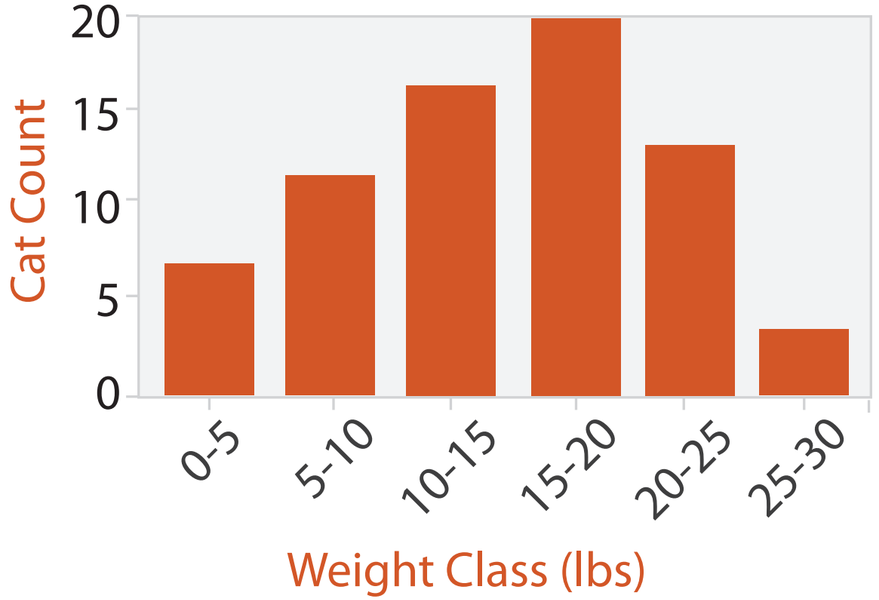
Aggregate

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



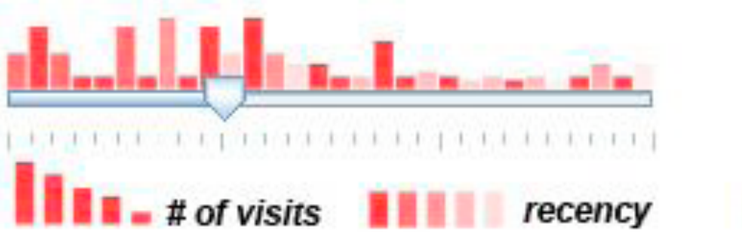
Idiom: **histogram**

- 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.]

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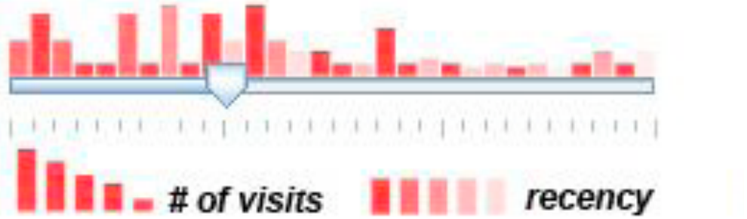

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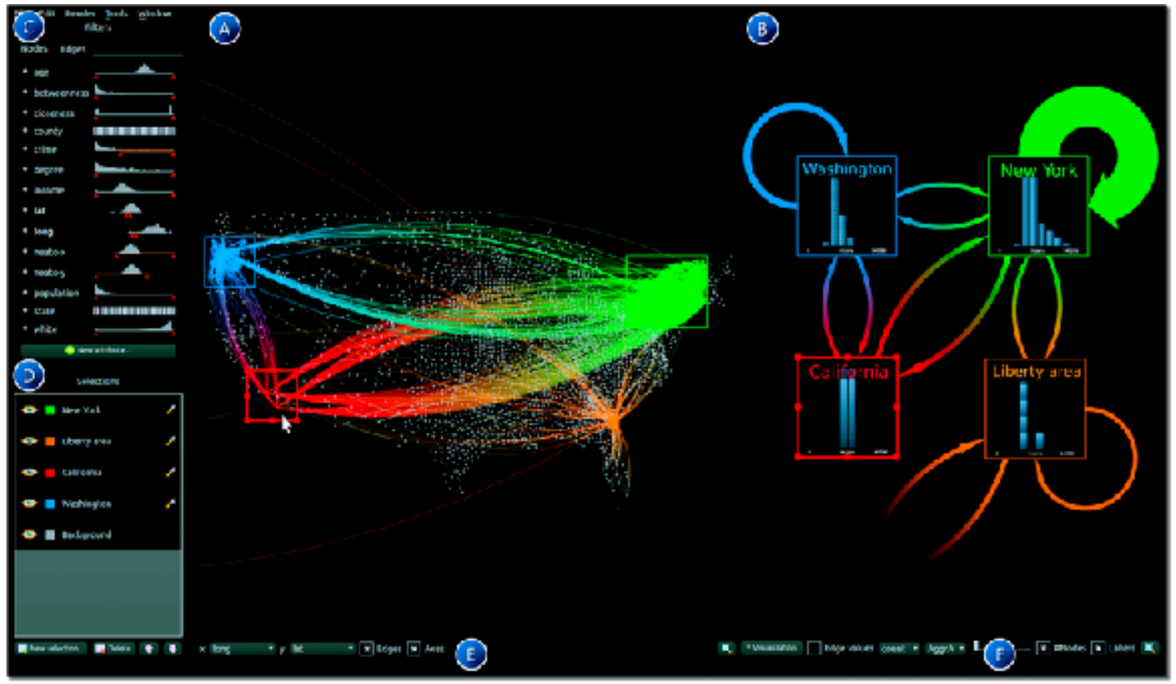

[Multivariate Network Exploration and Presentation: From Detail to Overview via Selections and Aggregations. van den Elzen, van Wijk, IEEE TVCG 20(12): 2014 (Proc. InfoVis 2014).]

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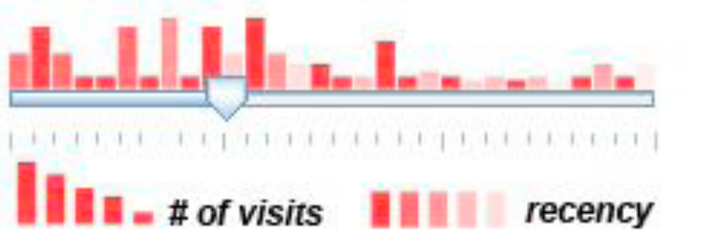

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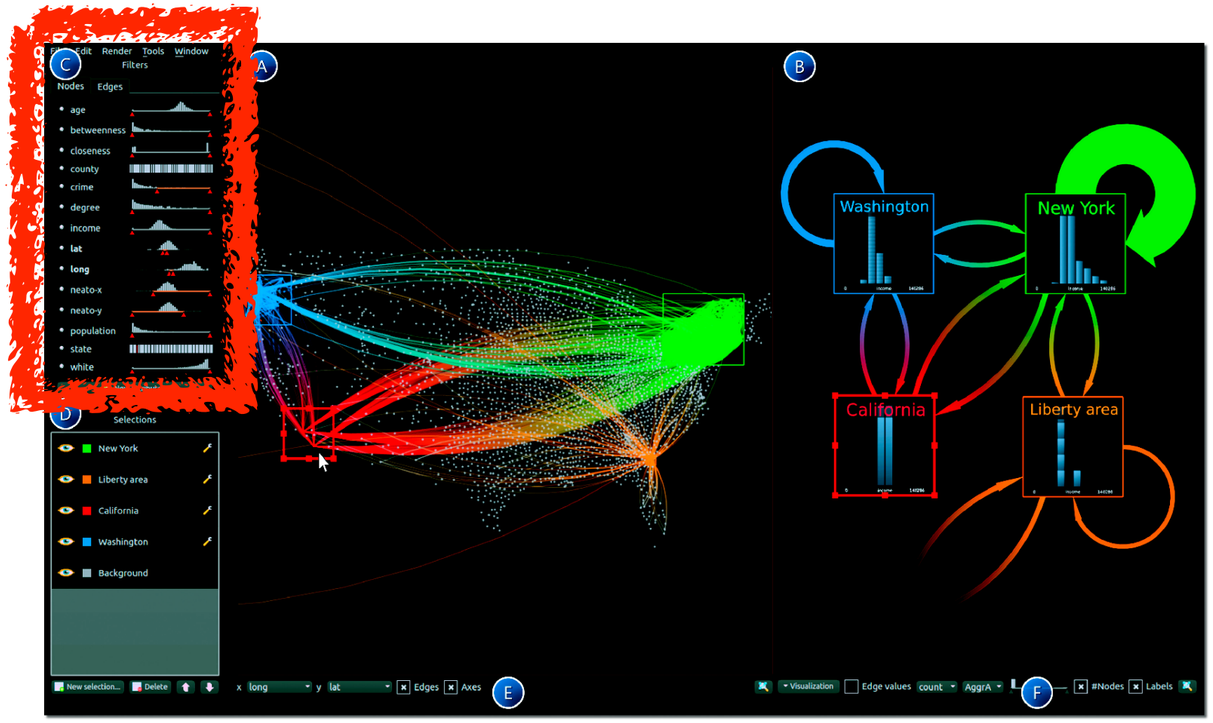

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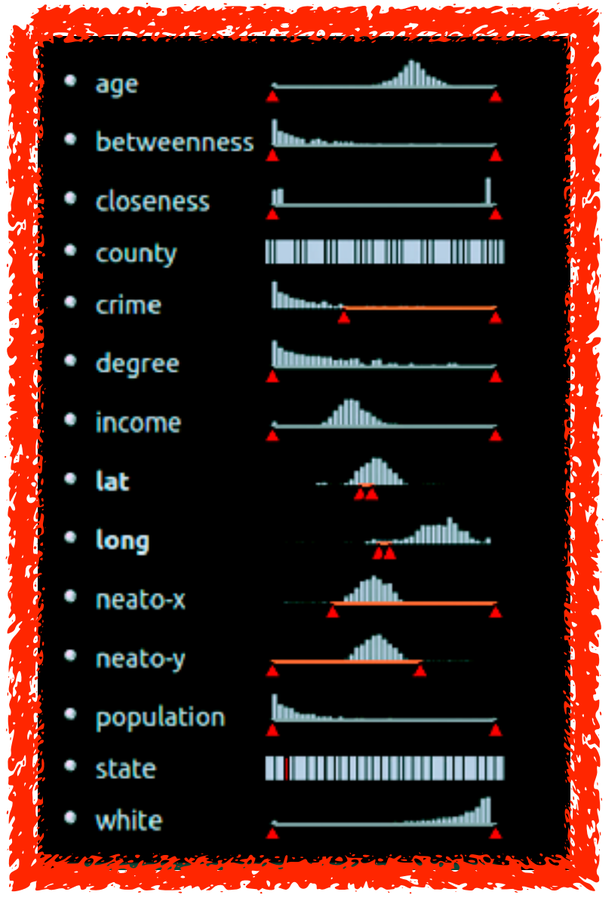
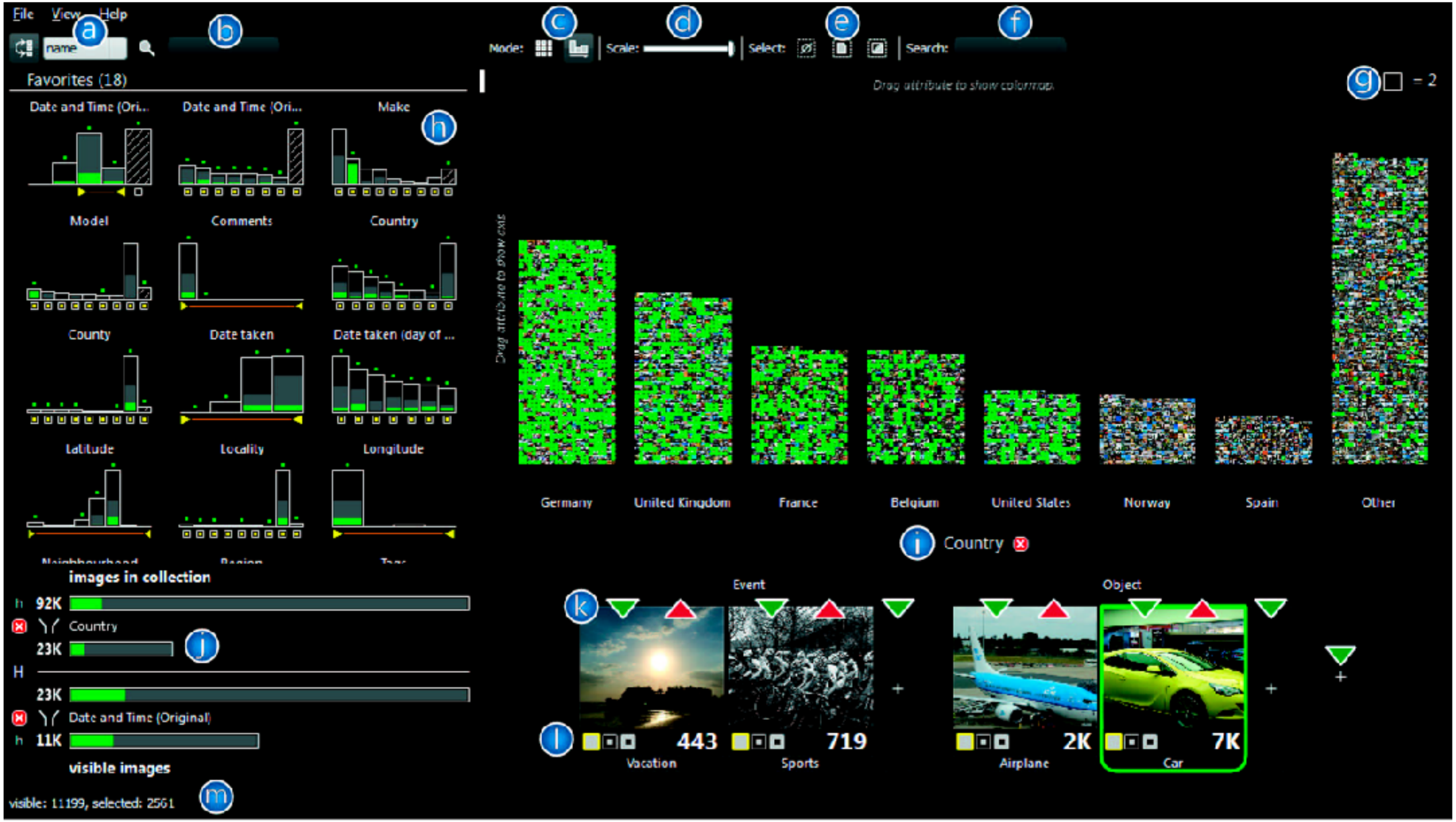


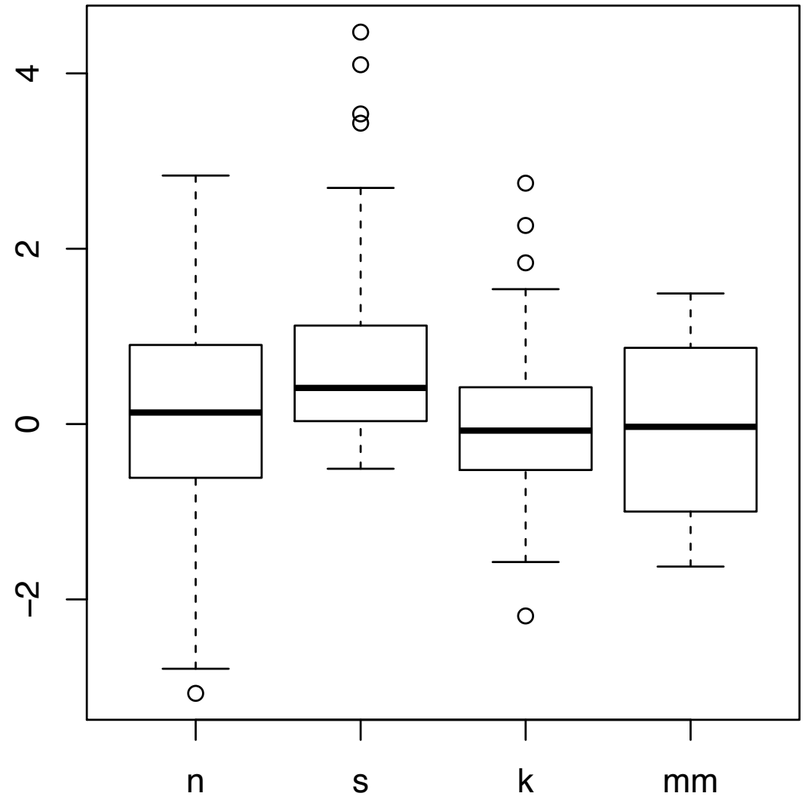
Scented histogram bisliders: detailed



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

Idiom: **boxplot**

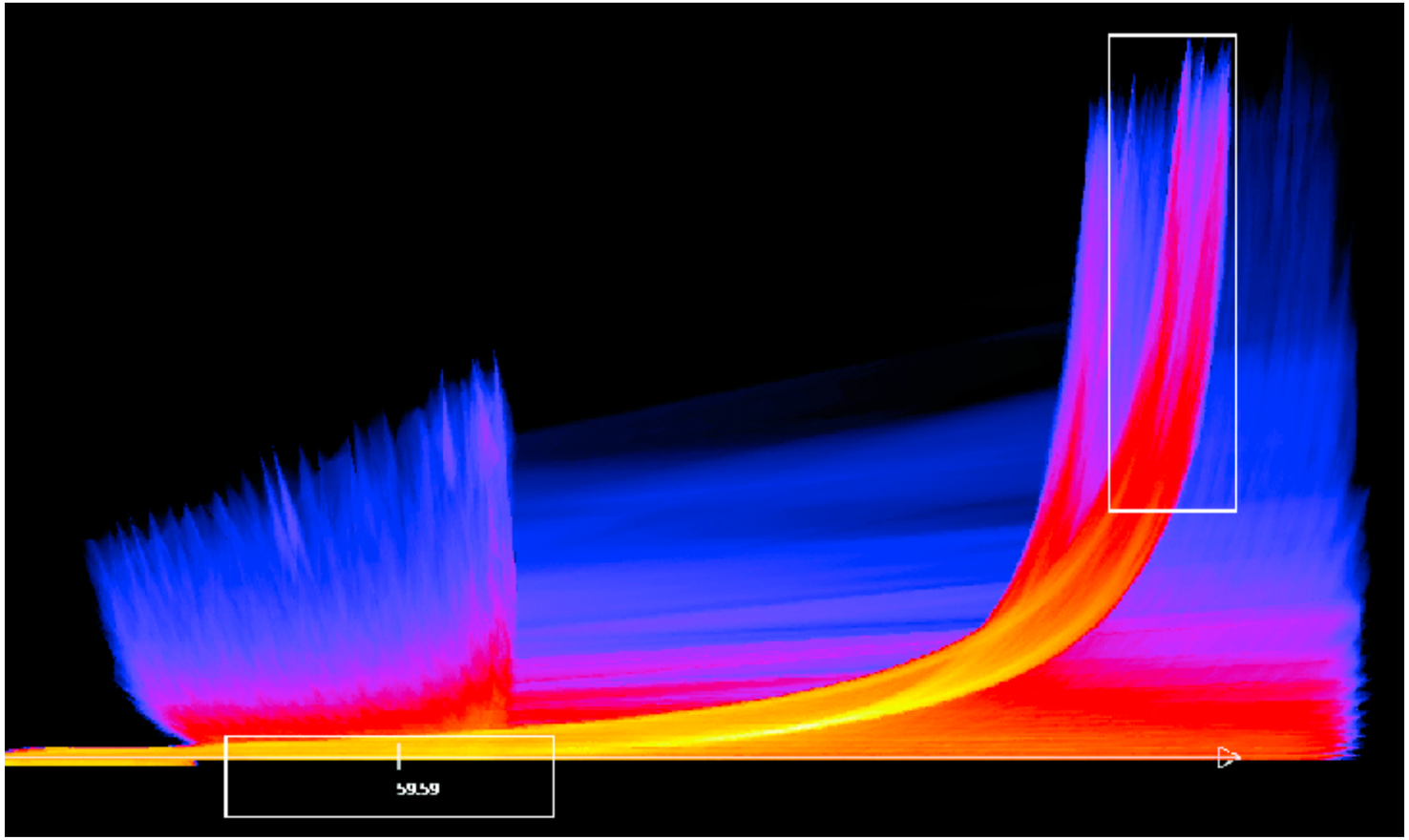
- static item aggregation
- task: find distribution
- data: table
- derived data
  - 5 quant attribs
    - median: central line
    - lower and upper quartile: boxes
    - lower upper fences: whiskers
      - values beyond which items are outliers
  - outliers beyond fence cutoffs explicitly shown
-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



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

Idiom: **Continuous scatterplot**

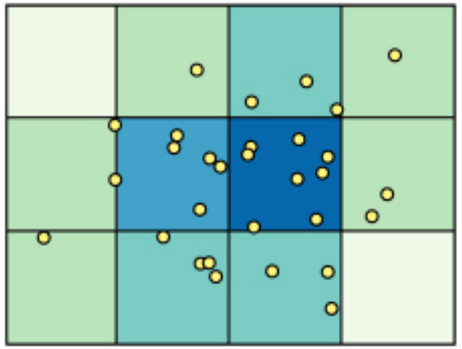
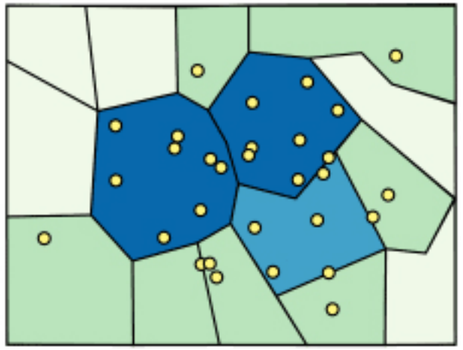
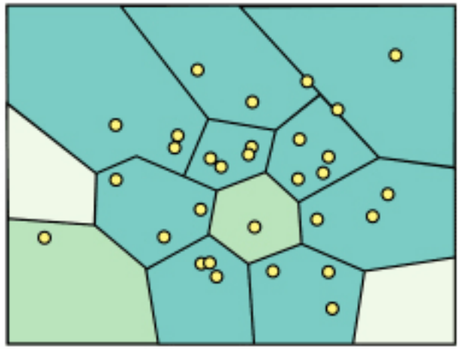
- static item aggregation
- data: table
- derived data: table
  - key attribs x,y for pixels
  - quant attrib: overplot density
- dense space-filling 2D matrix
- color:
  sequential categorical hue +
  ordered luminance colormap
- scalability
  - no limits on overplotting:
    millions of items



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

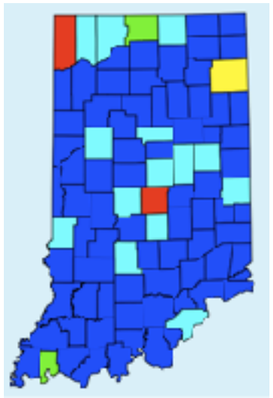
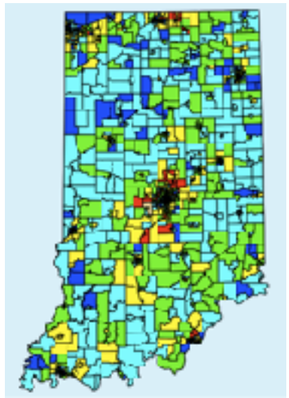
Spatial aggregation

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

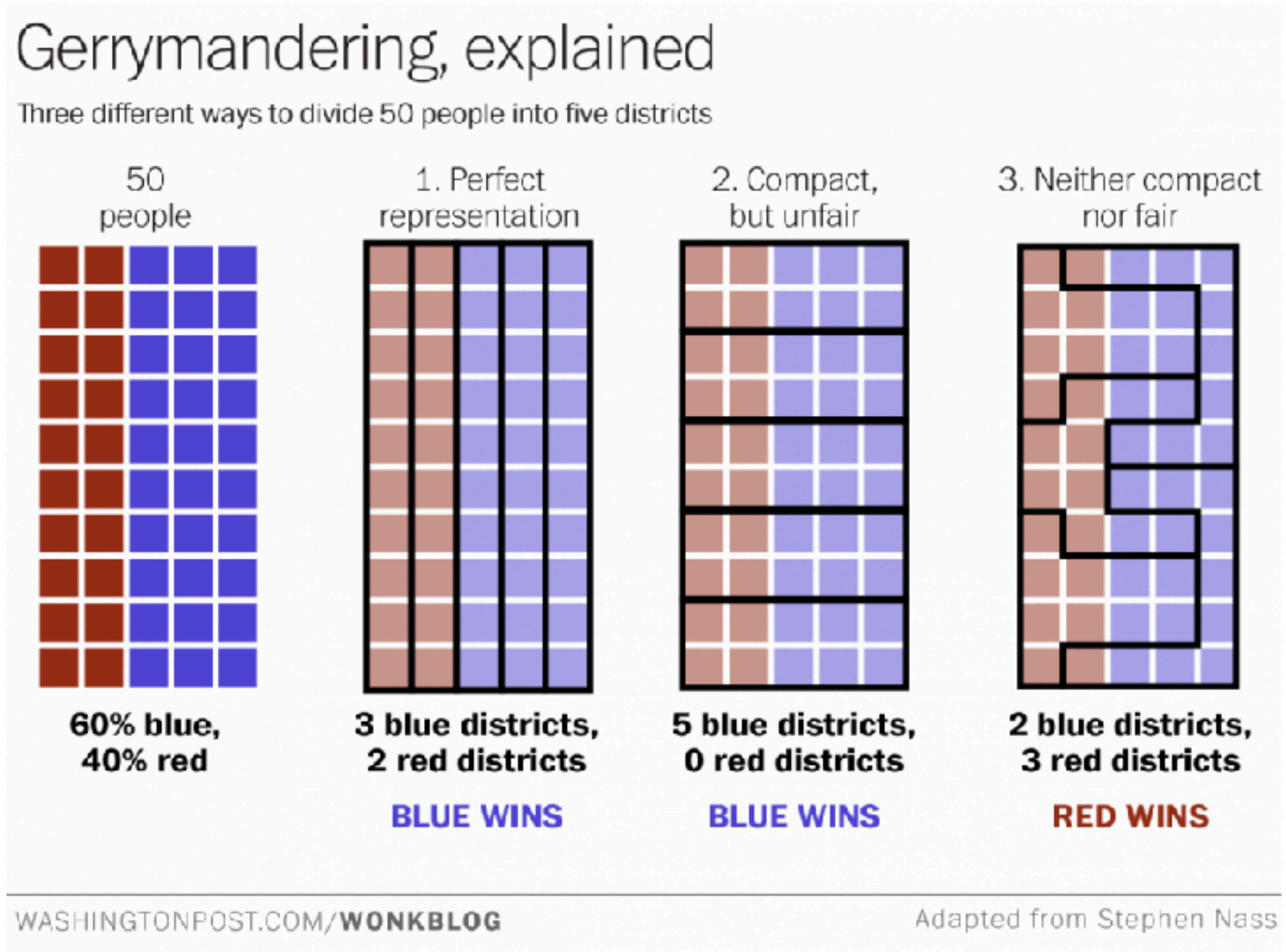
[http://www.e-education.psu/edu/geog486/l4_p7.html, Fig 4.cg.6]

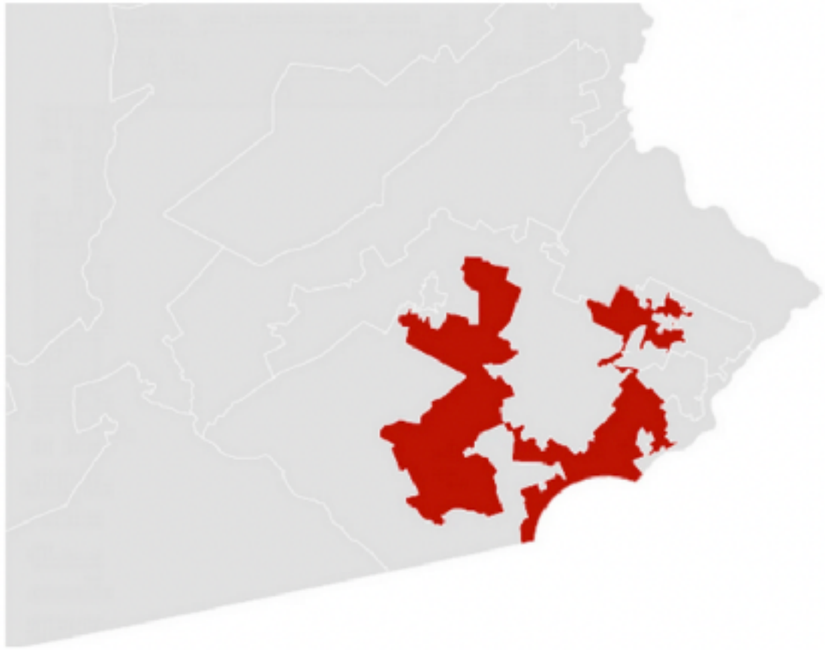
  - scale effects

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

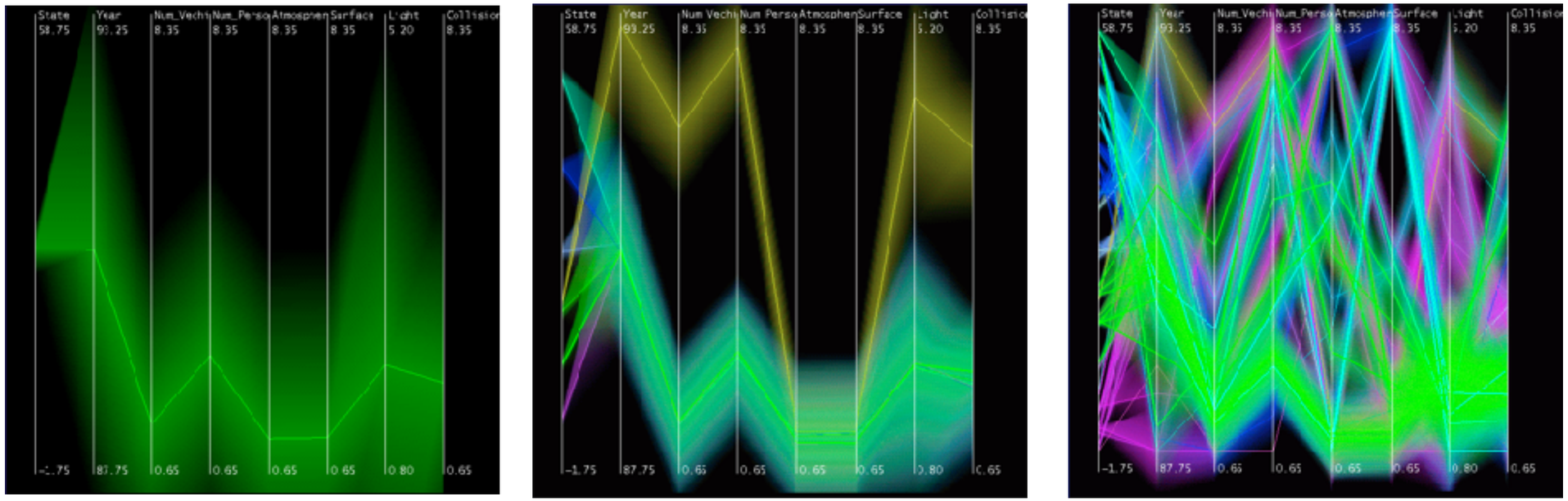
https://www.washingtonpost.com/news/wonk/wp/2015/03/01/this-is-the-best-explanation-of-gerrymandering-you-will-ever-see/

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**

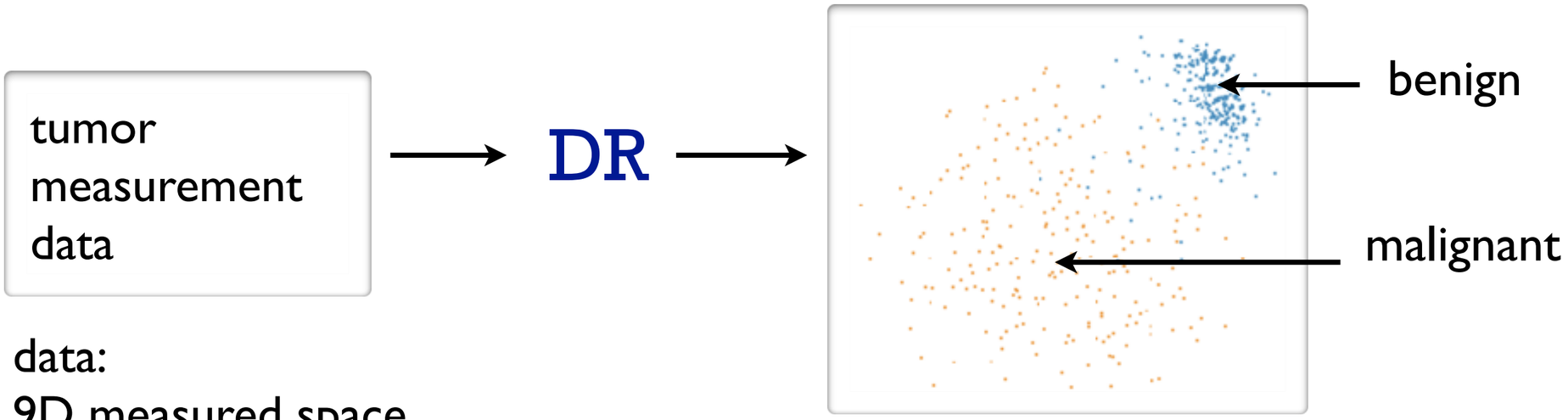
- dynamic item aggregation
- derived data: **cluster hierarchy**
- encoding:
  - cluster band with variable transparency, line at mean, width by min/max values
  - color by proximity in hierarchy



[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



data:
9D measured space

derived data:
2D target space

Idiom: **Dimensionality reduction for documents**

Task 1

In
HD data

Out
2D data

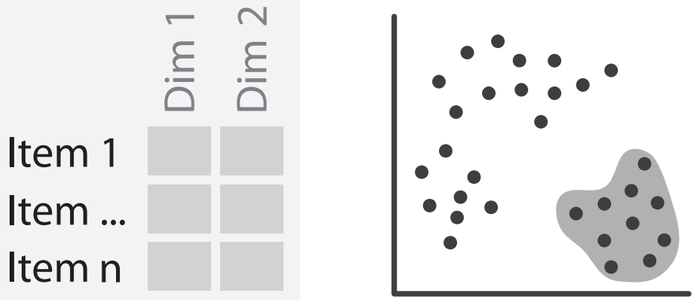
What?

- In High-dimensional data
- Out 2D data

Why?

- Produce
- Derive

Task 2



In
2D data

Out
Scatterplot
Clusters & points

What?

- In 2D data
- Out Scatterplot
- Out Clusters & points

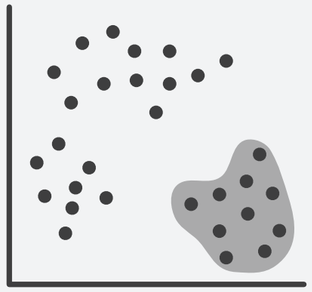
Why?

- Discover
- Explore
- Identify

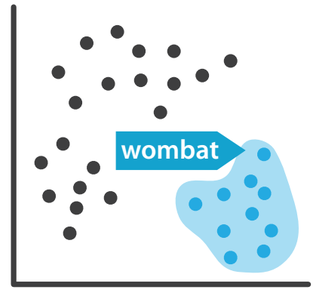
How?

- Encode
- Navigate
- Select

Task 3



In
Scatterplot
Clusters & points



Out
Labels for
clusters

What?

- In Scatterplot
- In Clusters & points
- Out Labels for clusters

Why?

- Produce
- Annotate

How?

Encode

Arrange

- Express
- Separate
- Order
- Align
- Use

Map

from categorical and ordered attributes

- Color
  - *Hue*
  - *Saturation*
  - *Luminance*
- Size, Angle, Curvature, ...
- Shape
- Motion

Direction, Rate, Frequency, ...

Manipulate

- Change
- Select
- Navigate

Facet

- Juxtapose
- Partition
- Superimpose

Reduce

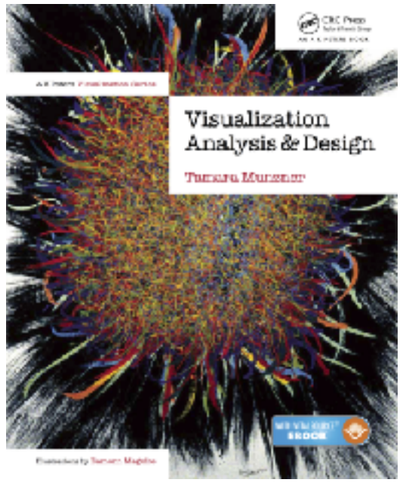
- Filter
- Aggregate
- Embed

What?

Why?

How?

Visualization Analysis & Design



Embed: Focus+Context (Ch 14)

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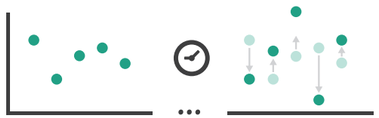
How to handle complexity: 4 strategies

→ *Derive*

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

Manipulate

→ Change



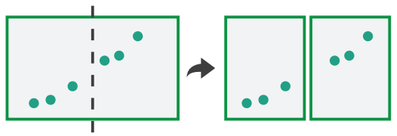
→ Select

→ Navigate

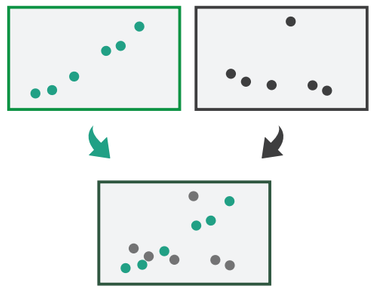
Facet

→ Juxtapose

→ Partition



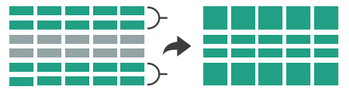
→ Superimpose



Reduce

→ Filter

→ Aggregate



→ Embed

Embed: Focus+Context

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

Embed: Focus+Context

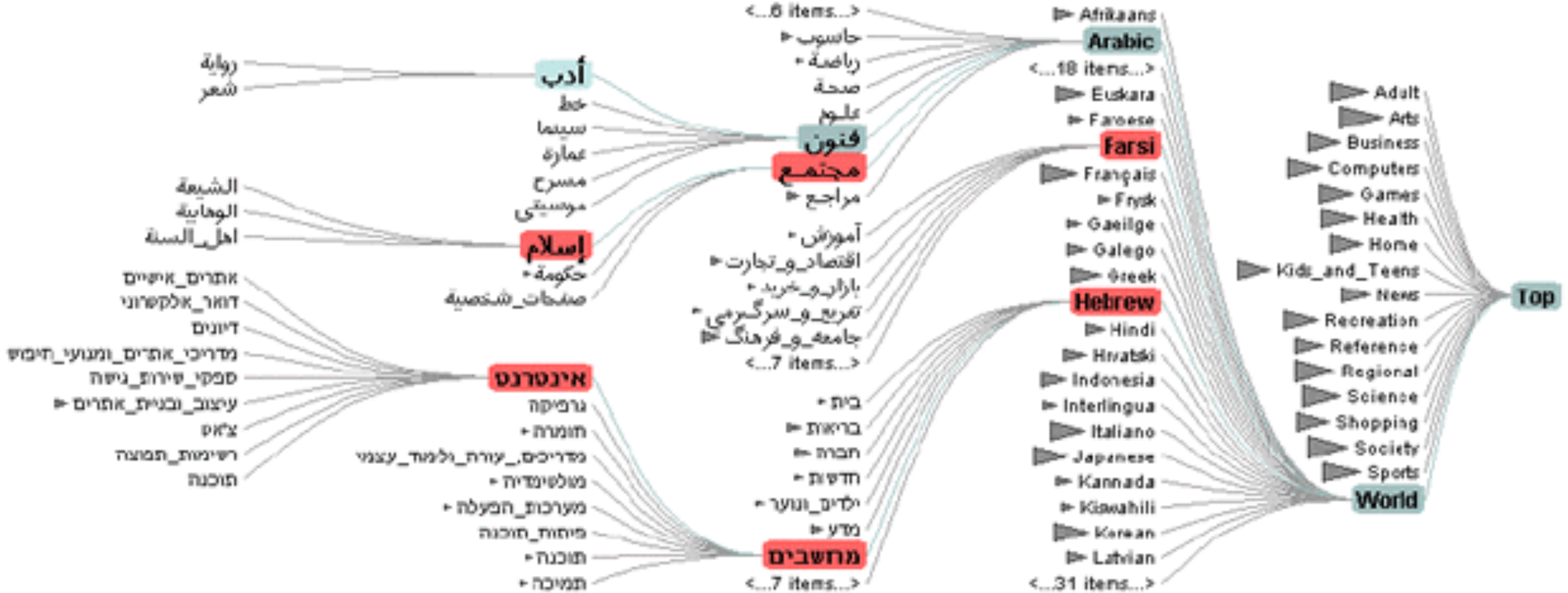
- combine focus + context info within single view
  - vs standard navigation within view
  - vs multiple views
- elide data
  - selectively filter and aggregate

➔ **Embed**

➔ Elide Data

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.]

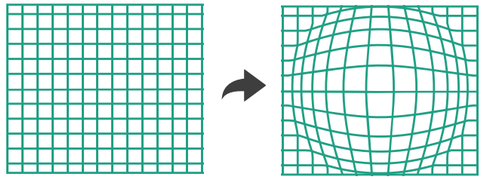
Embed: Focus+Context

- 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

➔ **Embed**

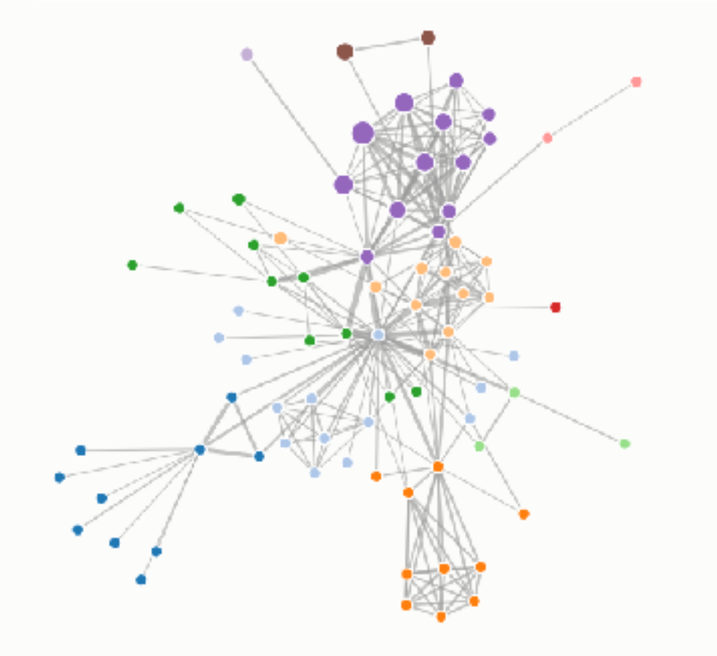
➔ Elide Data

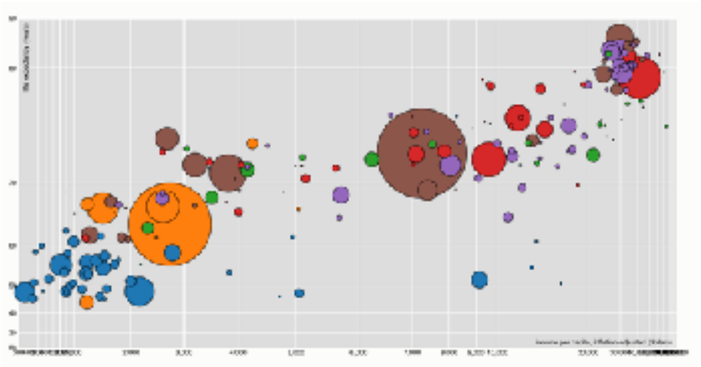
➔ Distort Geometry

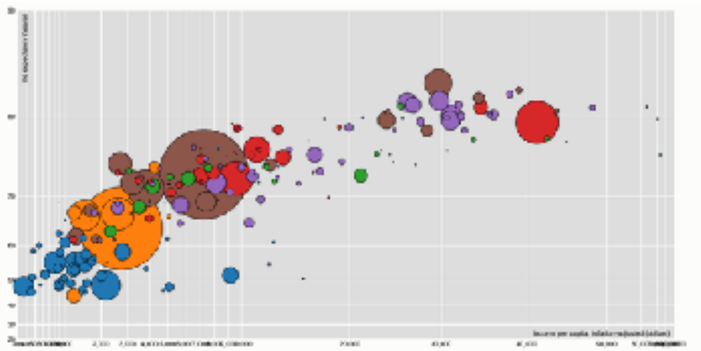


Idiom: **Fisheye Lens**

- 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/

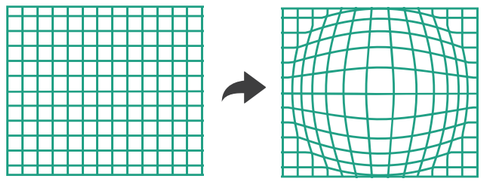
Embed: Focus+Context

- 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

Embed

→ Elide Data

→ Distort Geometry

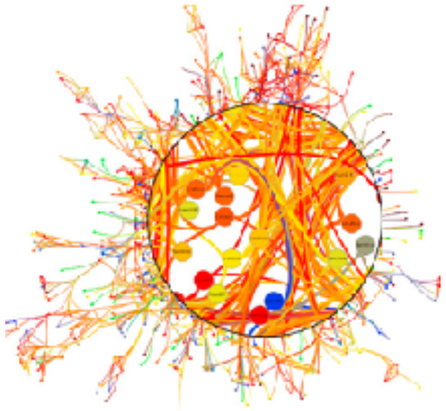


Distortion costs and benefits

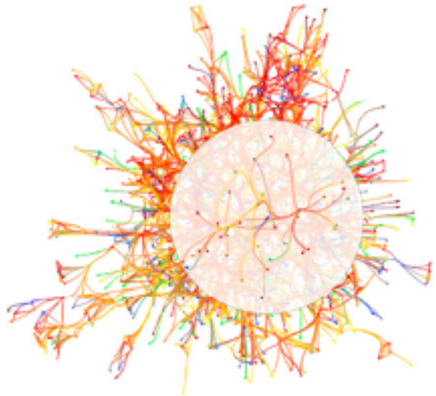
- benefits
  - combine focus and context information in single view
- costs
  - length comparisons impaired
    - topology comparisons unaffected: connection, containment
  - effects of distortion unclear if original structure unfamiliar
  - object constancy/tracking may be impaired

fisheye lens

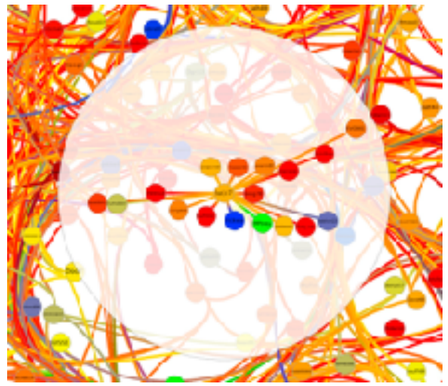
magnifying lens



neighborhood layering



Bring and Go



[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

Arrange

- Express
- Separate
- Order
- Align
- Use

Map

from categorical and ordered attributes

- Color
  - *Hue*
  - *Saturation*
  - *Luminance*
- Size, Angle, Curvature, ...
- Shape
- Motion

Direction, Rate, Frequency, ...

Manipulate

Change

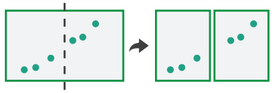
Select

Navigate

Facet

Juxtapose

Partition



Superimpose

Reduce

Filter

Aggregate

Embed