Data Visualization

Interaction in Data Viz

M126 | Maria Roussou

Why do we need interaction (in general)?

- Interaction amplifies cognition
  - We understand things better if we can “touch” them, if we can observe cause and effect
  - It helps the user answer a multitude of questions, which cannot be answered just by looking at a single chart

- Interaction feeds motivation
  - We are more likely to explore if we are able to do something ourselves rather than just look

Why do we need interaction (in data viz)?

- Too much data to show in one view
- Too complex data to show at once
  - giving a sense of the complexity of the data
  - explore data with different representations
- Different audiences with different questions
- Active learning, increase involvement

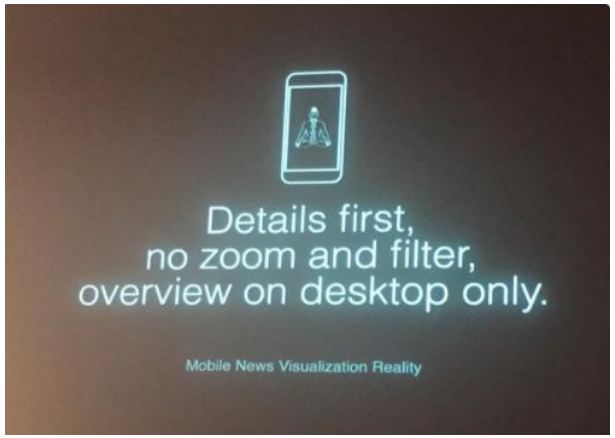
- Flexible, powerful, intuitive
  - exploratory data analysis: change as you go during the analysis process
  - fluid task switching: different visual encodings support different tasks
- Animated transitions provide excellent support
  - empirical evidence that animated transitions help people stay oriented

Issues with interaction (in general and in data viz)

- Takes time to learn
- Takes time to use
- Getting lost
  - remembering previous state imposes cognitive load (hard to compare visible item to memory of what you saw)
  - maintaining context/orientation when navigating
  - tracking complex changes during animation
- Controls may take screen real estate
  - or invisible functionality may be difficult to discover (lack of affordances)
- Users may not interact as planned by designer
  - NYTimes logs show ~90% don't interact beyond scrollytelling (Aisch, 2016) – see next slide

Challenges with various interaction display

- What do we design for?
  - mouse & keyboard on desktop?
    - large screens, hover, multiple clicks
  - touch interaction on mobile?
    - small screens, no hover, just tap
  - gestures from video / sensors?
    - ergonomic reality vs movie bombast
  - eye tracking?



Data visualization and the news - Gregor Aisch (37 min)

I Hate Tom Cruise – Alex Kauffmann (5 min)

slide by Tamara Munzner, inspired by: Alexander Lex, Utah

Shneiderman's Visual Information-Seeking Mantra

Overview first,

zoom and filter,

then details-on-demand.

Shneiderman, 1996

What are you trying to do with data viz?

- Reveal patterns
- Provide context
- Compare scales
- Describe geography

Let people look up stuff

Amanda Cox, Visualizing data at the NY Times

See also *Talk to the Newsroom: Interactive News Collaborative*

Interaction

Interaction techniques for information visualisation are essentially a form of selection, selecting a subset of objects.

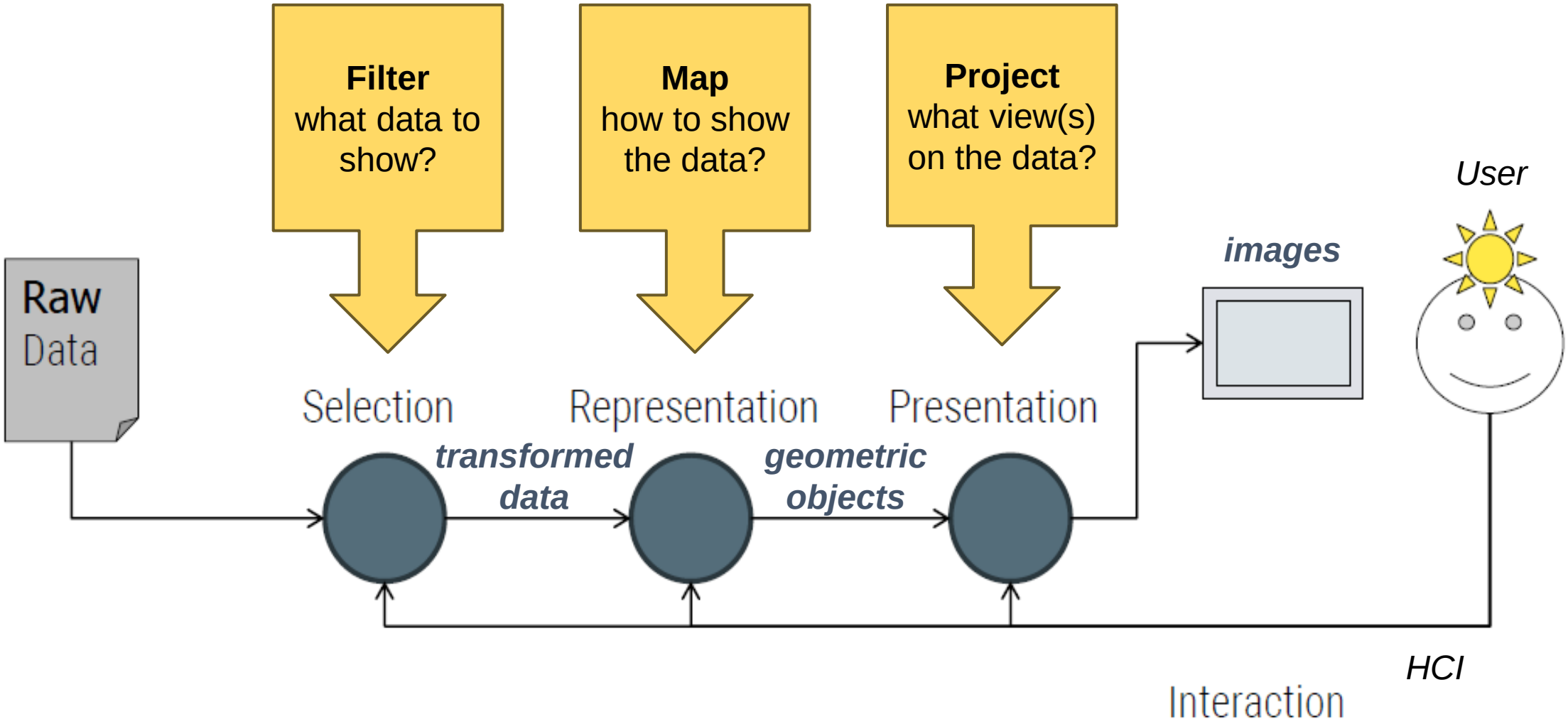
This allows them to be used to locate data, to reveal patterns in data, or to select the arguments of other transformations.

Shneiderman's Visual Information-Seeking Mantra

Overview first,
zoom and filter,
then details-on- demand.

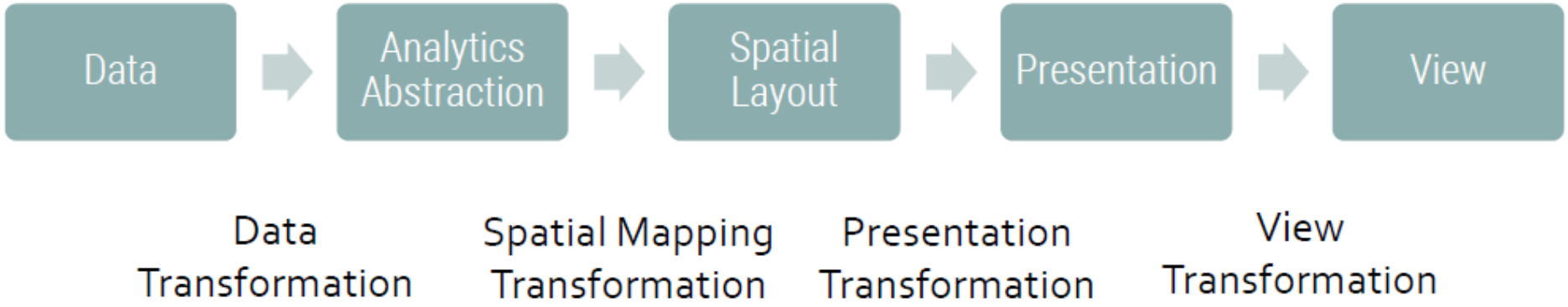
- Overview: Gain an overview of the entire collection.
- Zoom: Zoom in on items of interest
- Filter: filter out uninteresting items.
- Details-on-demand: Select an item or group and get details when needed.
- Relate: View relationships among items.
- History: Keep a history of actions to support undo, replay, and progressive refinement.
- Extract: Allow extraction of sub-collections and of the query parameters

Visualization pipeline



The Visualization Pipeline (Spence, 2000)

Visualization Reference Model



Visualization Reference Model (Card et al.)

(also a pipeline but a bit more expanded)

Types of Interactive Visual Representations

- Static representations
  - don’t allow users to perform any type of interaction, and only a single, unmodifiable view is generated
- Transformable representations
  - allow users to manipulate, in the preprocessing phase, the input data of the representations, e.g. through data filtering.
  - These manipulations usually influence and modify the images that are generated.
- Manipulable representations
  - allow users to manipulate the process that generates the view, via zooming, rotation, panning, etc.

Types of interaction (Card et al., 1999)

- Interaction with data transformations
- Interaction with the type of graphic representation
- Interaction with the geometric transformations

Table 1: Interaction techniques (Card et al., 1999).

Modifies Data Transformation	Modifies Statistical Transformations	Modifies View Transformation
Dynamic queries	Dataflow	Direct selection
Direct walk	Pivot tables	Camera movement
Details-on-demand		Magic lens
Attribute walk		Overview + detail
Brushing		Zoom & pan
Direct manipulation		

Interaction taxonomy (categories)

- Indicate: show me where I am pointing at
- Select: mark something as interesting
- Explore: show me something else
- Reconfigure: show me a different arrangement
- Encode: show me a different representation
- Abstract/Elaborate: show me more or less detail
- Filter: show me something conditionally
- Connect: show me related items
- Activate: trigger action
- Modify: manipulate elements

Soo Yi et al. (2007) & Raskin (2000)

Interaction taxonomy (Munzner)

- How to handle complexity: 1 + 3 strategies

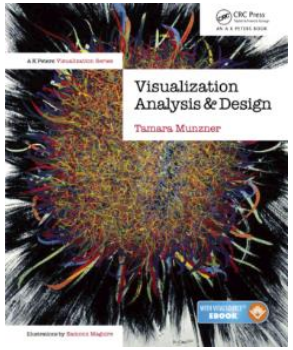
derive new data to show within view

change view over time

facet across multiple views

reduce items/attributes within single view

➔ *Derive*



Tamara Munzner

Manipulate

- Change

- Select

- Navigate

Facet

- Juxtapose

- Partition

- Superimpose

Reduce

- Filter

- Aggregate

- Embed

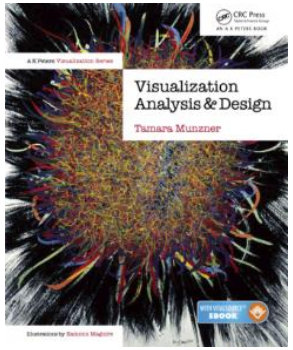
slide by Tamara Munzner

Interaction taxonomy (Munzner)

- How to handle complexity: 1 + 3 strategies

derive new data to show within view

→ *Derive*



Tamara Munzner

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slide by Tamara Munzner

Interaction taxonomy (Munzner)

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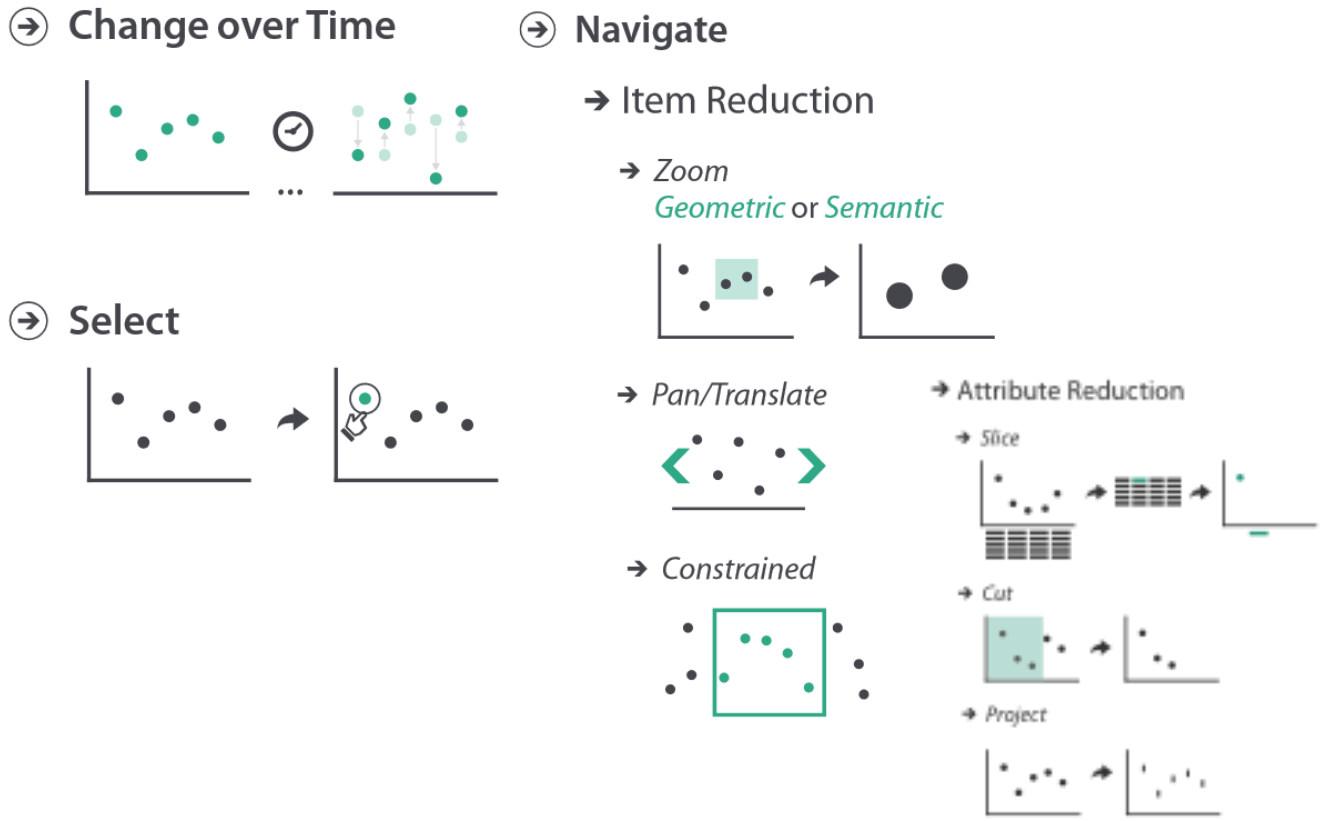

Manipulate > Change over time

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

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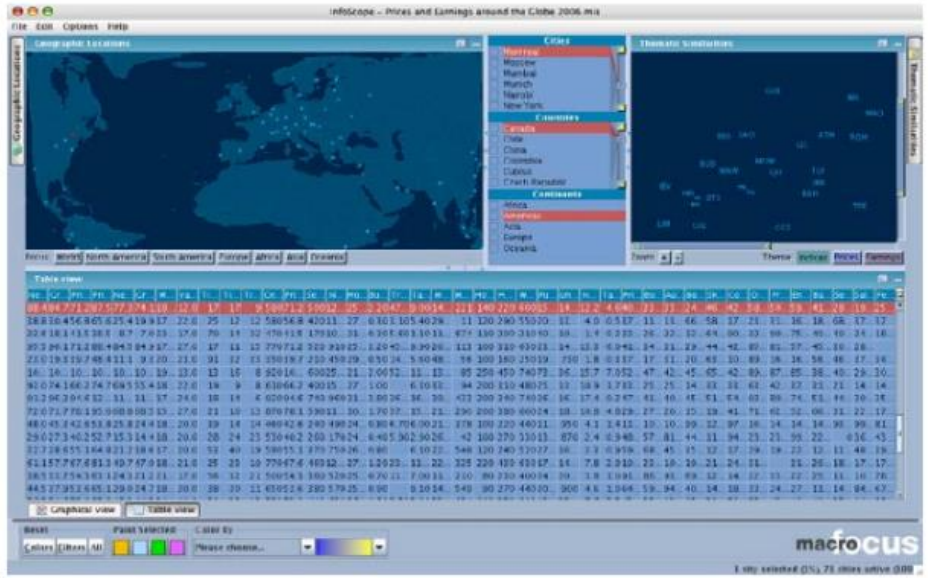
Manipulate > Change: Re-encode

- Change representation
  - e.g., from histogram to scatterplot



InfoScope https://infoscope.informer.com/

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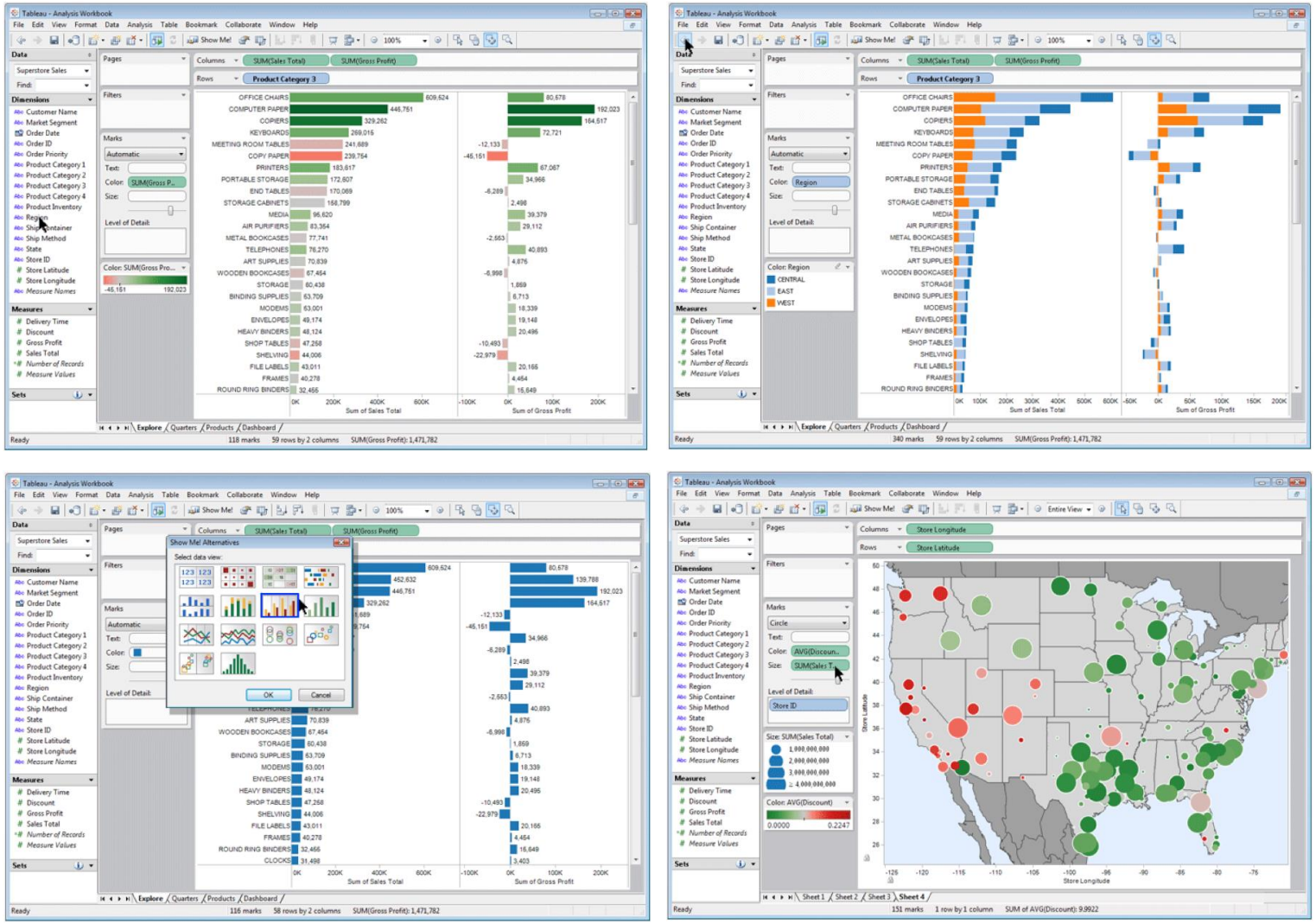
Manipulate > Change: Re-encode



made using Tableau

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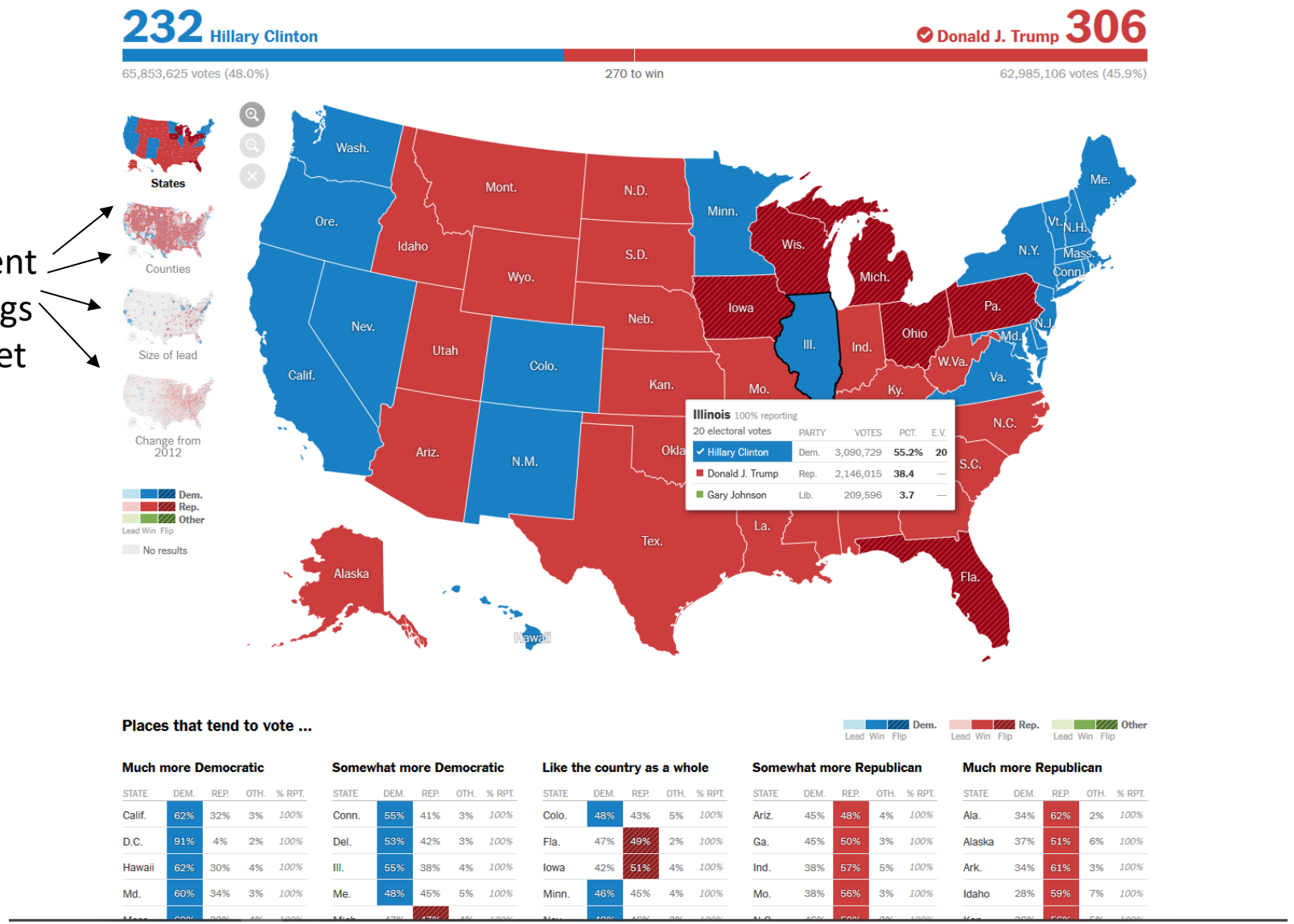
Manipulate > Change: Re-encode

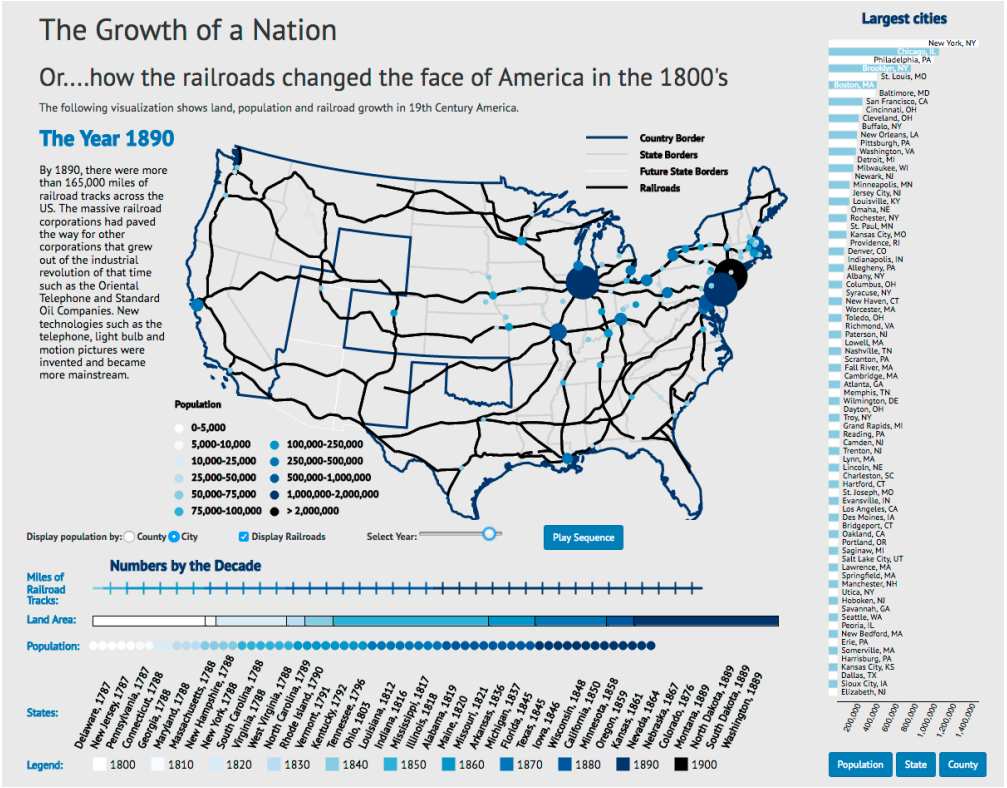
Choose different visual encodings of same dataset



NY Times Interactive

Manipulate > Change: Change parameters

- widgets and controls
  - sliders, buttons, radio buttons, checkboxes, dropdowns/comboboxes
- pros
  - clear affordances, self-documenting (with labels)
- cons
  - uses screen space
- design choices
  - separated vs interleaved
    - controls & canvas

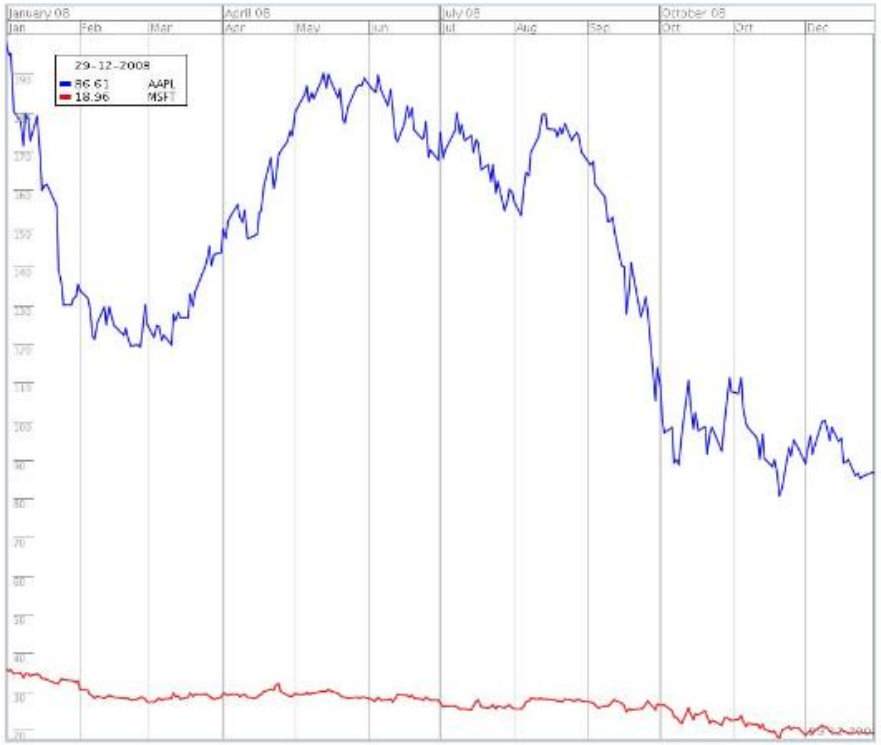


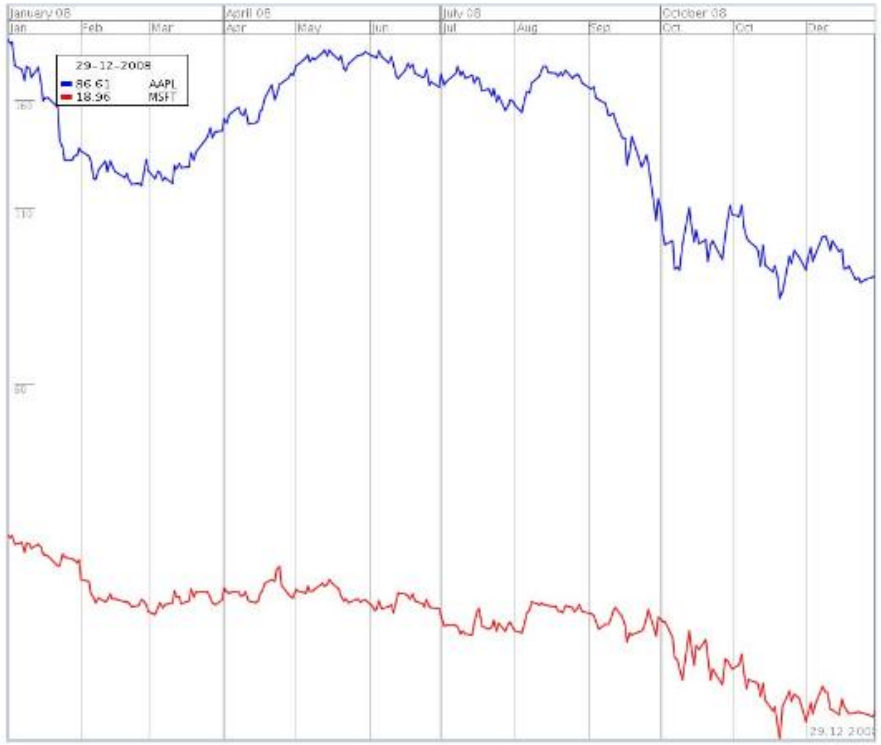
Growth of a Nation http://laurenwood.github.io/

slide by Tamara Munzner, inspired by: Alexander Lex, Utah

Manipulate > Change: Change order/arrangement

- Reconfigure to show a different arrangement
  - e.g., move view position, sorting items in a table, switch scale on axes





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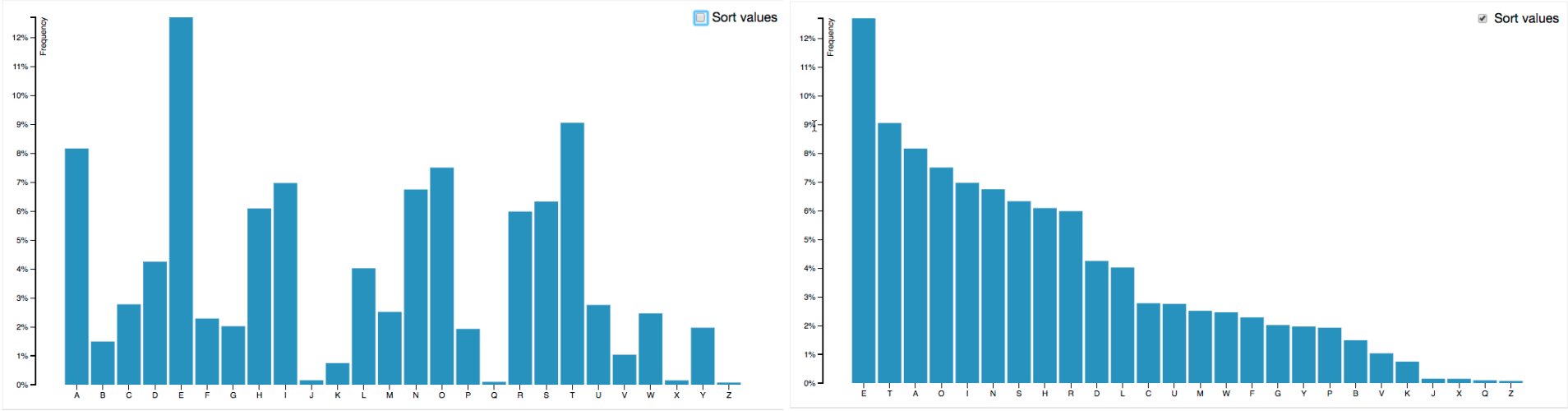
Manipulate > Change: Change order/arrangement

- Reconfigure to show a different arrangement
  - e.g. data-driven reordering of a simple table to find extreme values, trends



Sortable Bar Chart, https://bl.ocks.org/mbostock/3885705

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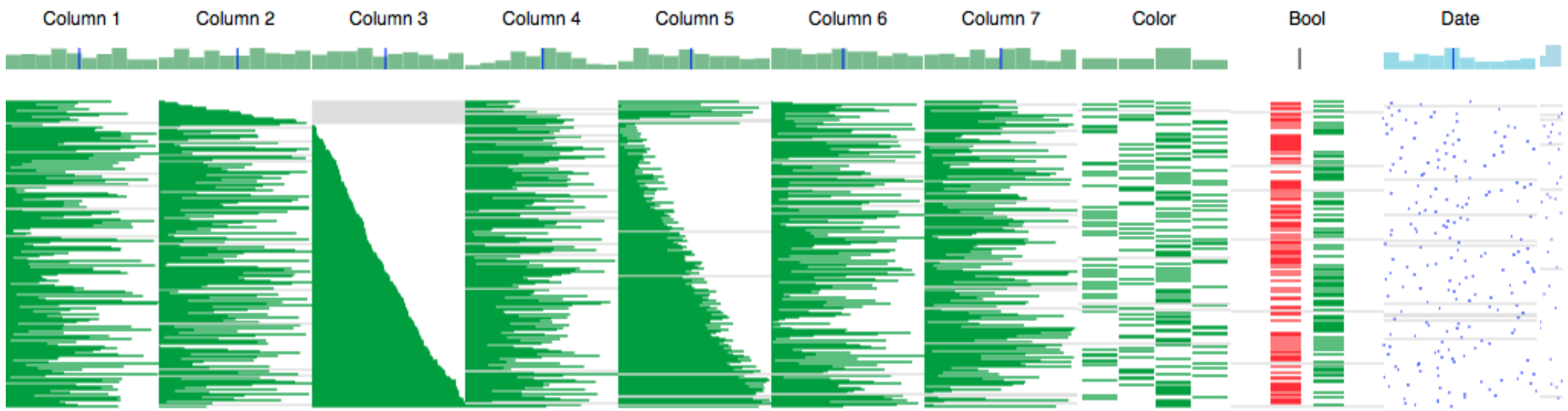
Manipulate > Change: Reorder

- table with many attributes
- how: data-driven reordering by selecting column
- why: find correlations between attributes



DataStripes, http://carlmanaster.github.io/datastripes/

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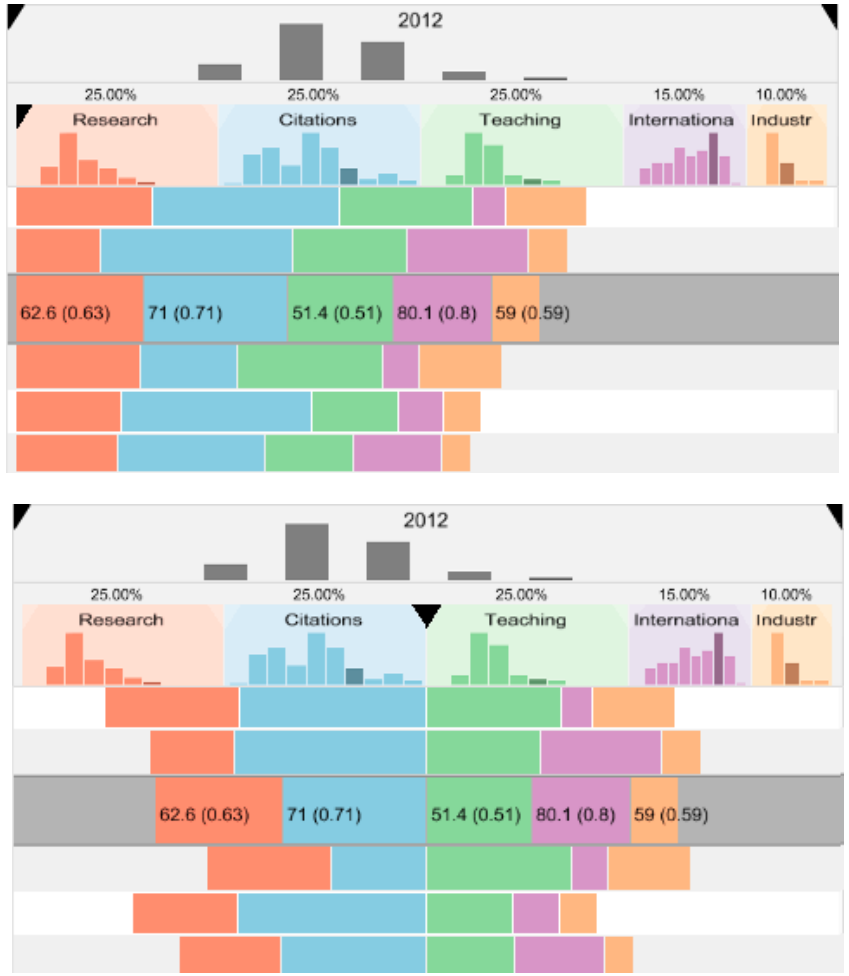
Manipulate > Change: Change alignment

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



Gratzlet al. LineUp: visual analysis of multi-attribute rankings, 2013

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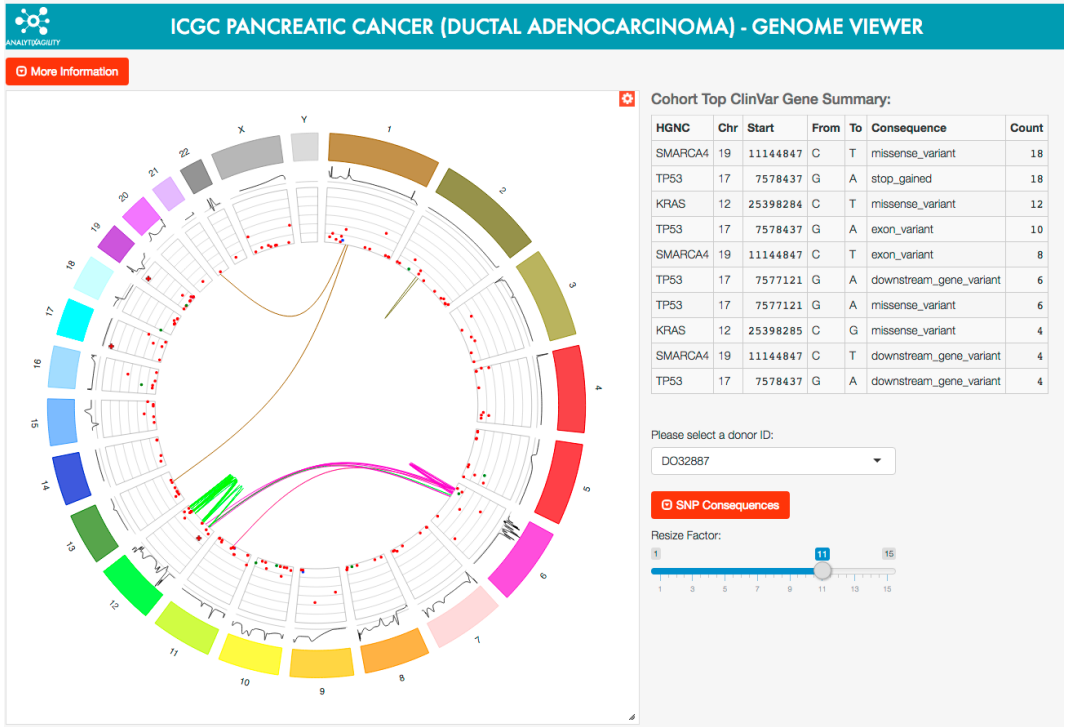
Manipulate > Change

- APGI genome browser (tooling: R/Shiny)
  - tooltip detail on demand on hover
  - expand/contract chromosomes
  - expand/contract control panes



https://gallery.shinyapps.io/genome_browser/

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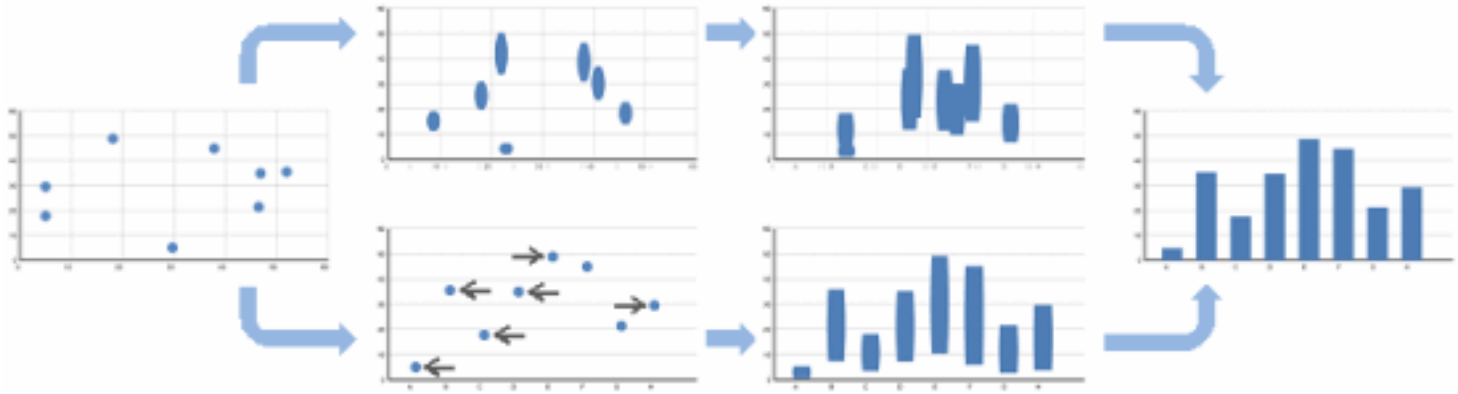
Manipulate > Change: Animated transitions

- smooth interpolation from one state to another
  - alternative to jump cuts, supports item tracking best case for animation
  - staging to reduce cognitive load
- example: animated transitions in statistical data graphics



Animated Transitions in Statistical Data Graphics. Heer and Robertson. IEEE TVCG (Proc InfoVis 2007) 13(6):1240-1247, 2007

slide by Tamara Munzner

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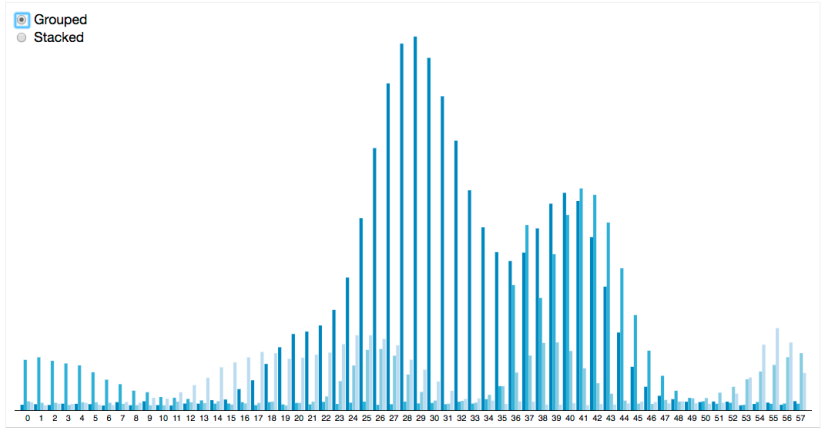
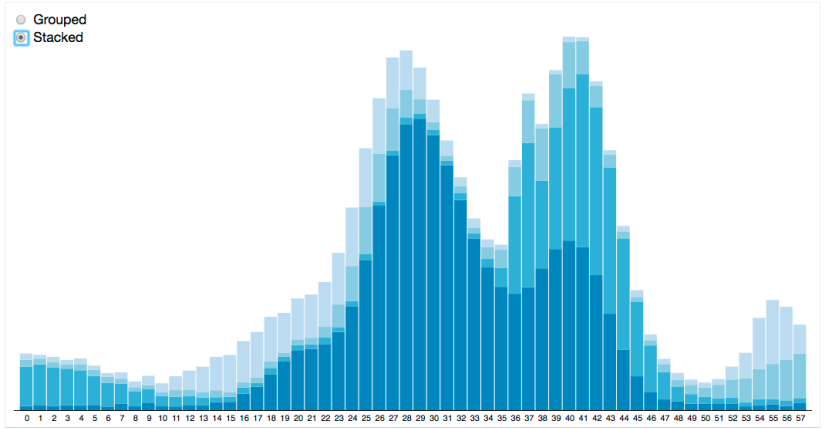


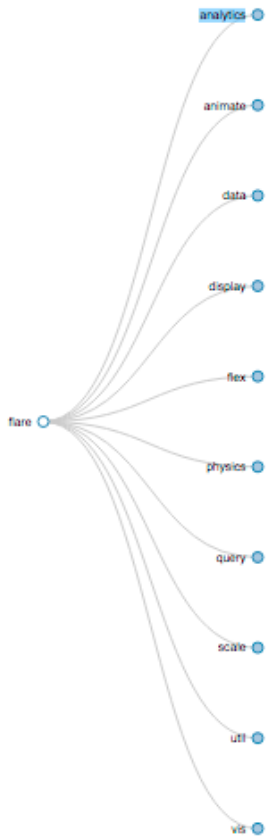


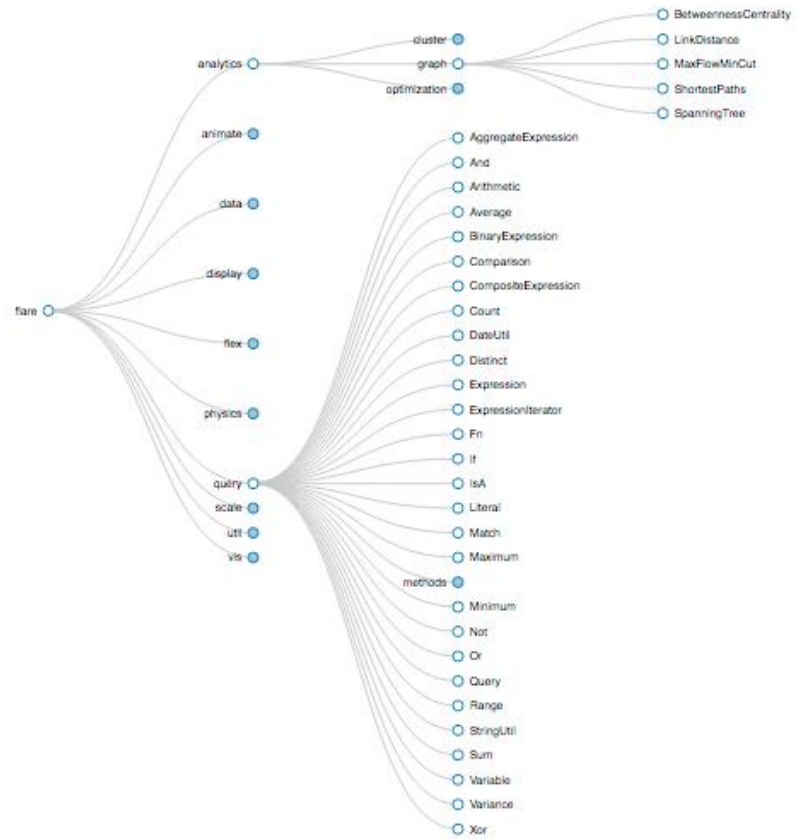
Stacked to Grouped Bars *http://bl.ocks.org/mbostock/3943967*

slide by Tamara Munzner

Manipulate > Change: Animated transition - tree detail

- animated transition
  - network drilldown/rollup



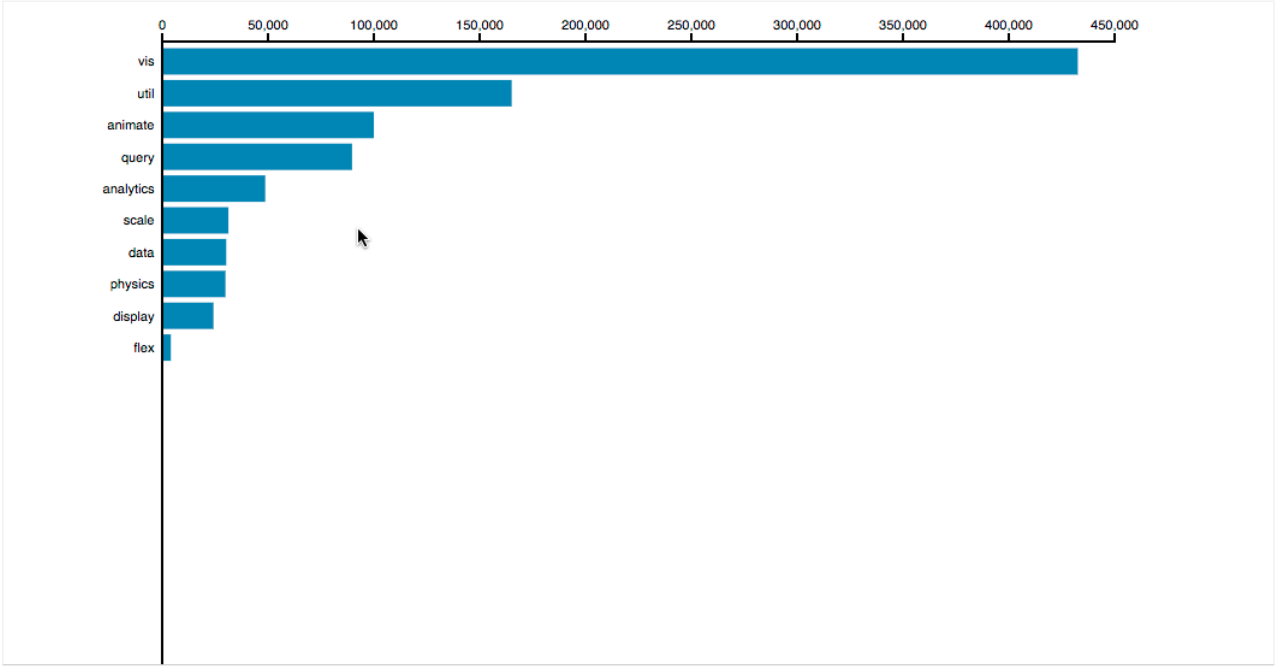


Collapsible Treehttps://bl.ocks.org/mbostock/4339083

slide by Tamara Munzner

Manipulate > Change: Animated transition - bar detail

- example: hierarchical bar chart
  - add detail during transition to new level of detail



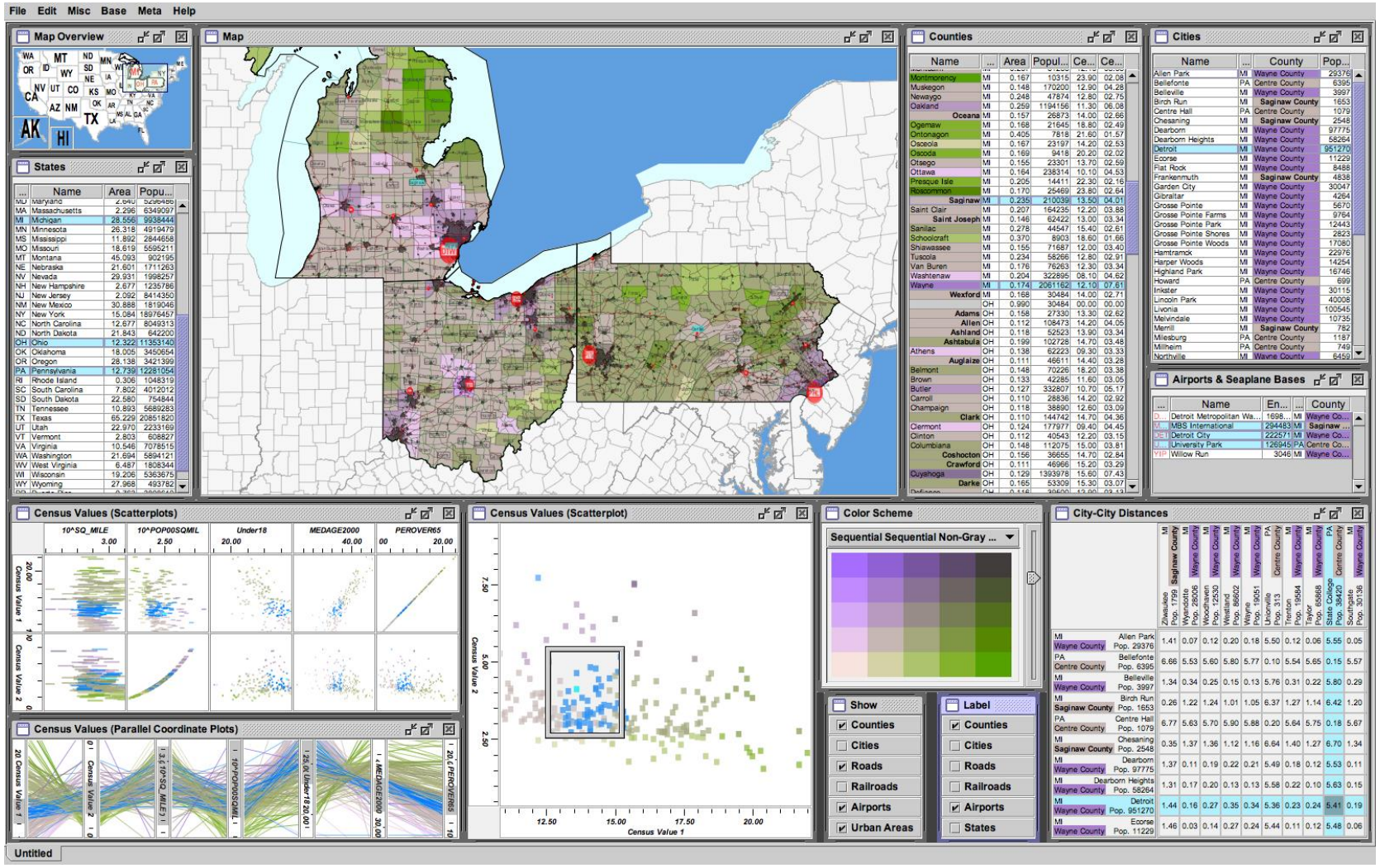
Hierarchical Bar Chart https://bl.ocks.org/mbostock/1283663

slide by Tamara Munzner

Manipulate > Change: multiple views

- Linked views, multiple views, coordinated views, coupled views
- Vary:
  - what is shown
  - how it is shown
- per view

Manipulate > Change: multiple, coordinated views



Chris Weaver. “Patterns of Coordination in Improvise Visualizations”. *Proc. of the IS&T/SPIE Conf. on Visualization and Data Analysis*, San Jose, CA, January 2007.

Manipulate > Change: multiple views

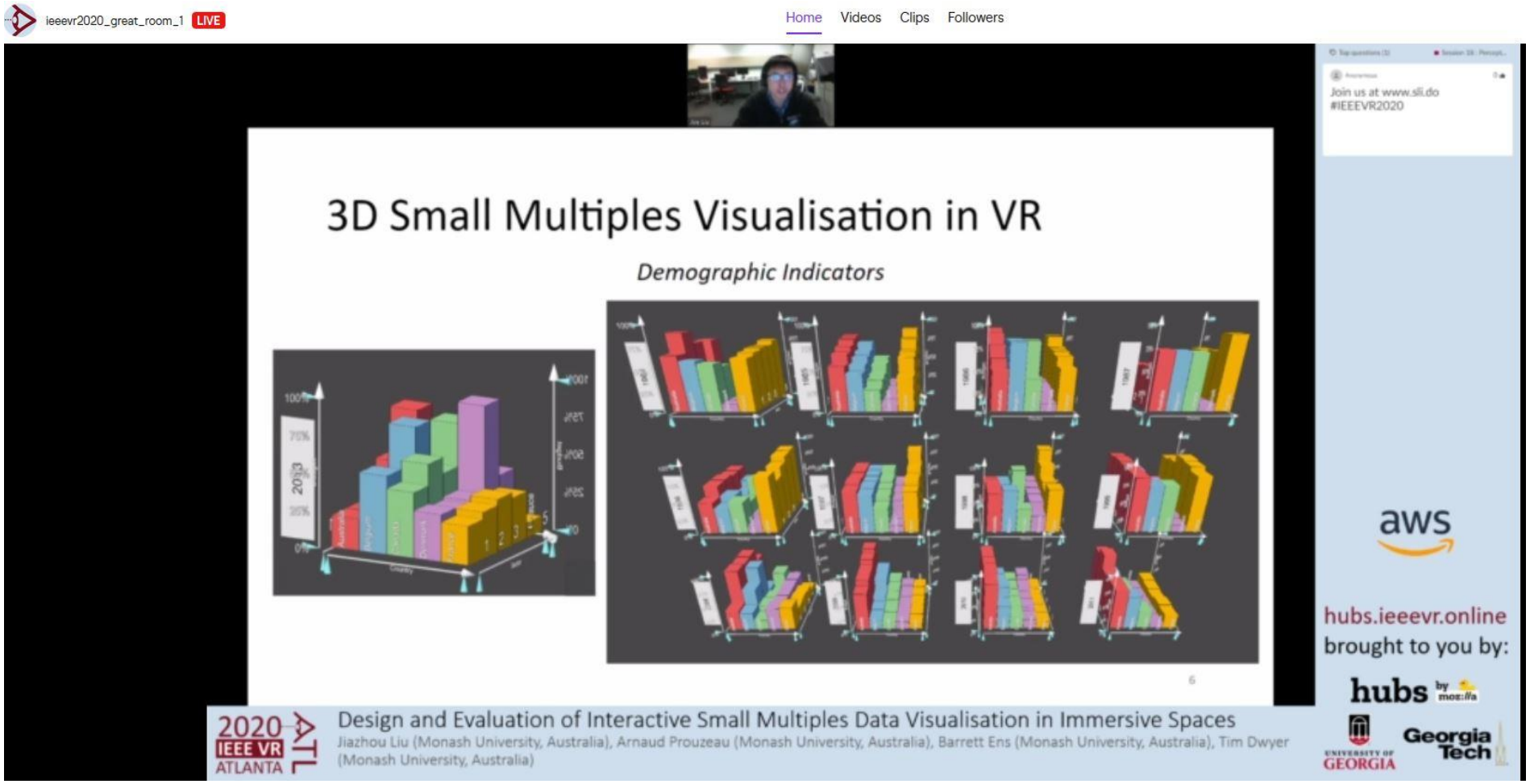
- Small multiples: same visual encoding, shared navigation

Jim Vallandingham

http://vallandingham.me/small_mults_talk/

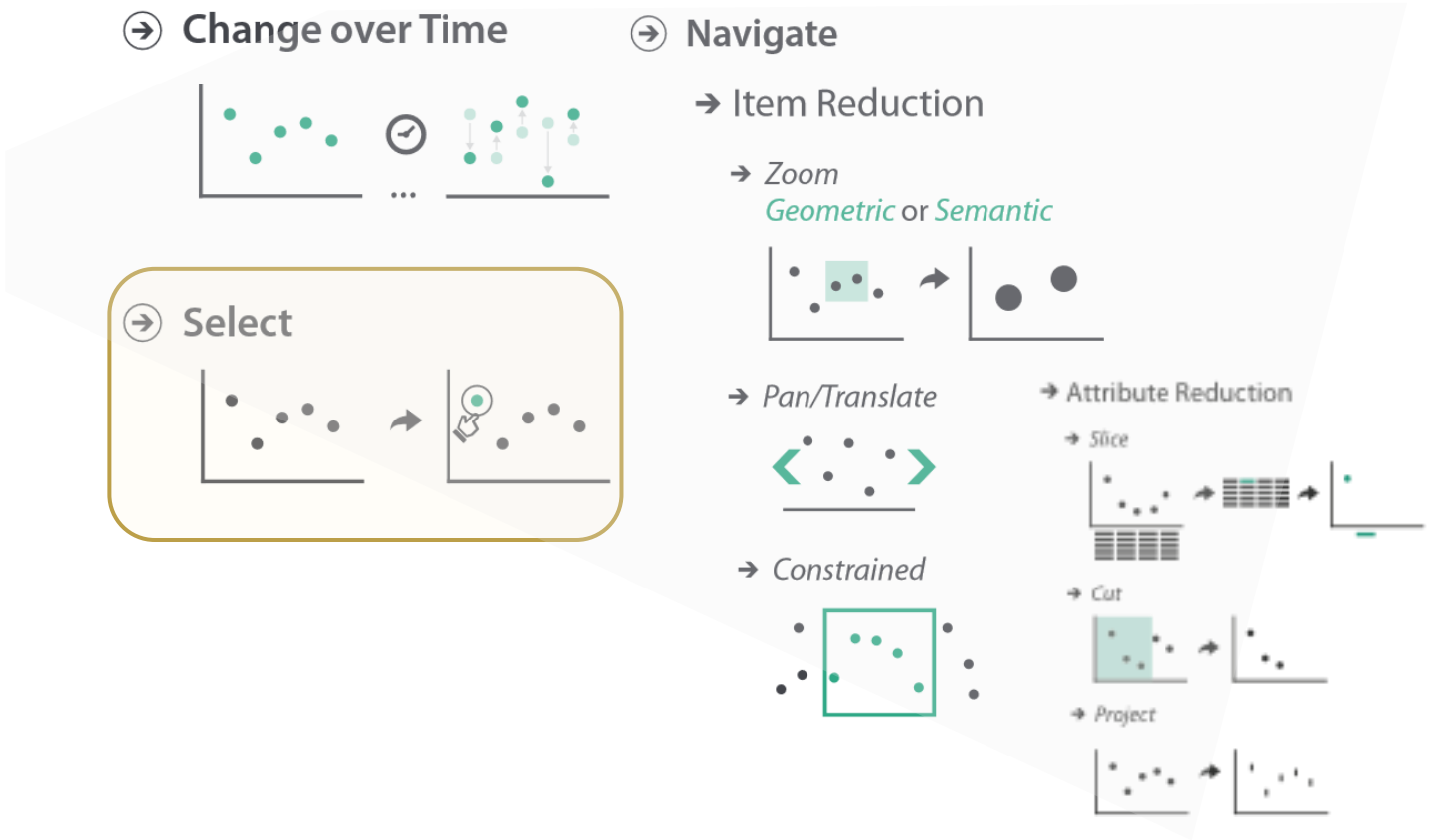
Manipulate > Change: multiple views

- Small multiples: same visual encoding, shared navigation



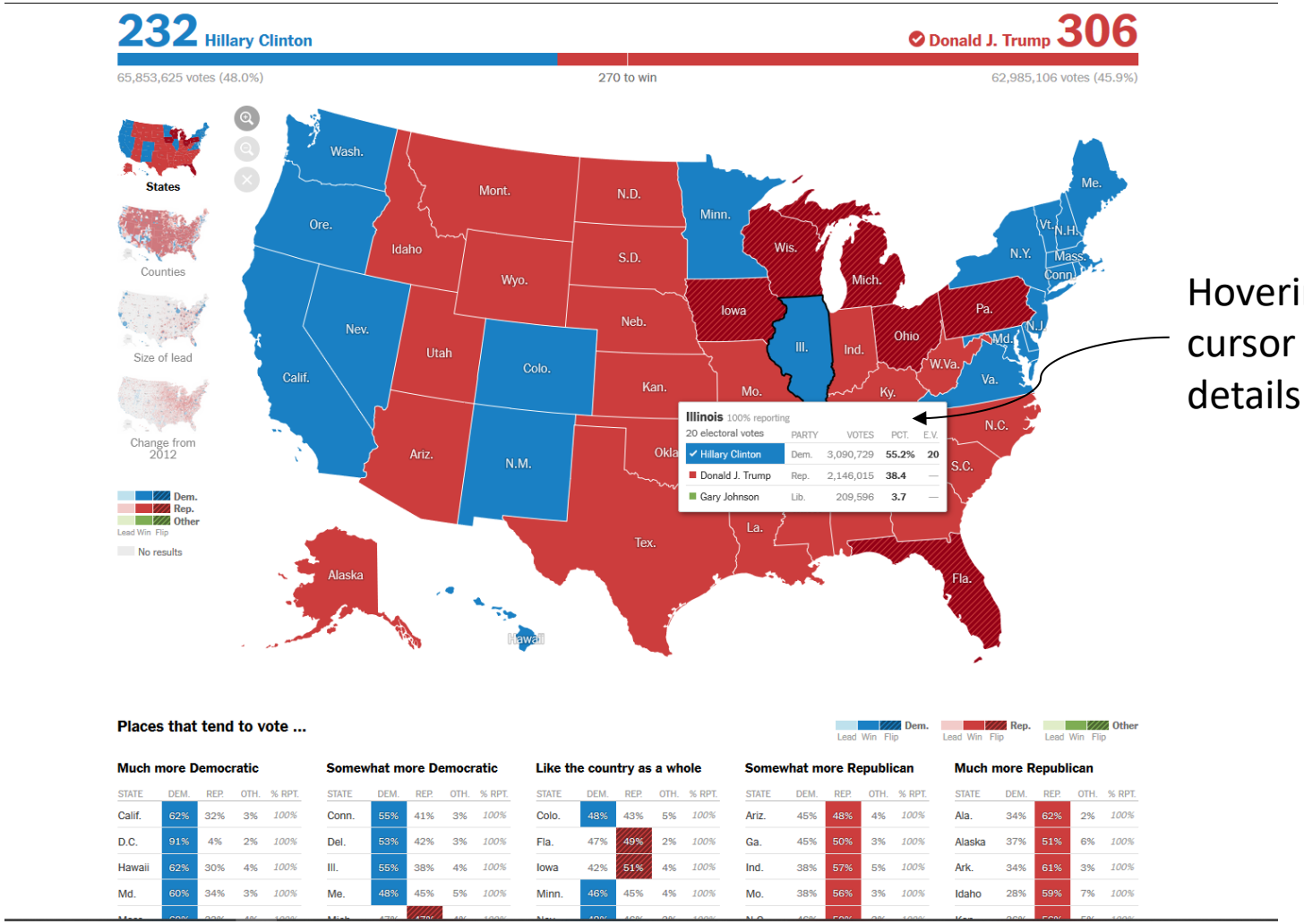
Interaction taxonomy (Munzner)

- **Manipulate**
  - Change
  - **Select**
  - Navigate
- Facet
  - Juxtapose
  - Partition
  - Superimpose
- Reduce
  - Filter
  - Aggregate
  - Embed



Indicate (show me where I am pointing at)

- Visual Feedback, pop-up tooltips (mouse over)



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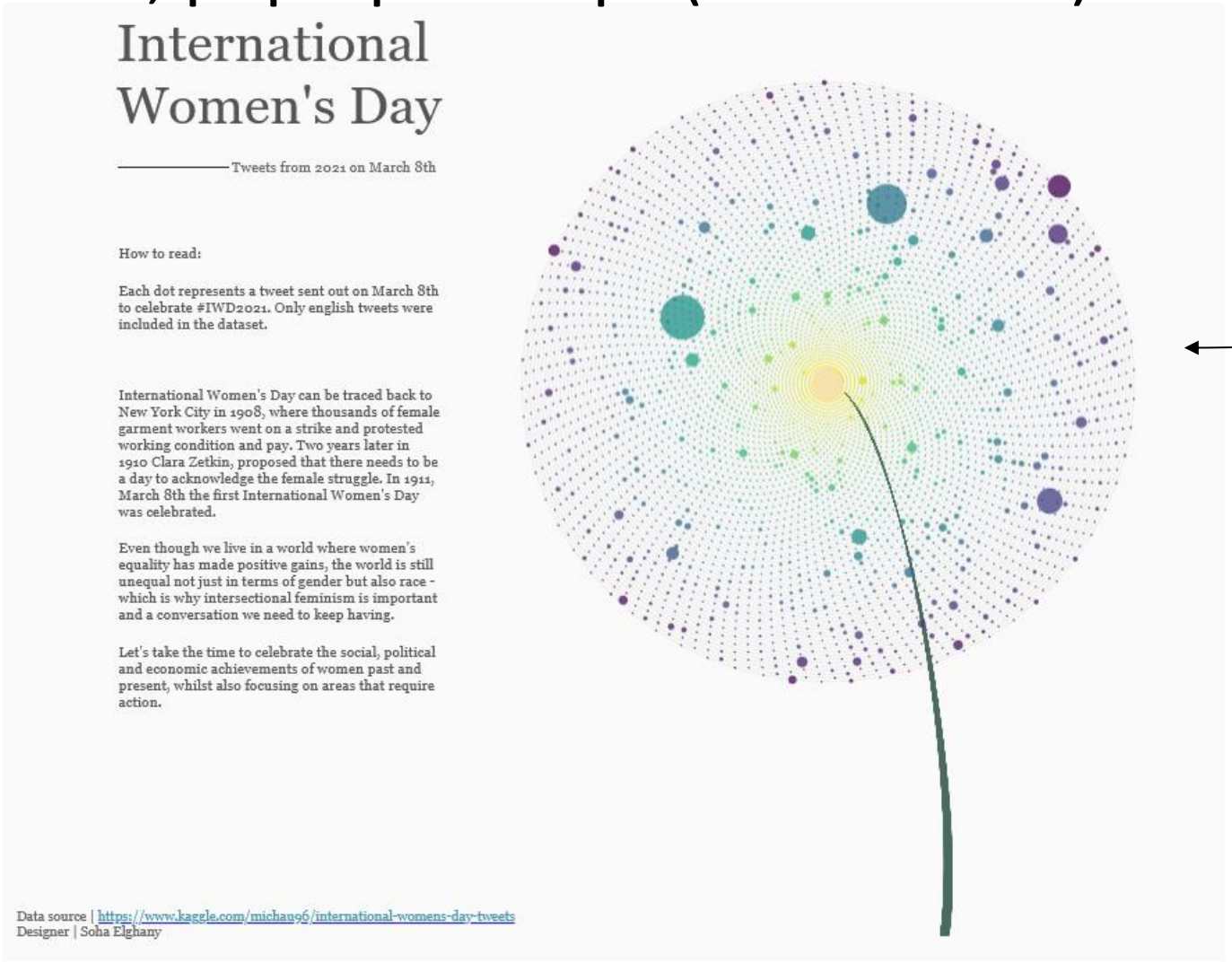

Hovering mouse cursor over each dot brings up details of item

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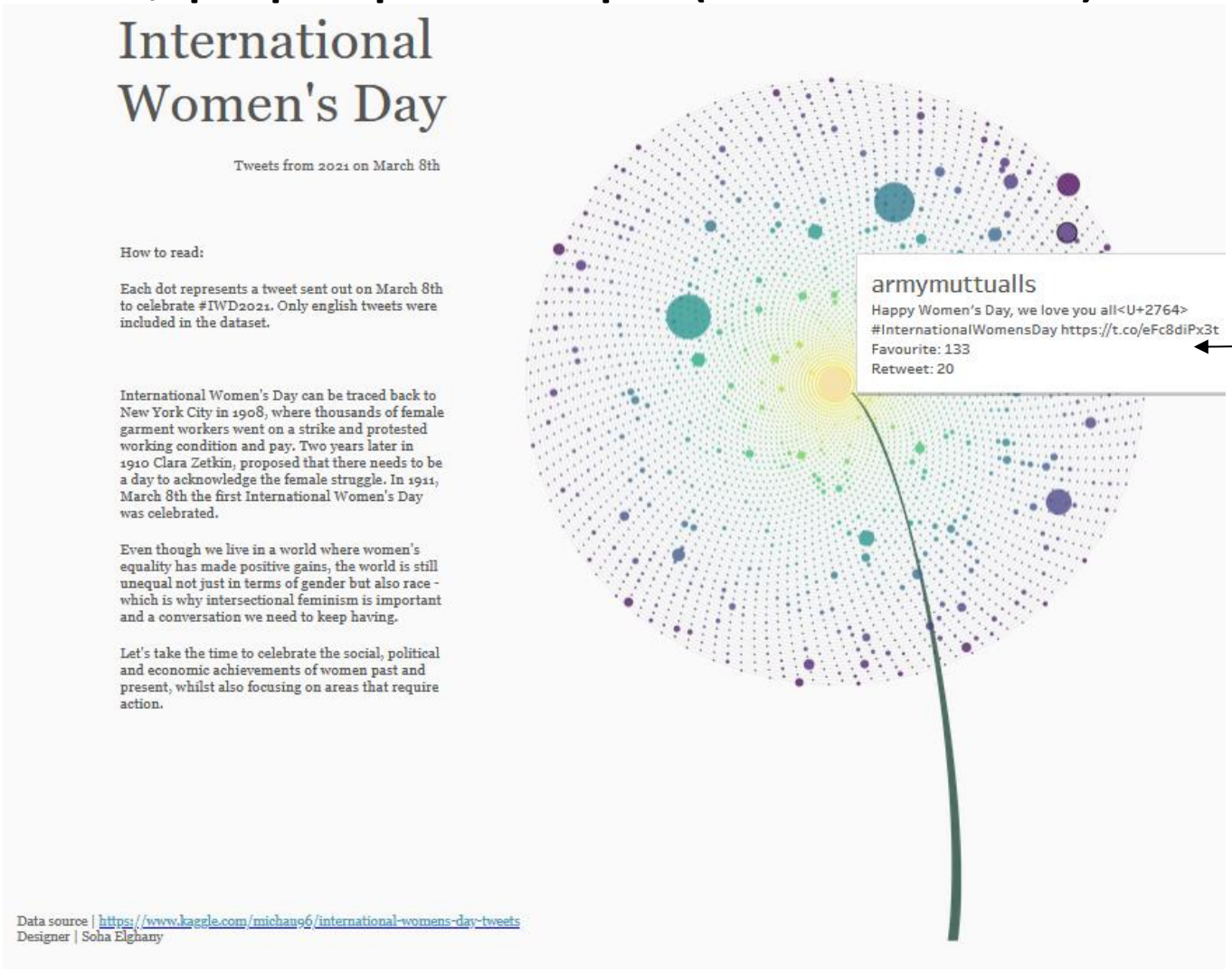
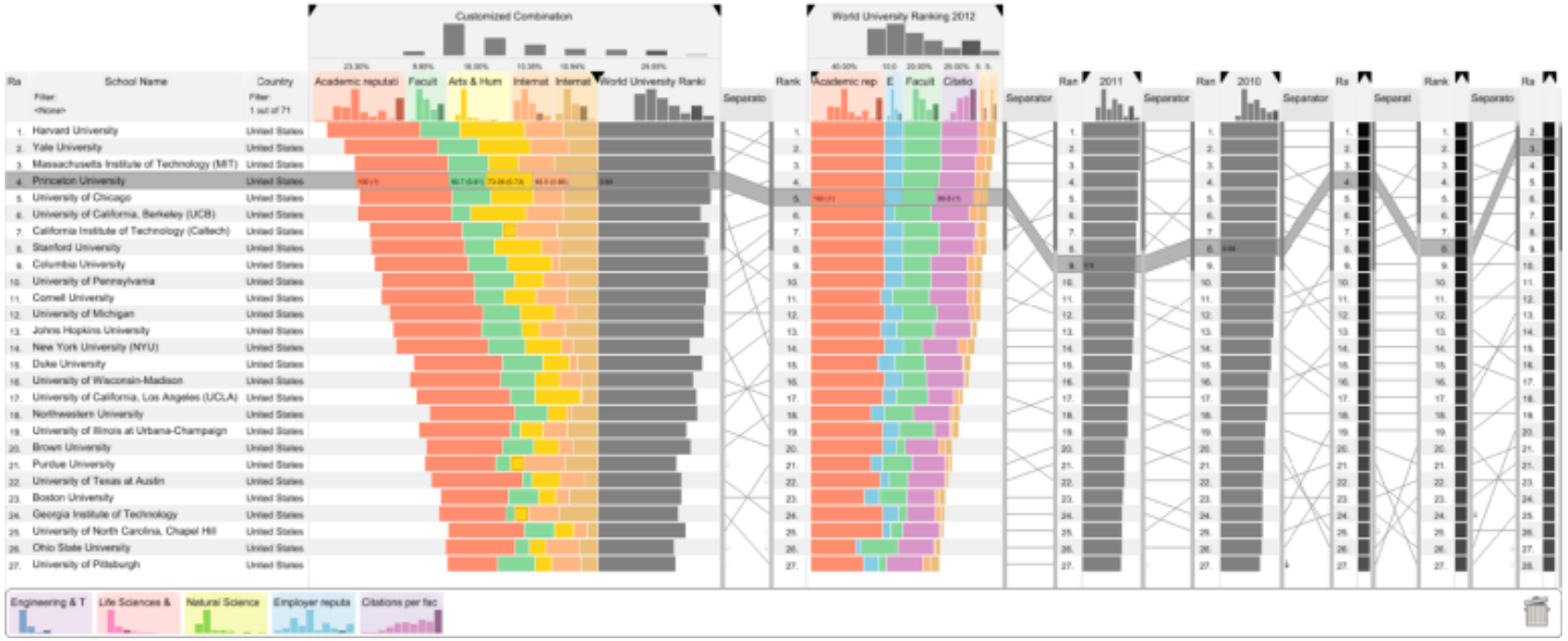


Hovering mouse cursor over each dot brings up details of item

Manipulate > Select: mark something as interesting

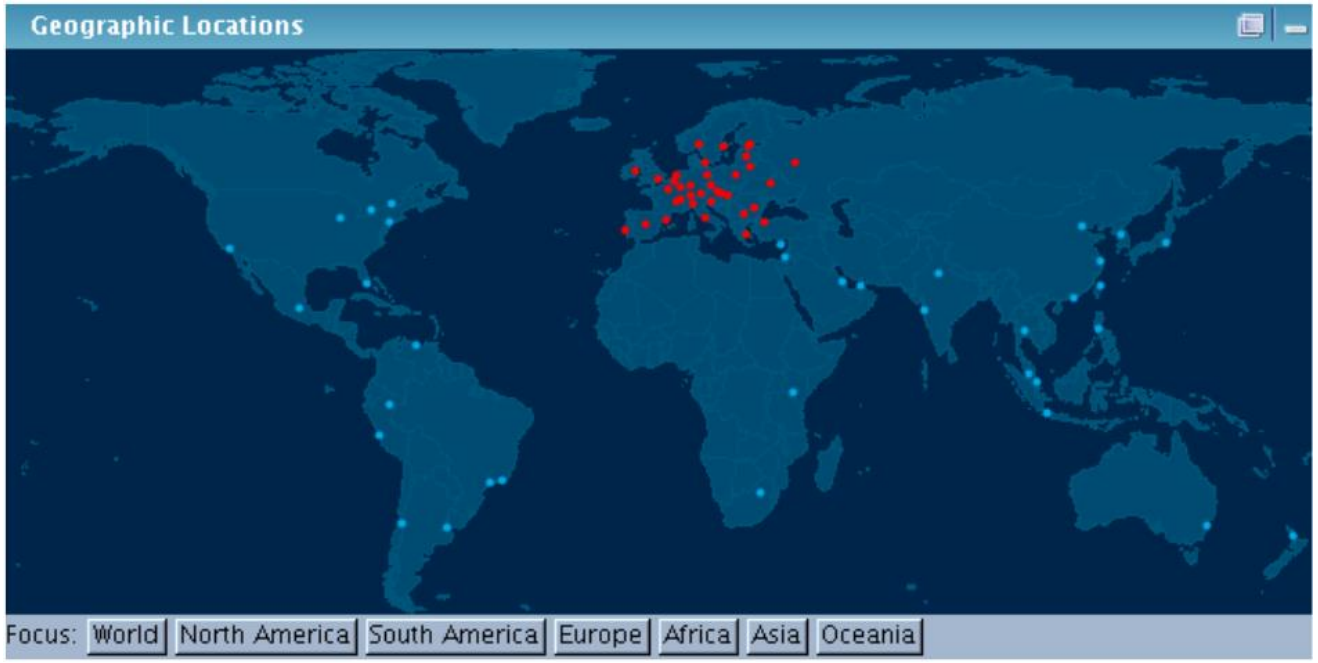
- Basic operation for all interaction
- Point + click (or double click) vs hover
- Change: color, border, or link items



Gratzlet al. LineUp: visual analysis of multi-attribute rankings, 2013

Manipulate > Select: mark something as interesting

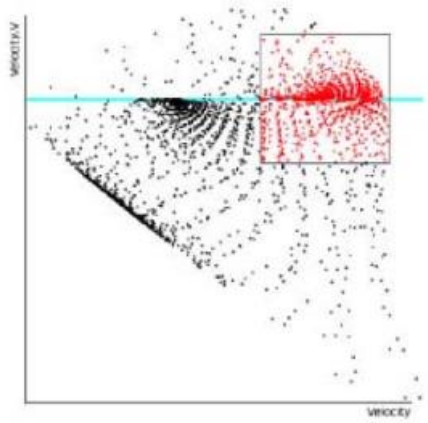
- Region selection: point + click + drag
  - Highlights a certain subset



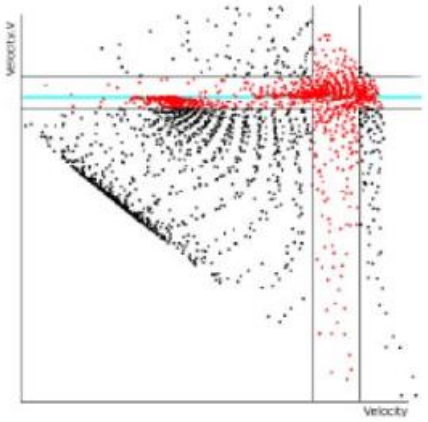
InfoScope https://infoscope.informer.com/

Manipulate > Select: Brushing

- More complex than simple selection
- Brush is an interactive interface tool to select /mark subsets of data in a single view
  - e.g. by sweeping a virtual brush across items of interest
- Usually used to visually filter data (via highlighting)
- Additional manipulation / operations may be performed on the subsets
  - e.g. masking, magnification, labeling etc.
- Different types of brushes (Hauser et al. 2002)
  - e.g. simple brush, composite brush, angular brushing, smooth brushing



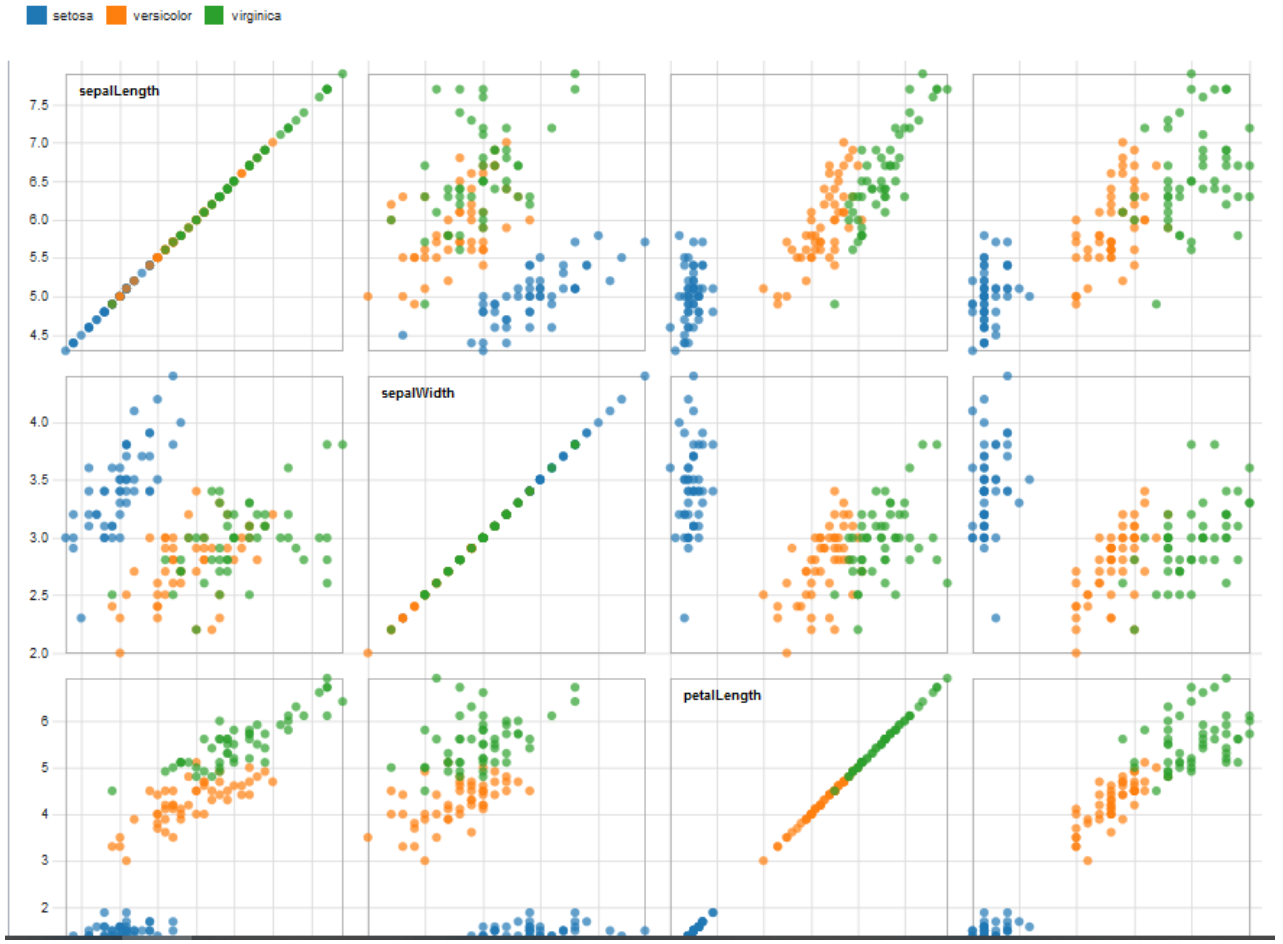
AND-brush



OR-brush

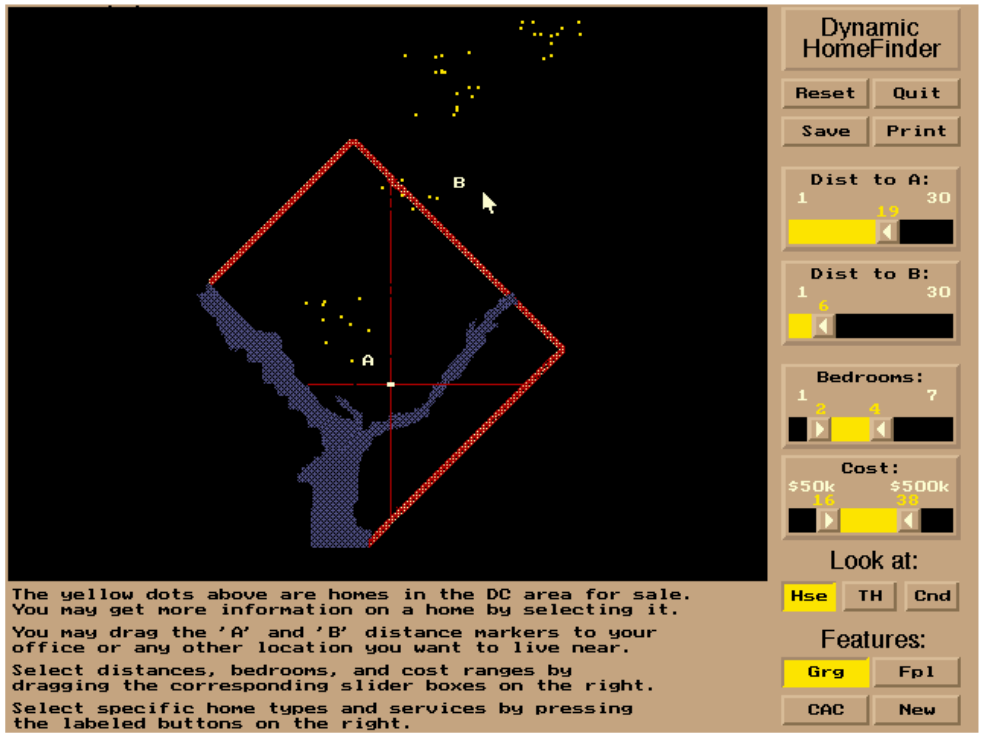
Manipulate > Select: Brushing and linking

- Common interaction technique
- Select items in one view, highlight in other views



Manipulate > Select: Dynamic query

- Selection/filtering by pointing (not typing)
- Immediate and continuous display of results
- Promote exploration

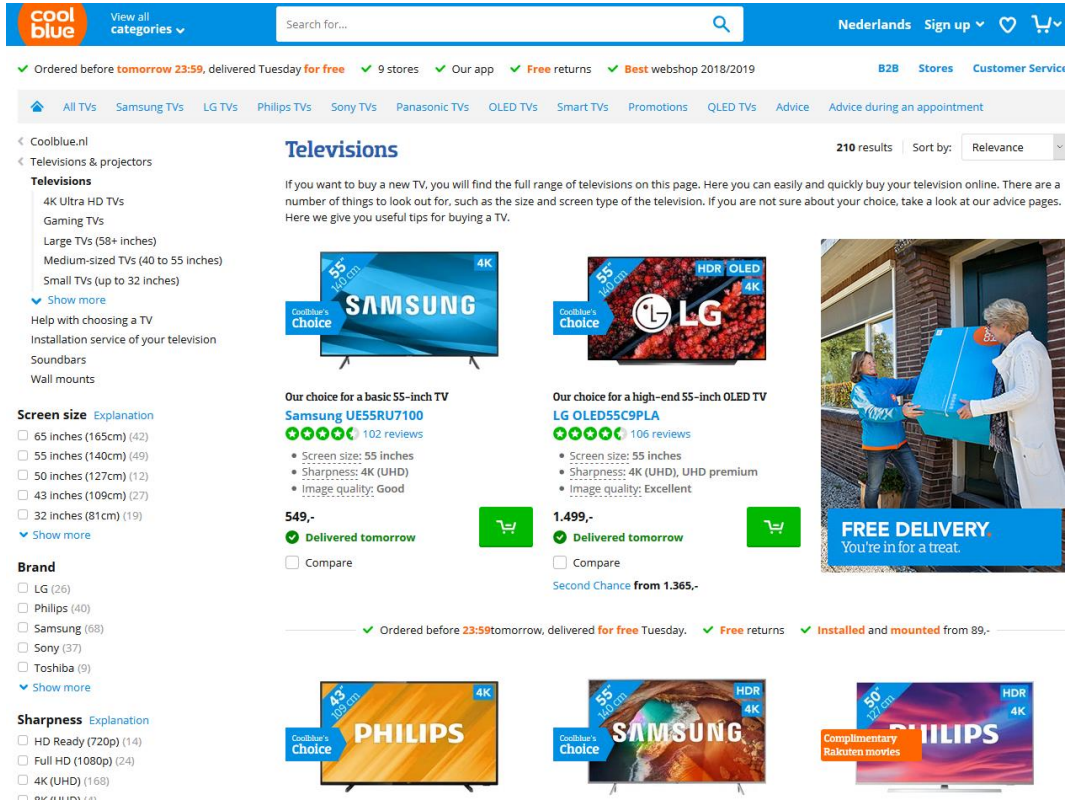


Williamson & Shneidermann:
Dynamic HomeFinder, 1992

http://www.youtube.com/watch?v=5X8XY9430fM

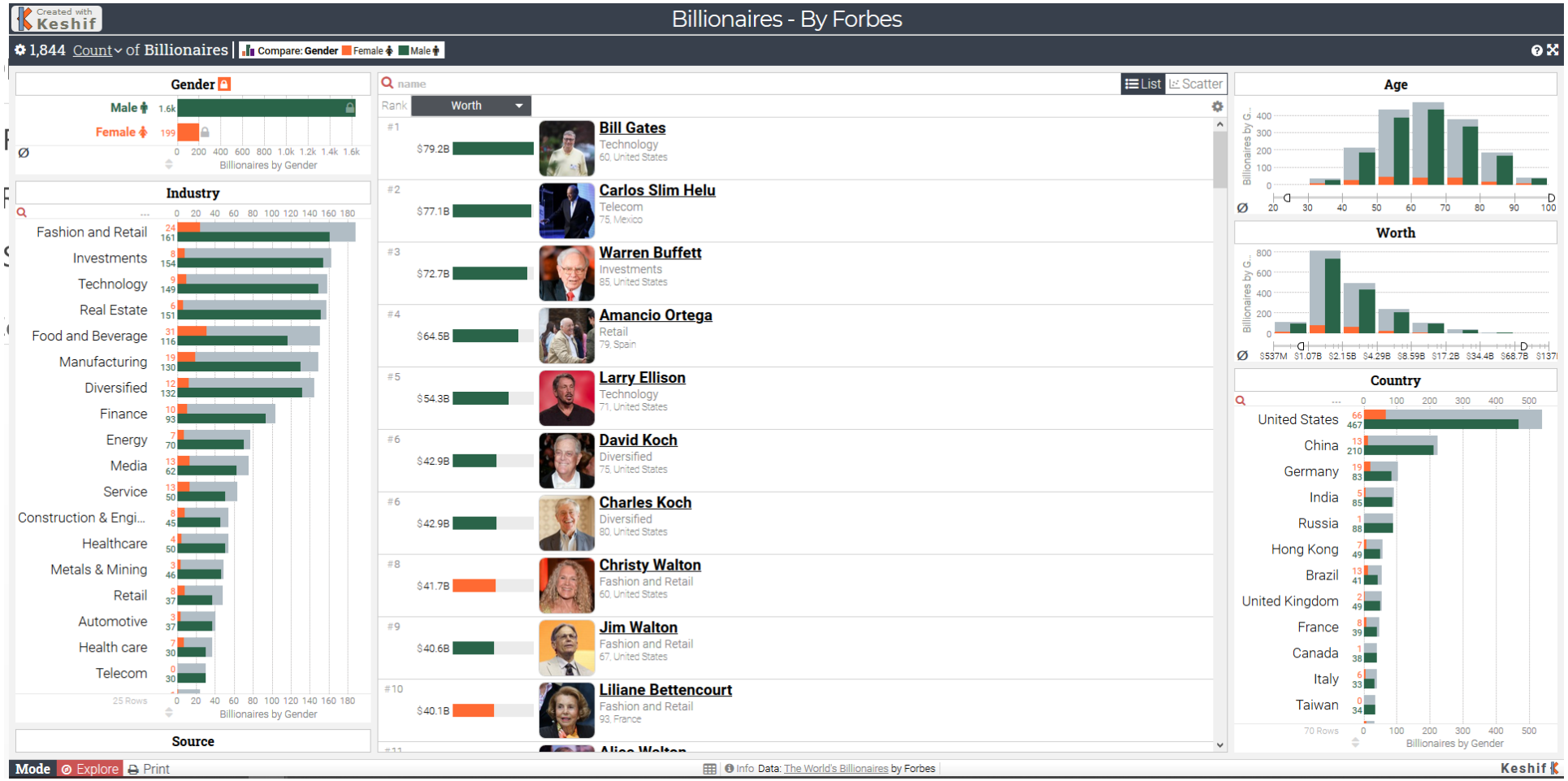
Manipulate > Select: Facetted Search

- Selection/filtering by pointing (not typing)
- Immediate and continuous display of results
- Promote exploration
- Ubiquitous!



Manipulate > Select

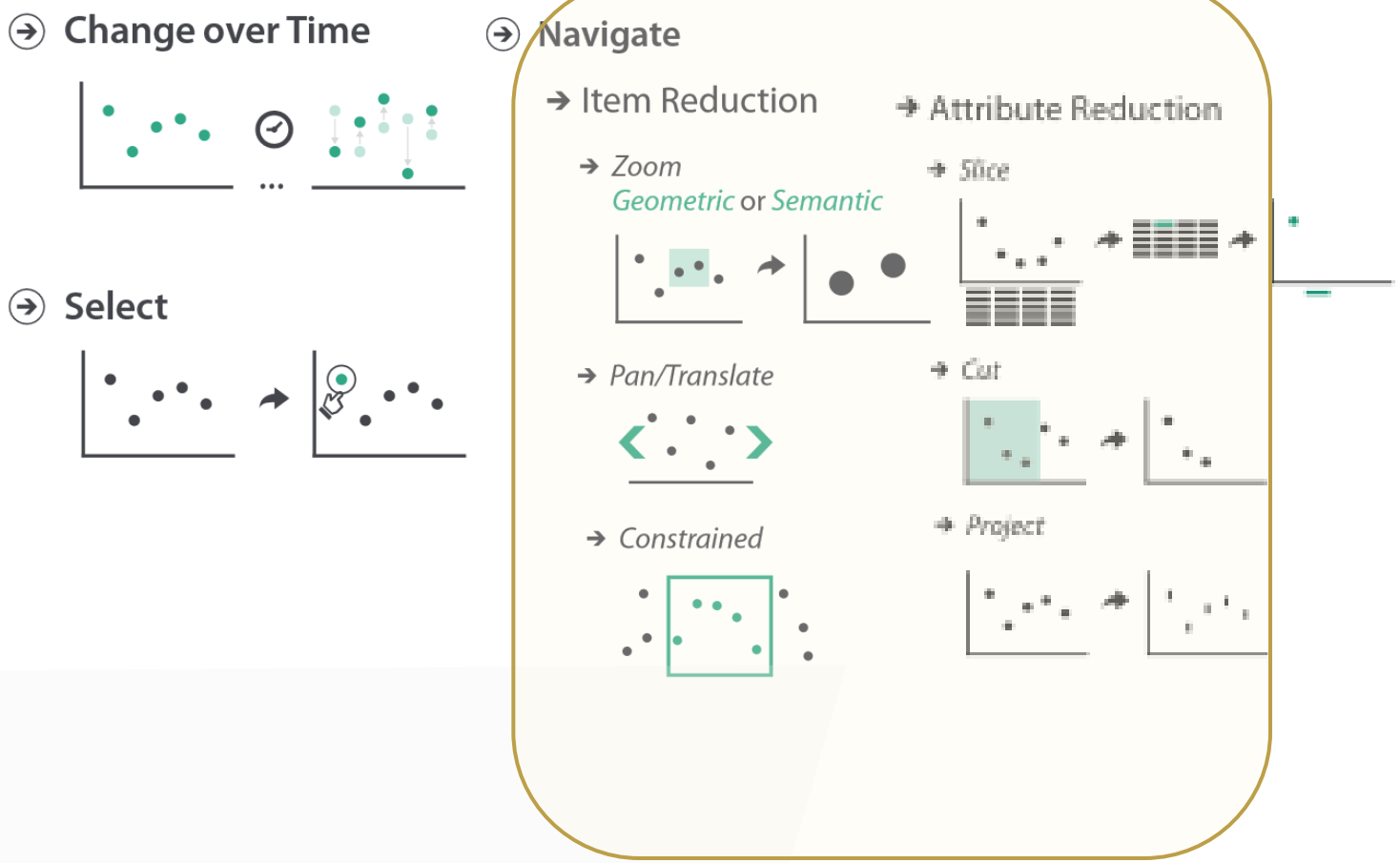
- Combine selection, brushing, filtering



Keshif.me (M. Adil Yalçın et al.)

Interaction taxonomy (Munzner)

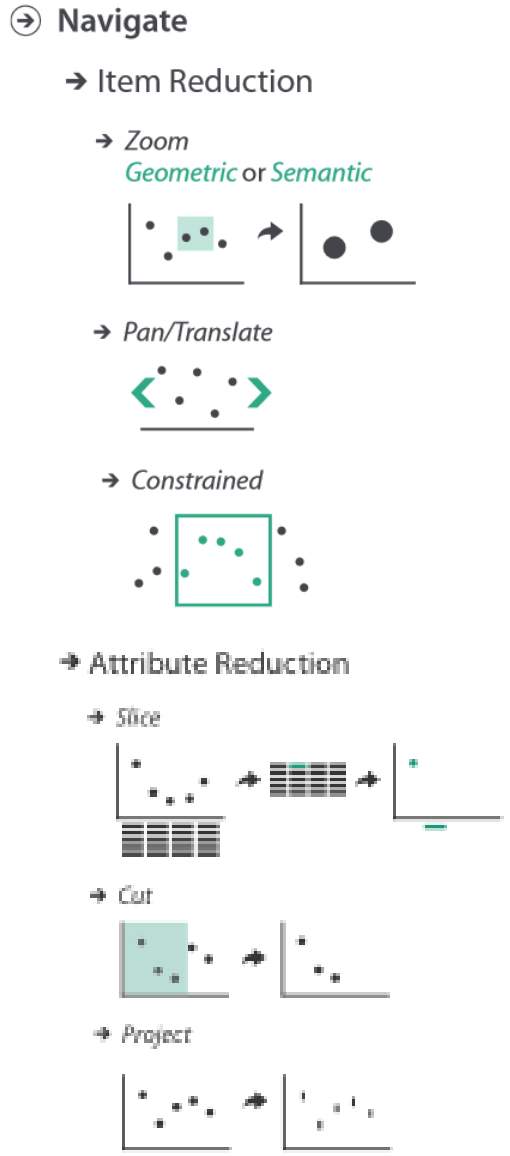
- **Manipulate**
  - Change
  - Select
  - **Navigate**
- Facet
  - Juxtapose
  - Partition
  - Superimpose
- Reduce
  - Filter
  - Aggregate
  - Embed



Manipulate > Navigate

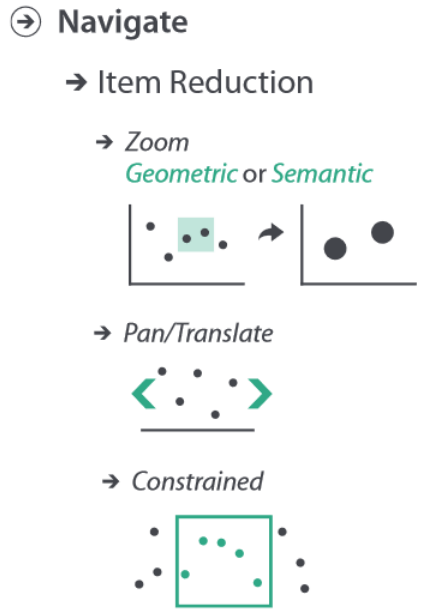
- Item reduction
  - Zoom
  - Pan
  - Constrained

- Attribute reduction
  - Slice
  - Cut
  - Project



Manipulate > Navigate: Changing viewpoint/visibility

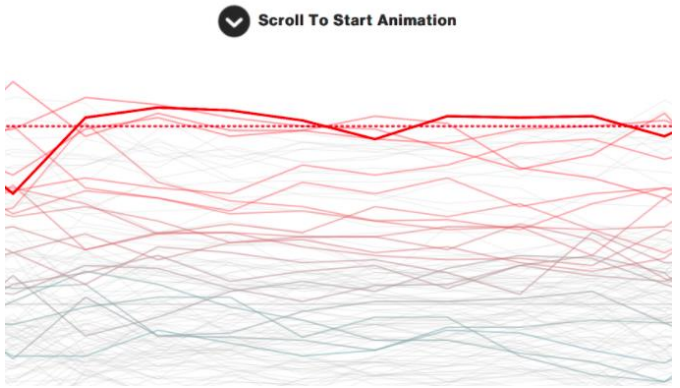
- change viewpoint
  - changes which items are visible within view
- camera metaphor
  - pan/translate/scroll
    - move up/down/sideways
  - rotate/spin
    - typically in 3D
  - zoom in/out
    - enlarge/shrink world == move camera closer/further
    - geometric zoom: standard, like moving physical object



slide by Tamara Munzner

Manipulate > Navigate: Scrollytelling

- Interaction by scrolling (panning down to navigate page)
- pros:
  - familiar & intuitive, from standard web browsing
  - linear (only up & down) vs possible overload of click-based interface choices
- cons:
  - full-screen mode may lack affordances
  - scrolljacking, no direct access
  - unexpected behaviour
  - continuous control for discrete steps



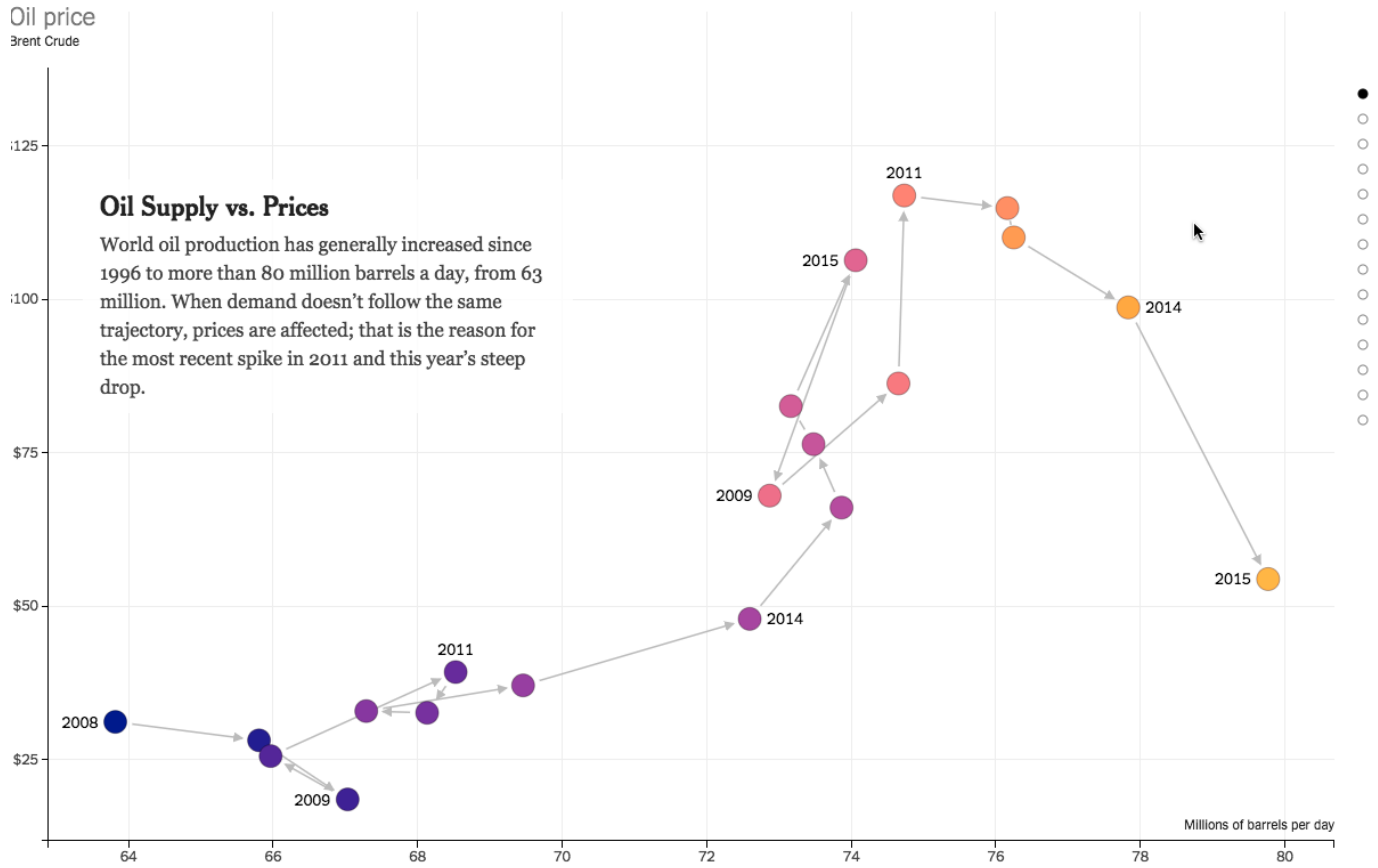
https://eagereyes.org/blog/2016/the-scrollytelling-scourge

How to Scroll, Bostock https://bost.ocks.org/mike/scroll/

slide by Tamara Munzner, inspired by: Alexander Lex, Utah

Manipulate > Navigate: Scrollytelling examples

- How the US and O.P.E.C. drive oil prices

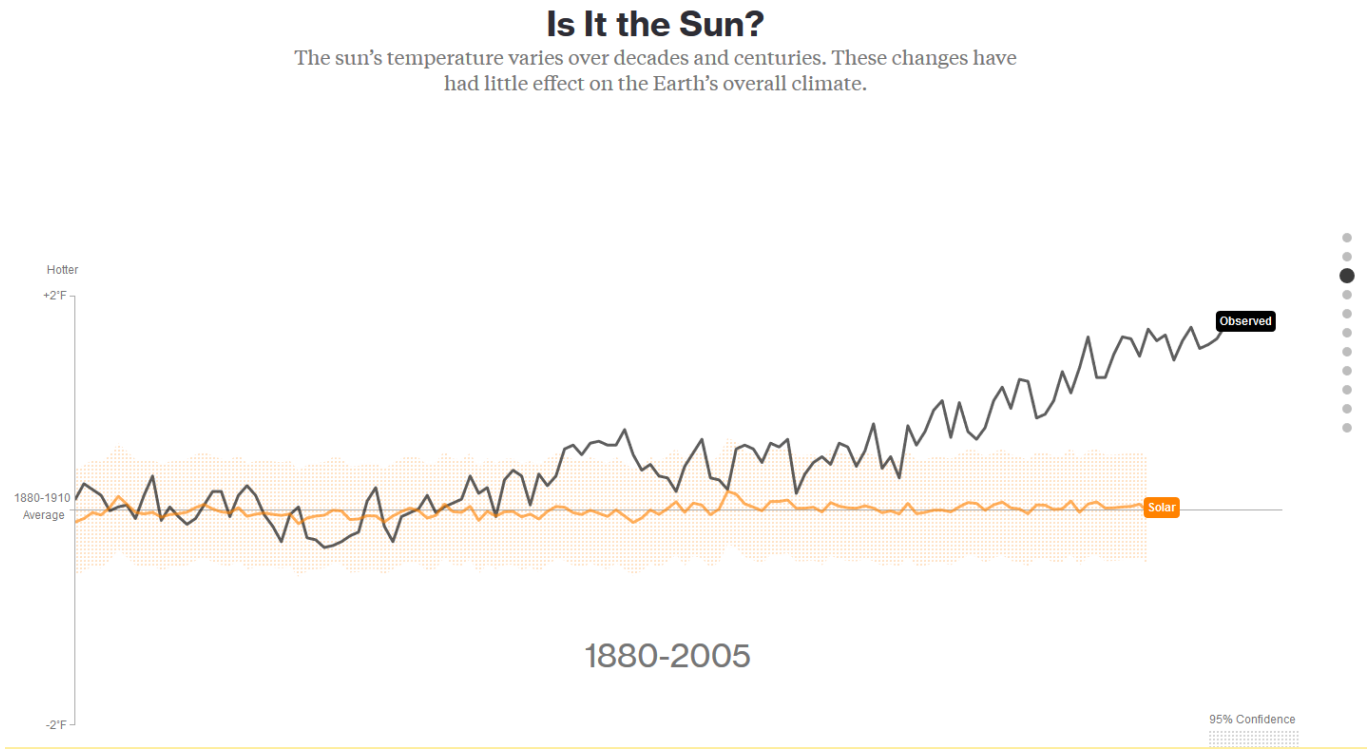


https://www.nytimes.com/interactive/2015/09/30/business/how-the-us-and-opec-drive-oil-prices.html?_r=1

slide by Tamara Munzner, inspired by: Alexander Lex, Utah

Manipulate > Navigate: Scrollytelling examples

- What's really warming the world?

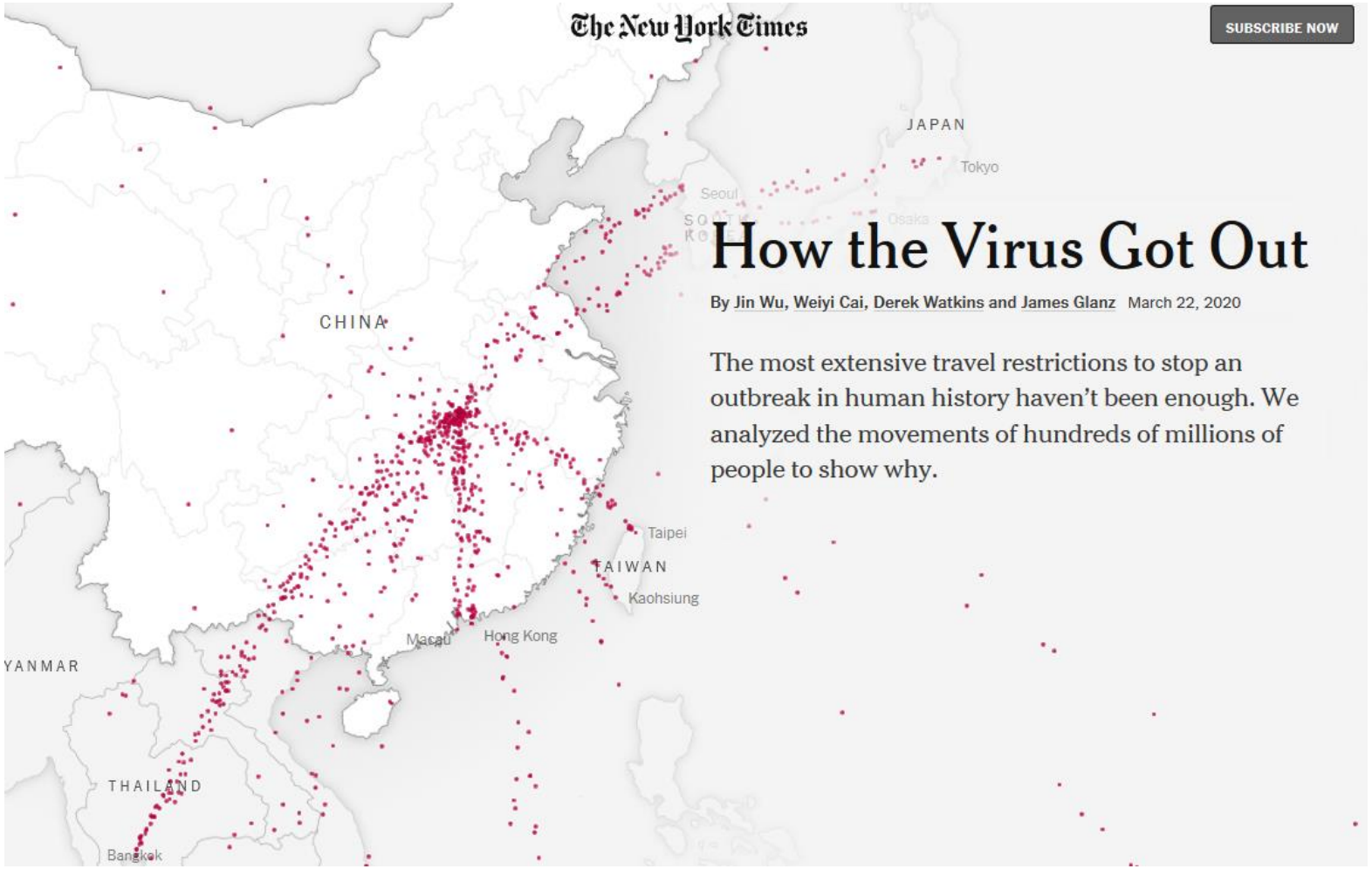


https://www.bloomberg.com/graphics/2015-whats-warming-the-world/

slide by Tamara Munzner, inspired by: Alexander Lex, Utah

Manipulate > Navigate: Scrollytelling examples

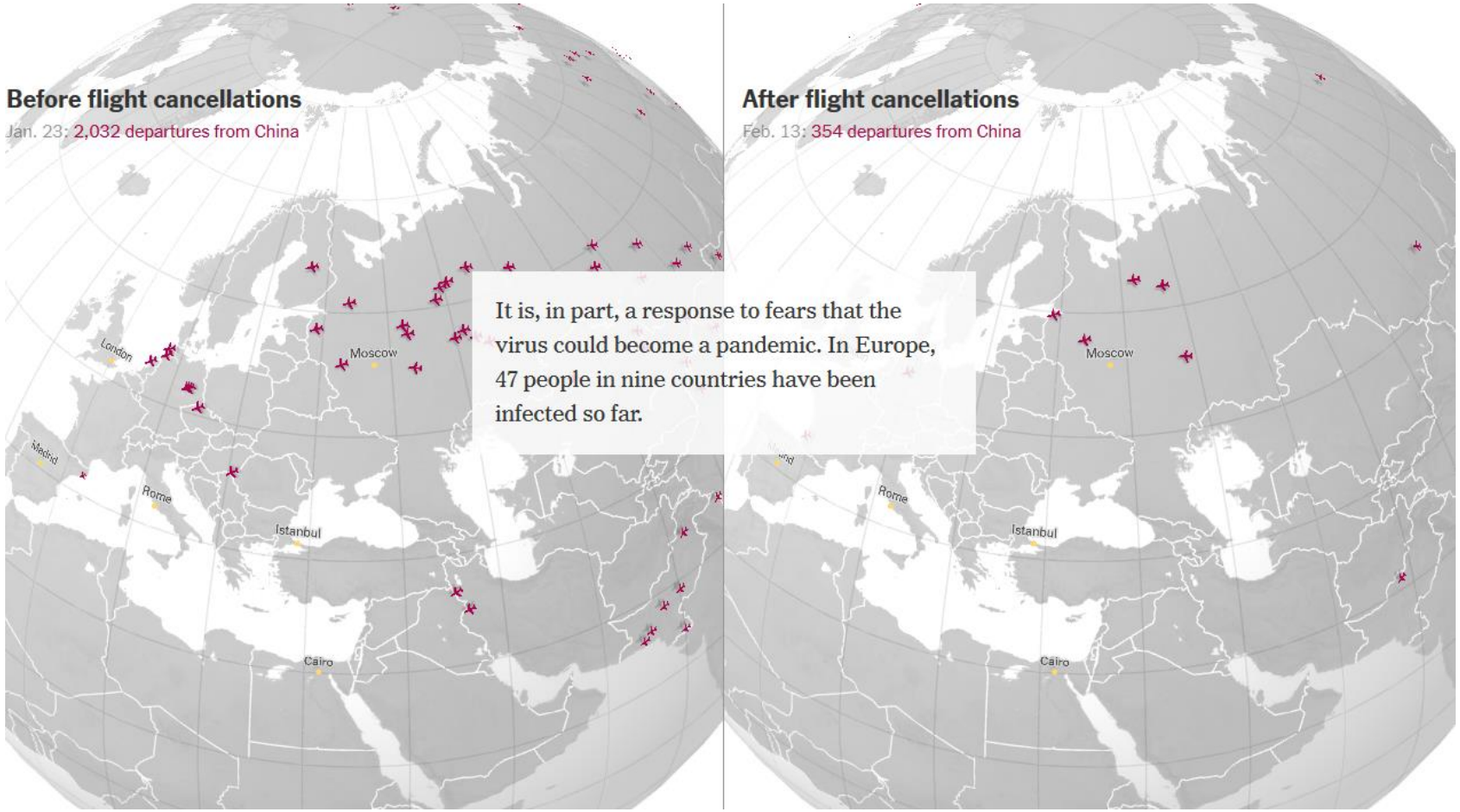
- How the Virus Got Out



New York Times Interactive, 2020

Manipulate > Navigate: Scrollytelling examples

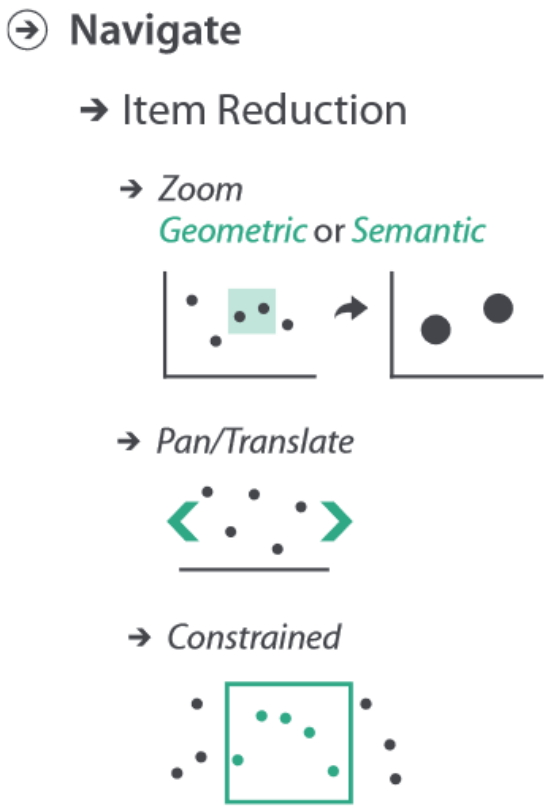
- 13,000 Missing Flights: The Global Consequences of the Coronavirus



New York Times Interactive, 2020

Manipulate > Navigate: Unconstrained vs constrained

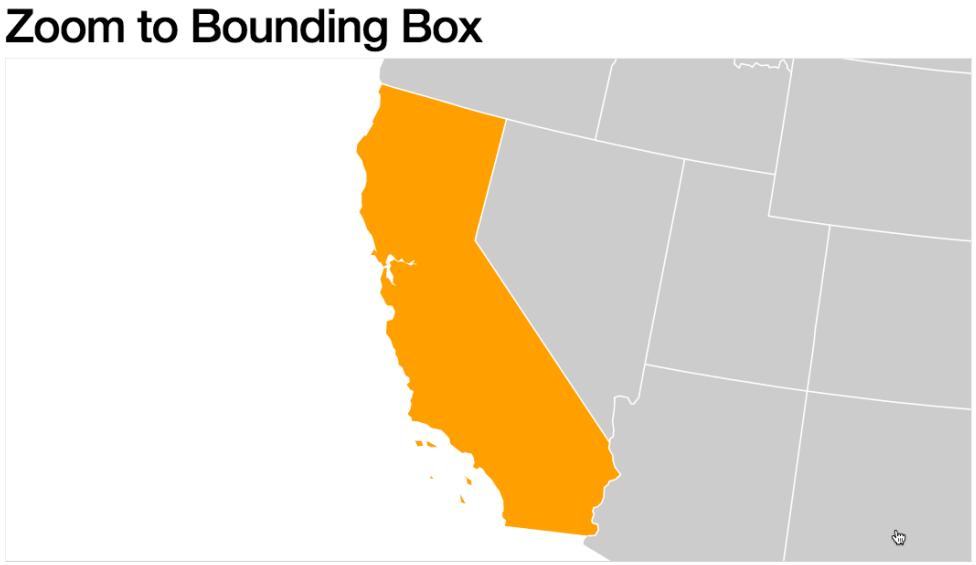
- unconstrained navigation
  - easy to implement for designer
  - hard to control for user
    - easy to overshoot/undershoot
- constrained navigation
  - typically uses animated transitions
  - trajectory automatically computed based on selection
    - just click; selection ends up framed nicely in final viewport



slide by Tamara Munzner

Manipulate > Navigate: Animated transition + constrained navigation

- example: geographic map
  - simple zoom, only viewport changes, shapes preserved

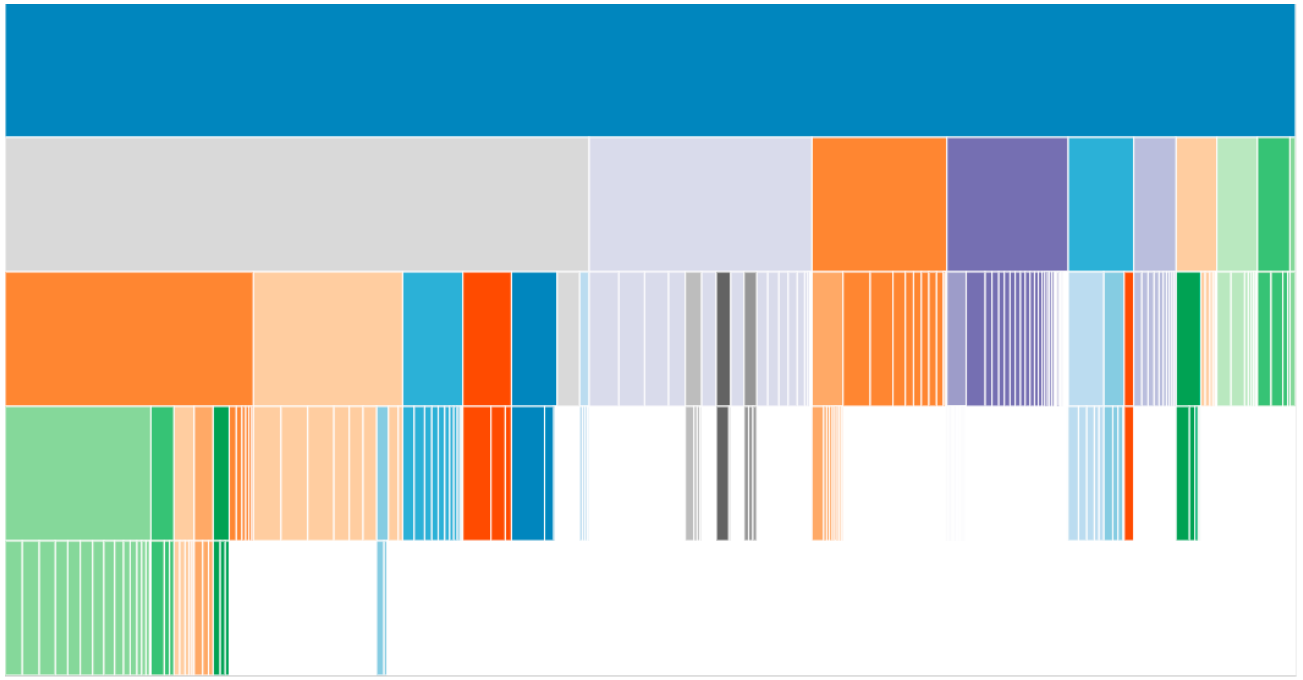


Zoom to Bounding Box
https://bl.ocks.org/mbostock/4699541

slide by Tamara Munzner

Manipulate > Navigate: Animated transition + constrained navigation

- example: icicle plot
  - transition into containing mark causes aspect ratio (shape) change

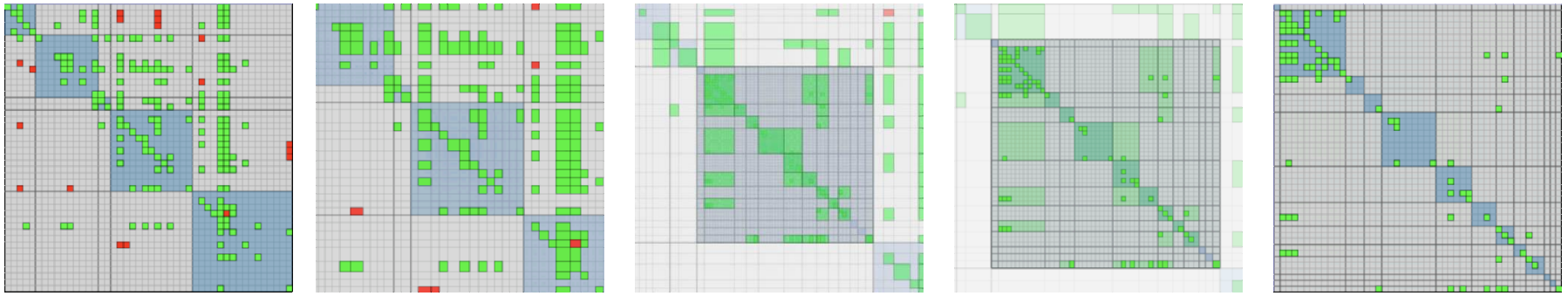


Zoomable Icicle
https://bl.ocks.org/mbostock/1005873

slide by Tamara Munzner

Manipulate > Navigate: Animated transition + constrained navigation

- example: multilevel matrix views
  - add detail during transition



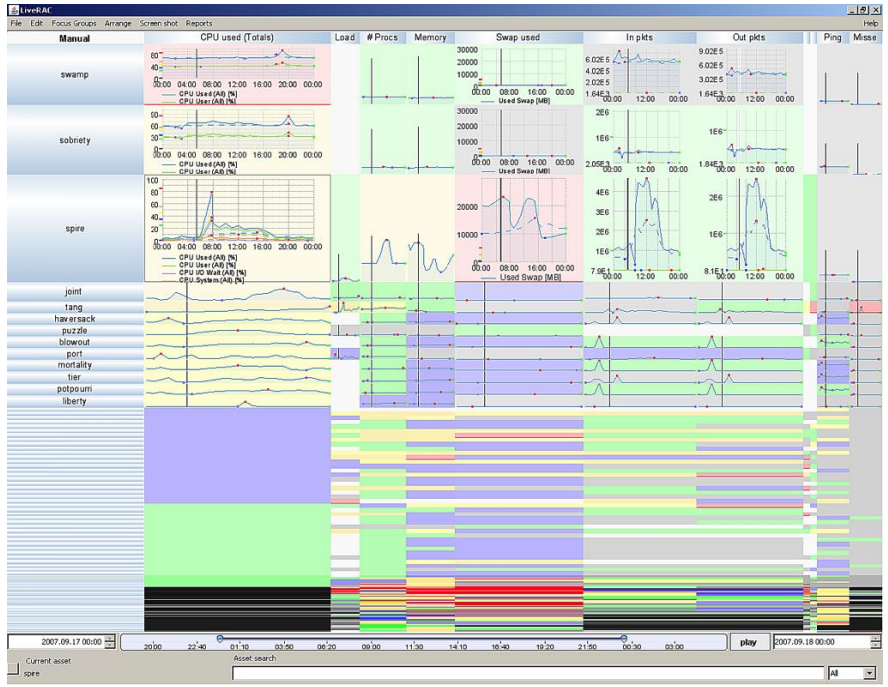
Using Multilevel Call Matrices in Large Software Projects. van Ham. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 227–232, 2003.

https://www.win.tue.nl/~vanwijk/zoompan.pdf

slide by Tamara Munzner

Manipulate > Navigate: Semantic zooming

- semantic zoom: As you zoom in, content is updated
  - alternative to geometric zoom
  - resolution-aware layout adapts to available space
  - goal: legible at multiple scales
  - dramatic or subtle effects
- visual encoding change
  - colored box
  - sparkline
  - simple line chart
  - full chart: axes and tickmarks

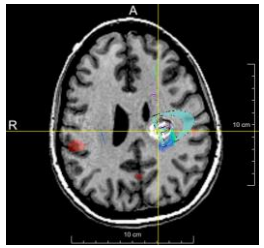


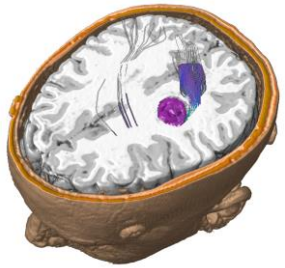
LiveRAC - Interactive Visual Exploration of System Management Time-Series Data. McLachlan, Munzner, Koutsofios, and North. Proc. ACM Conf. Human Factors in Computing Systems (CHI), pp. 1483–1492, 2008.

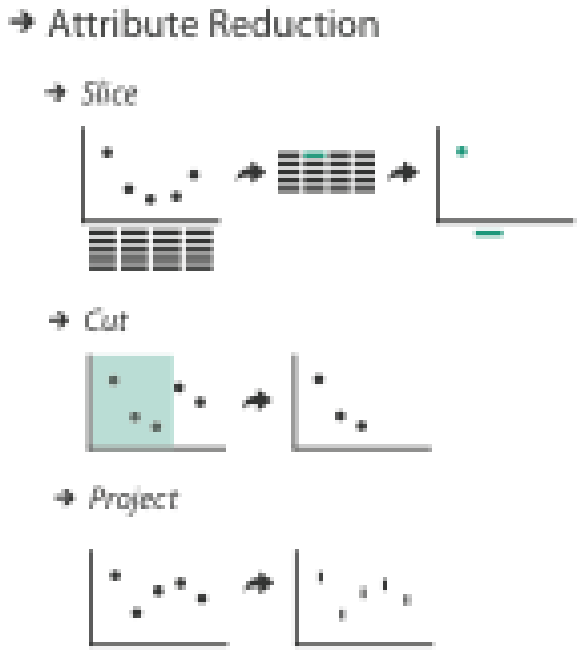
slide by Tamara Munzner

Manipulate > Navigate: Attribute reduction

- 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 (eliminate 3rd dimension)
    - perspective (foreshortening captures limited 3D information)



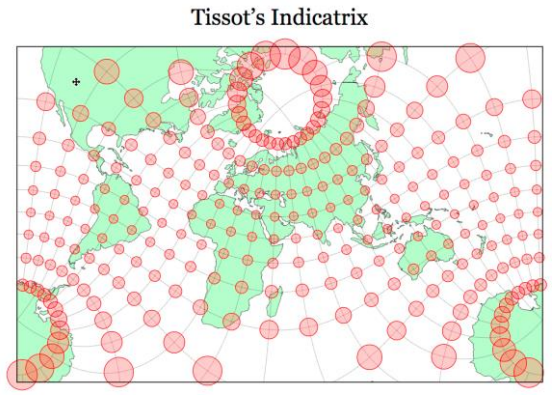




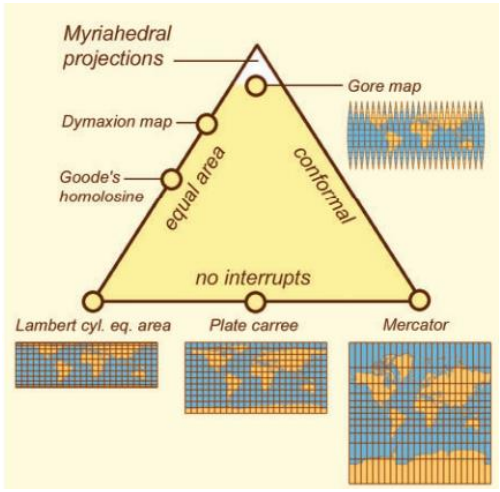
Interactive Visualization of Multimodal Volume Data for Neurosurgical Tumor Treatment. Rieder, Ritter, Raspe, and Peitgen. Computer Graphics Forum (Proc. EuroVis 2008) 27:3 (2008), 1055–1062.]

Manipulate > Navigate: Cartographic projections

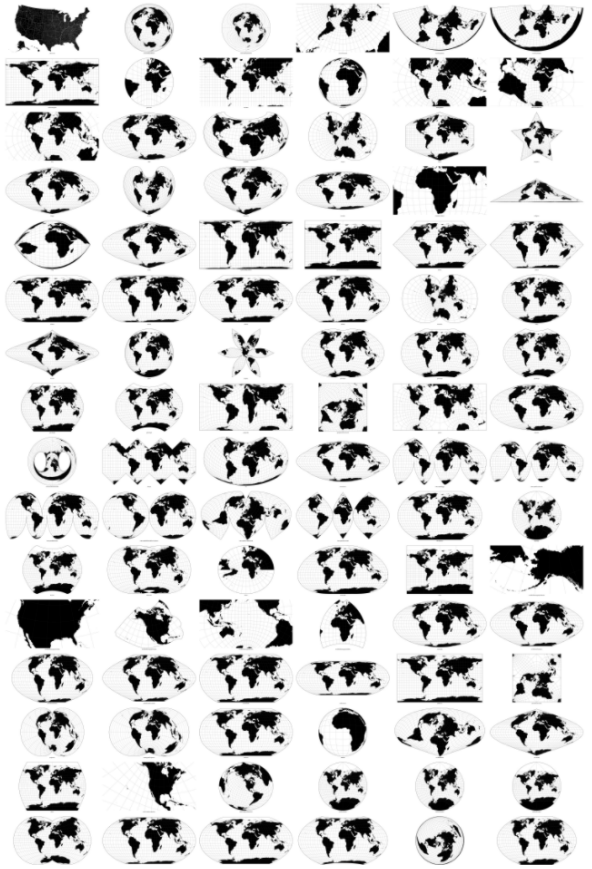
- project from 2D sphere surface to 2D plane
  - can only fully preserve 2 out of 3
    - angles: conformal
    - area: equal area
    - contiguity: no interruptions



https://www.jasondavies.com/maps/tissot/



https://www.win.tue.nl/~vanwijk/myriahedral/



[Every Map Projection https://bl.ocks.org/mbostock/29cddc0006f8b98eff12e60dd08f59a7

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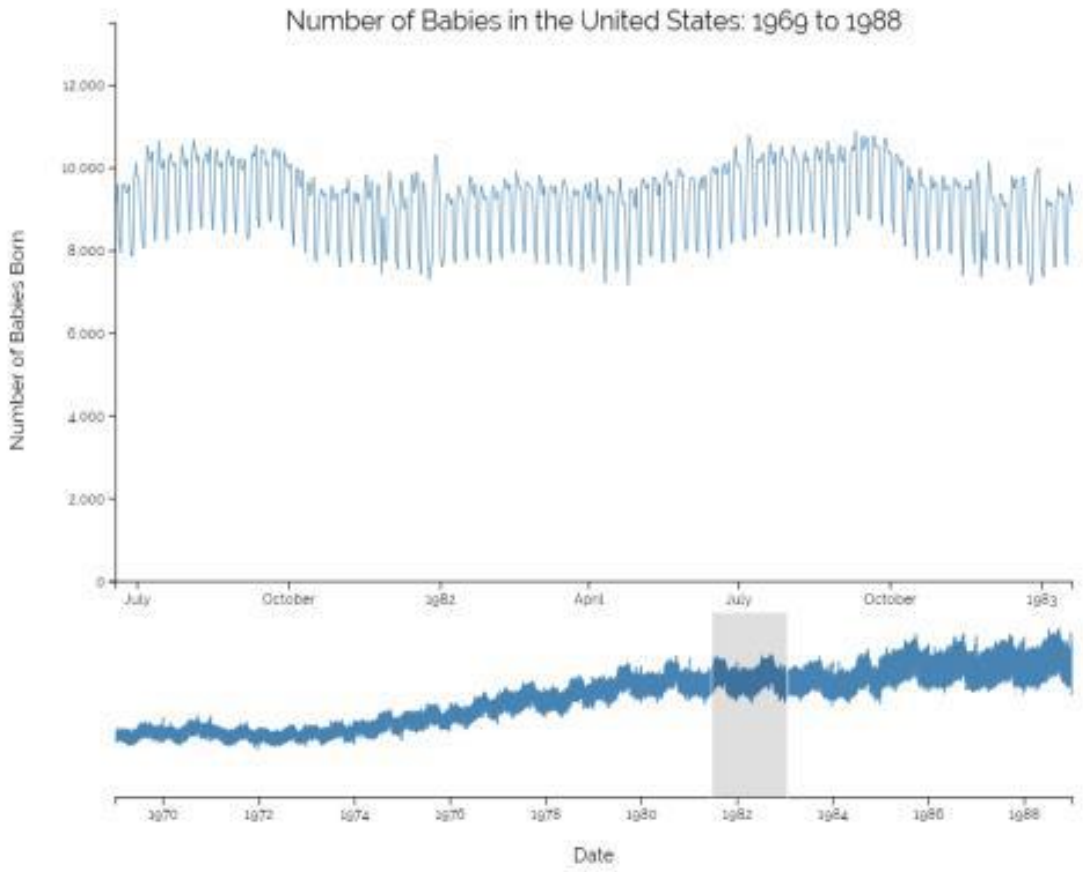
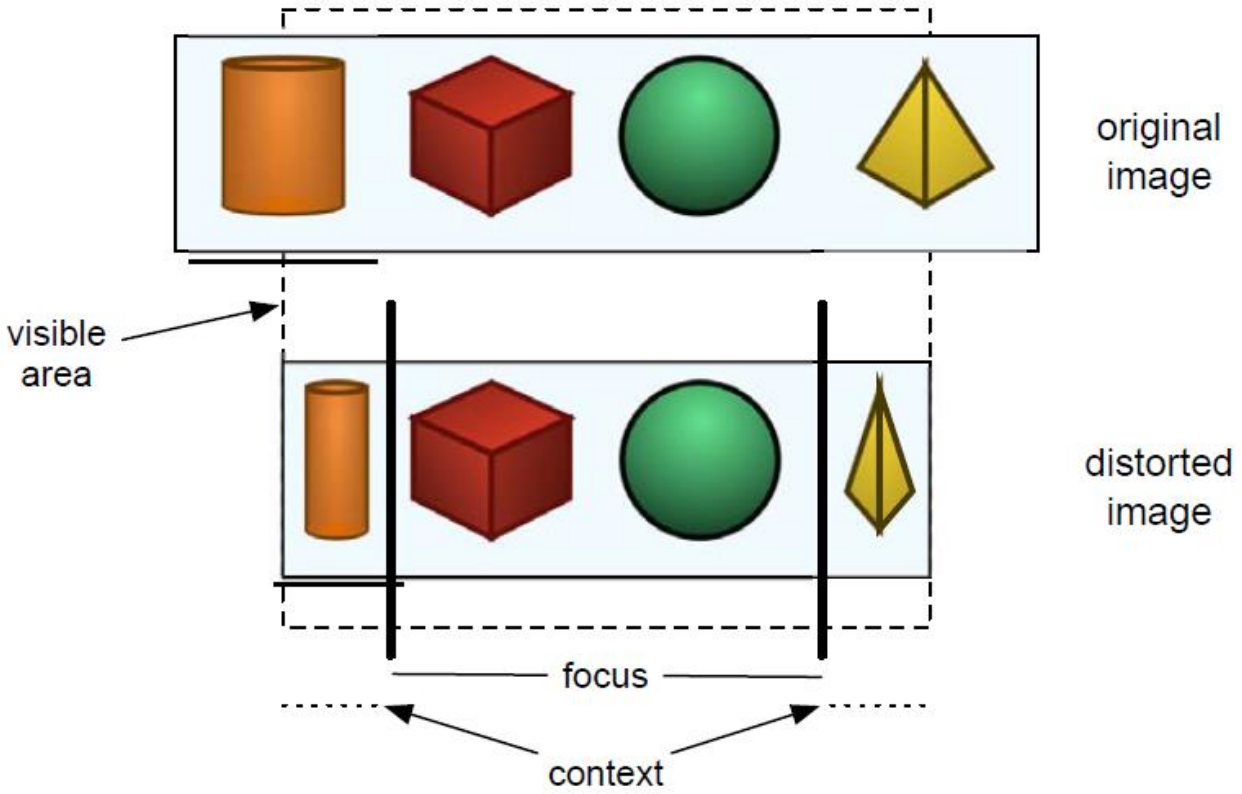
Manipulate > Navigate: Focus & Context



ɔng/raw/884bb566c84775d92b3d/

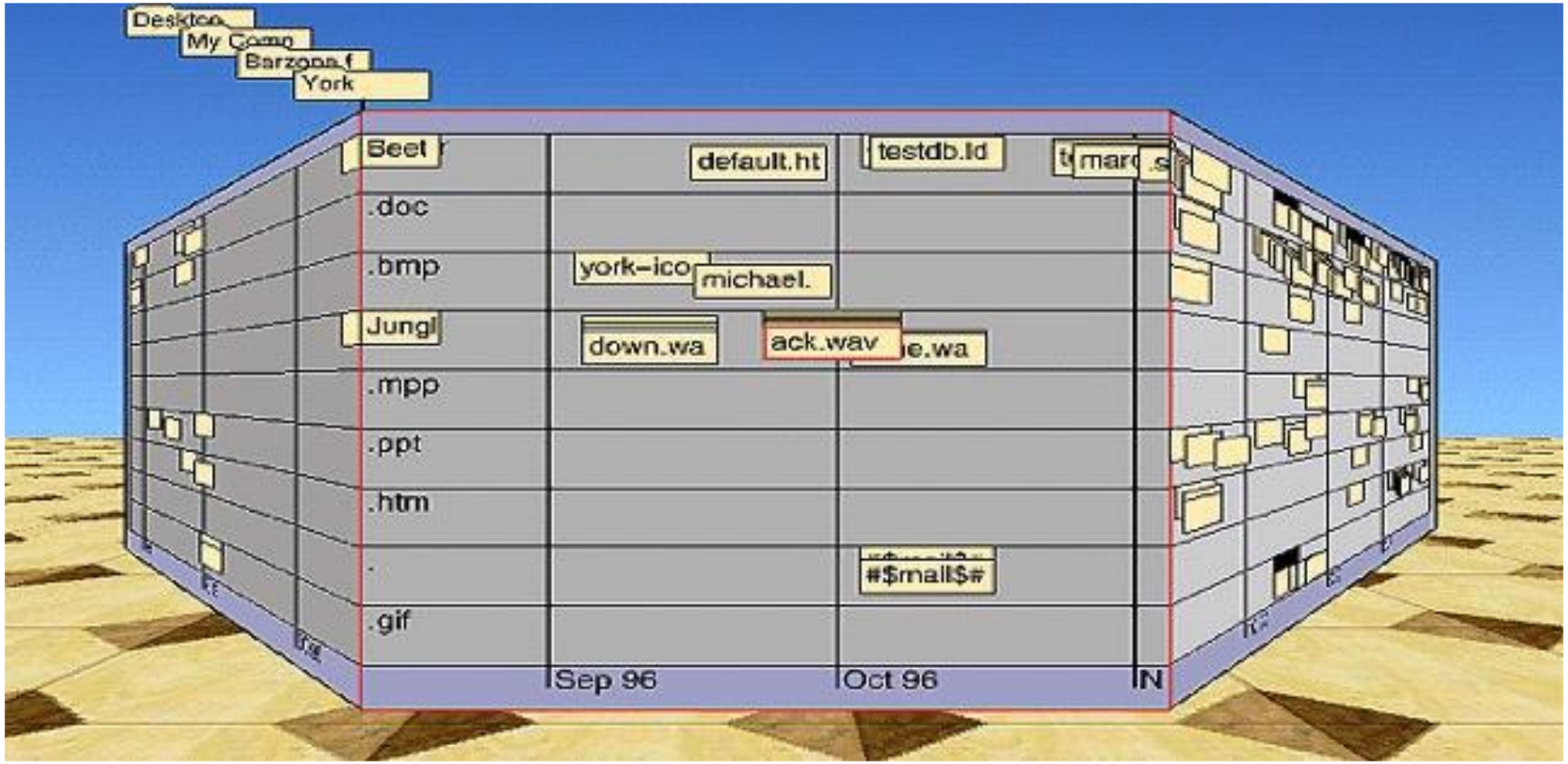
Manipulate > Navigate: Focus & Context

- Bifocal display



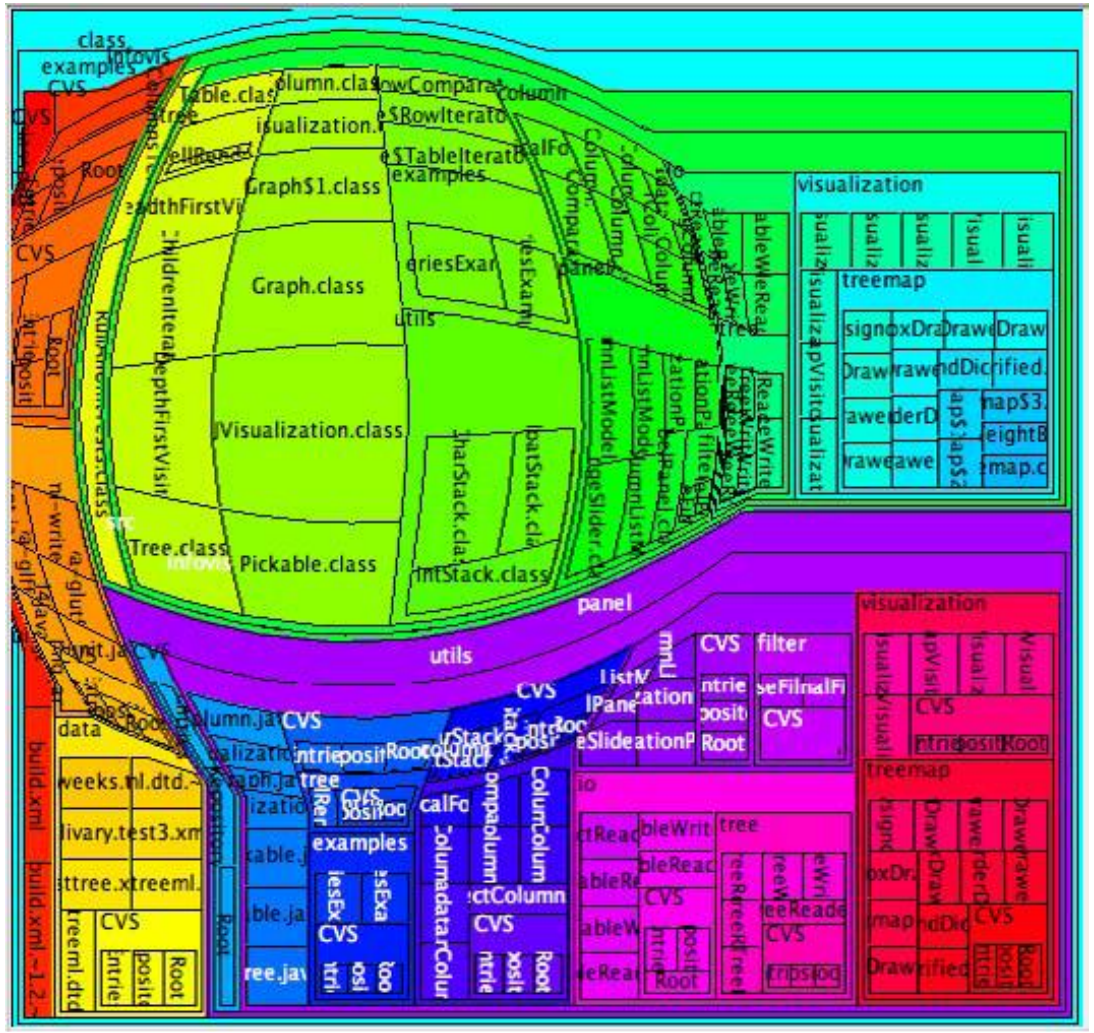
Manipulate > Navigate: Focus & Context

- The perspective wall



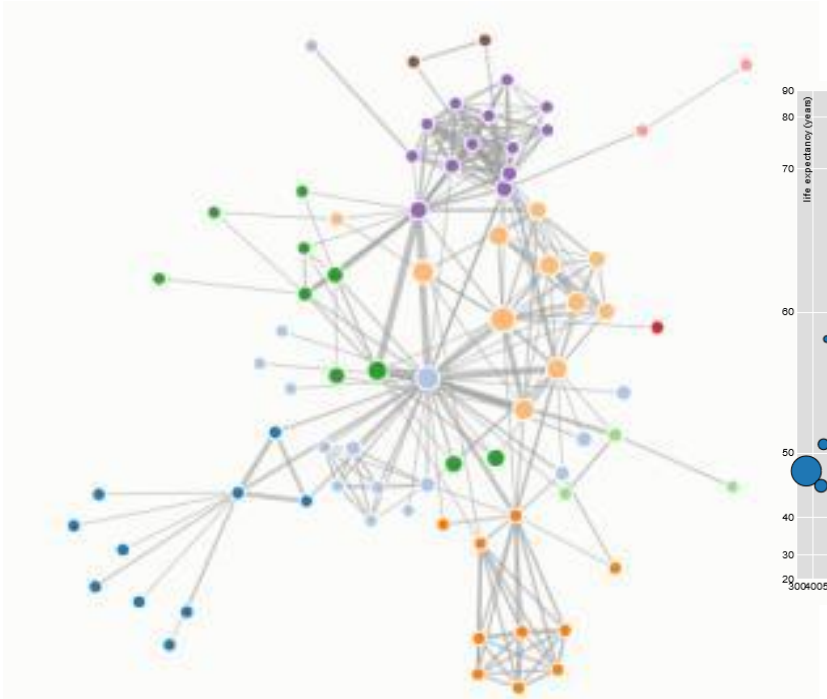
Manipulate > Navigate: Overview-detail

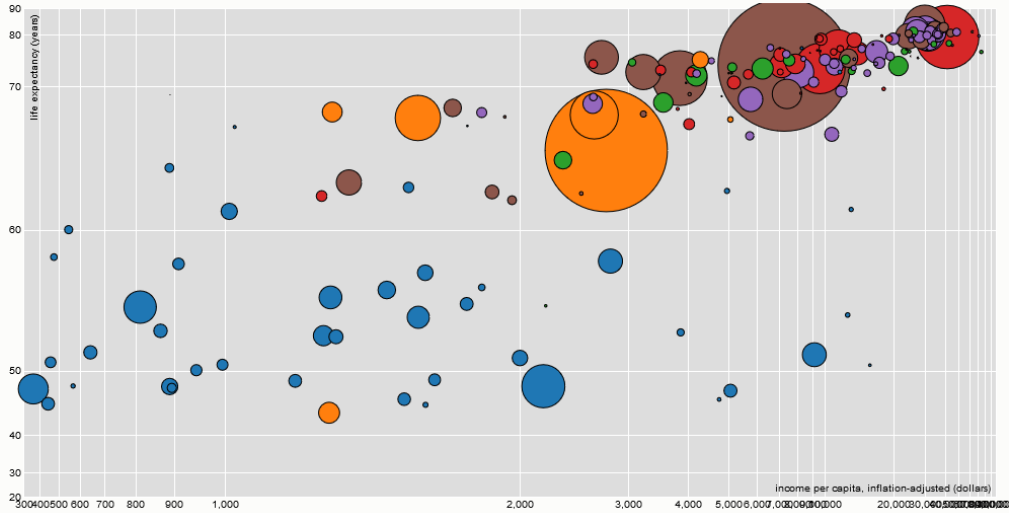
- Fisheye view

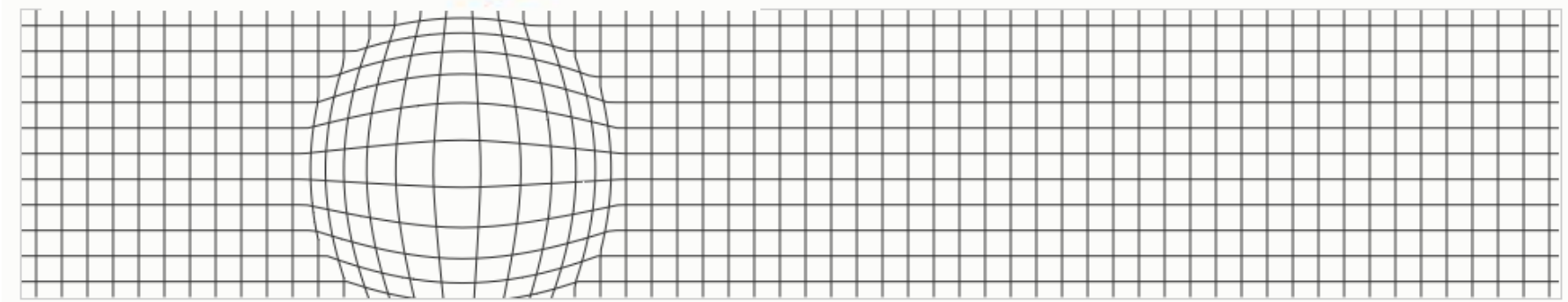


Manipulate > Navigate: Overview-detail

- Fisheye view

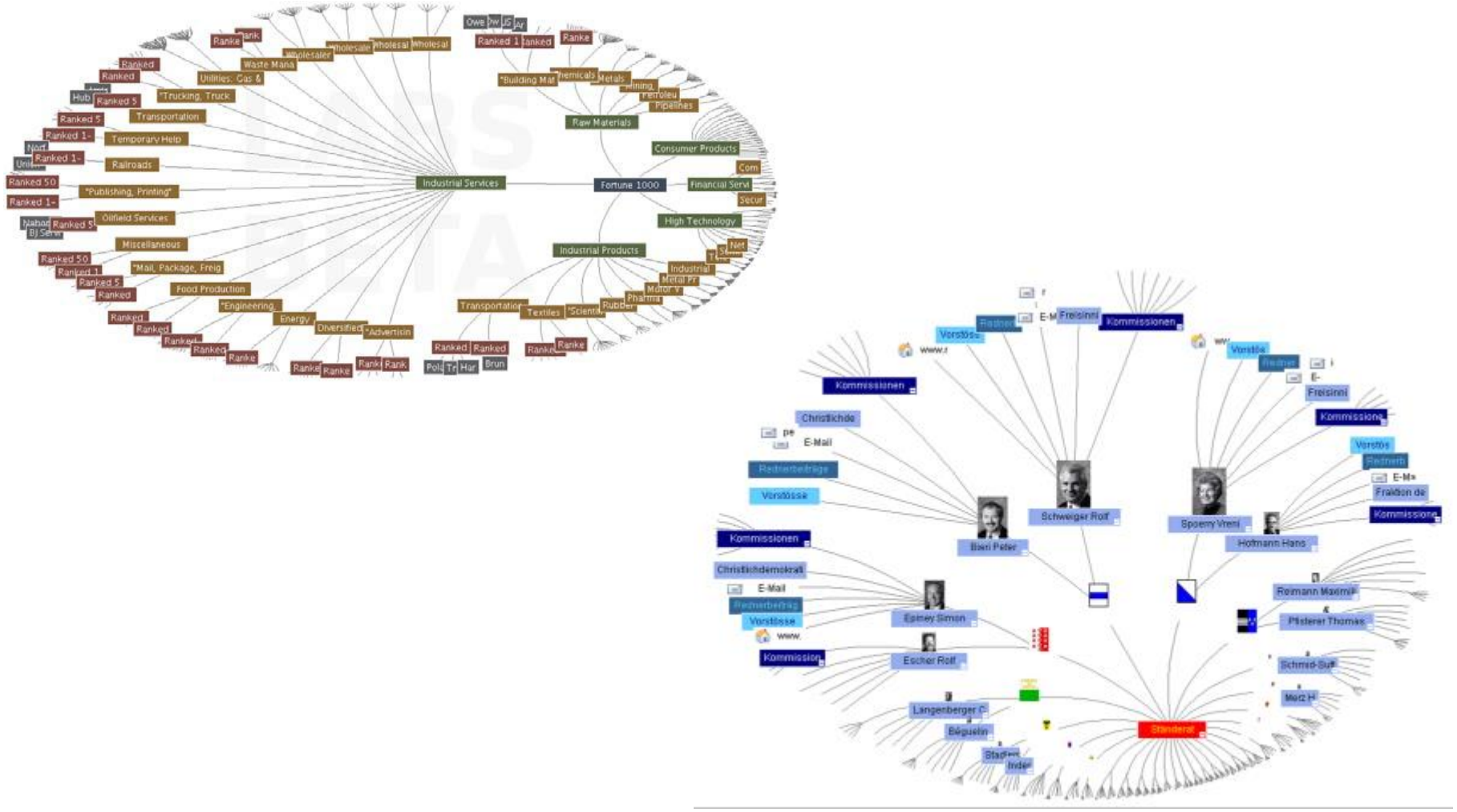






Manipulate > Navigate: Focus & Context

- Hyperbolic browser



Interaction taxonomy (Munzner)

- How to handle complexity: 1 + 3 strategies

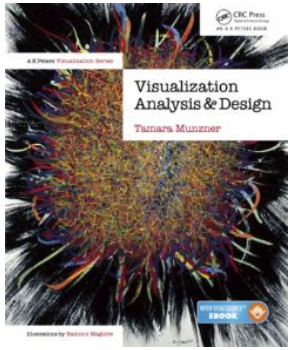
derive new data to show within view

change view over time

facet across multiple views

reduce items/attributes within single view

→ *Derive*



Tamara Munzner

Manipulate

- Change
- Select
- Navigate

Facet

- Juxtapose
- Partition
- Superimpose

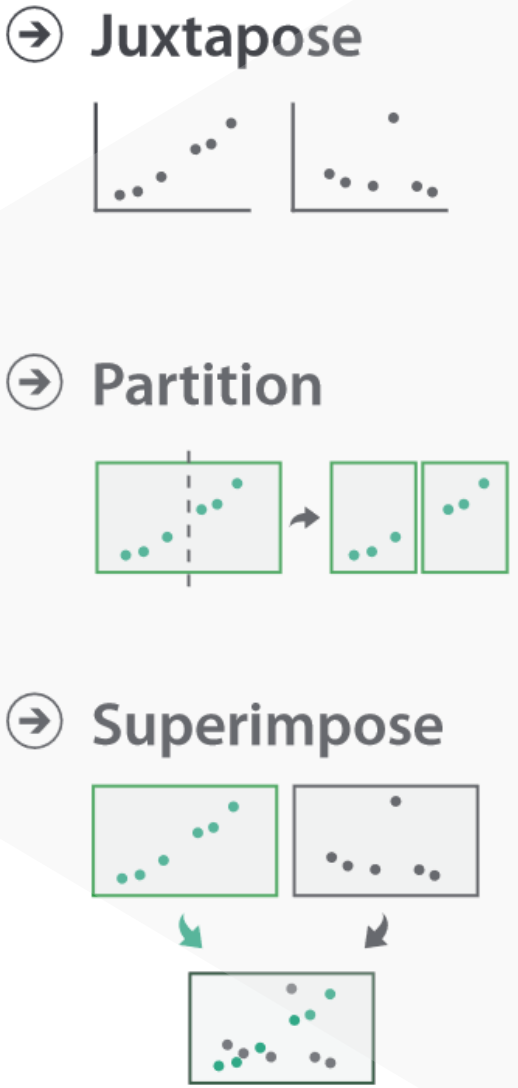
Reduce

- Filter
- Aggregate
- Embed

slide by Tamara Munzner

Interaction taxonomy (Munzner)

- Manipulate
  - Change
  - Select
  - Navigate
- **Facet**
  - Juxtapose
  - Partition
  - Superimpose
- Reduce
  - Filter
  - Aggregate
  - Embed



Facet > Juxtapose and coordinate views

- Juxtapose
  - Share encoding: same/different
    - Linked highlighting
  - Share data: All/subset/none
  - Share navigation

➔ Share Encoding: Same/Different

➔ *Linked Highlighting*

➔ Share Data: All/Subset/None

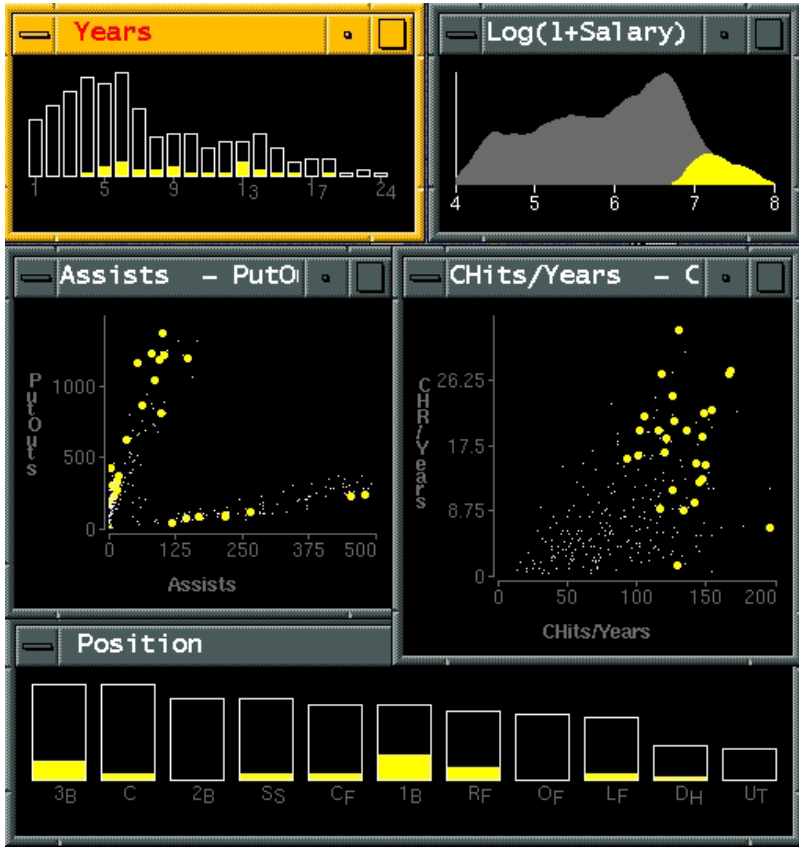
➔ Share Navigation

- Partition

- Superimpose

Facet > Juxtapose: Linked highlighting

- (brushing and linking)
- see how regions contiguous in one view are distributed within another
  - powerful and pervasive interaction idiom
- multiform encoding
- all data shared

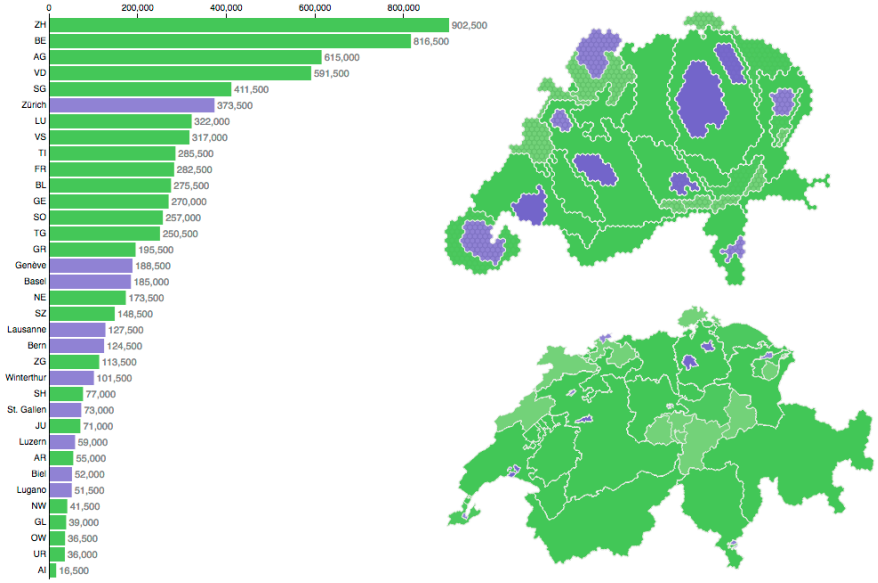


Visual Exploration of Large Structured Datasets. Wills. Proc. New Techniques and Trends in Statistics (NTTS), pp. 237–246. IOS Press, 1995.

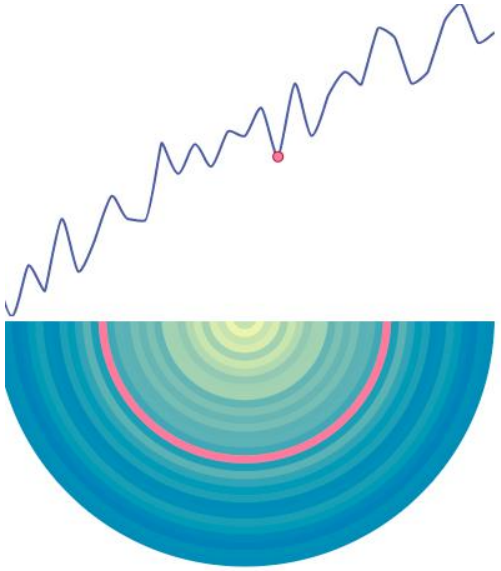
slide by Tamara Munzner

Facet > Juxtapose: Linked highlighting, linked views

- unidirectional vs bidirectional linking

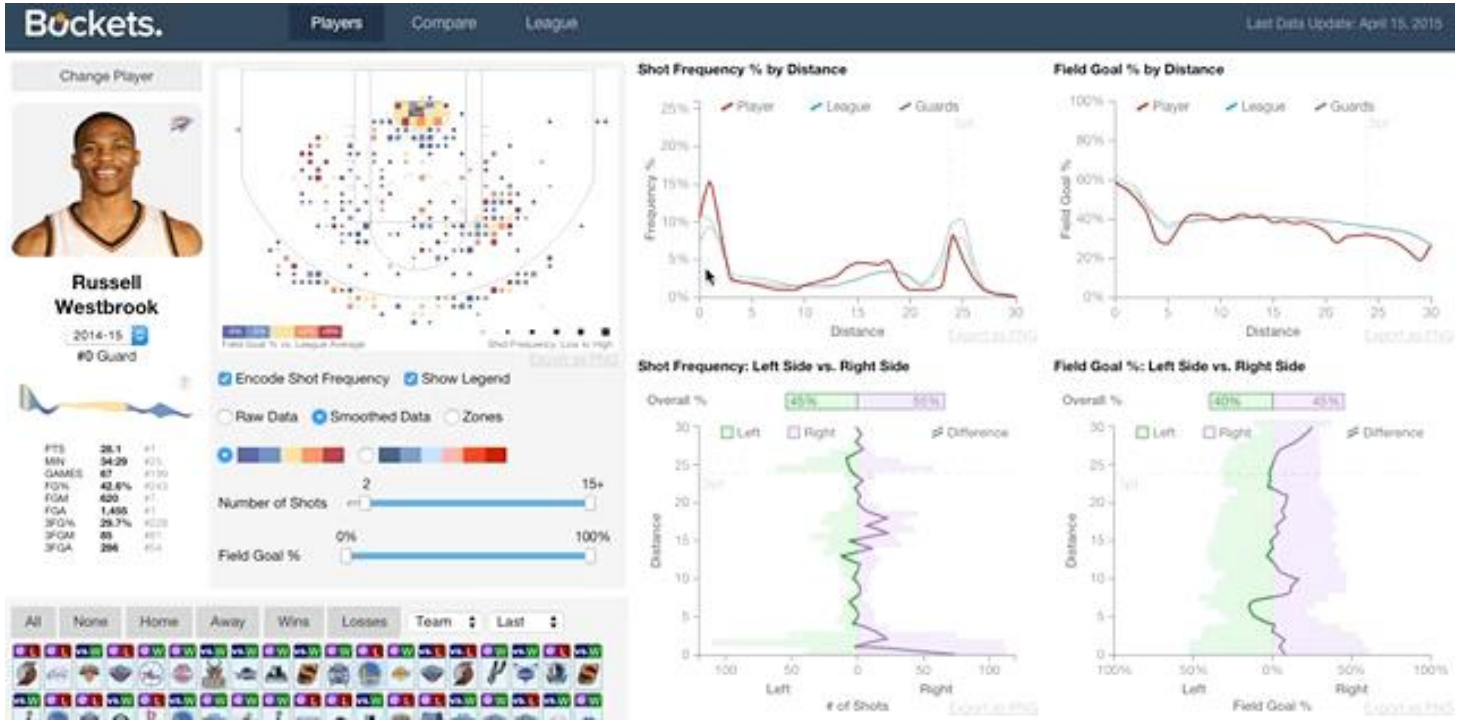


Population: les cantons et les 10 plus grandes villes de la Suisse



Example using React. D3.js and Reflux

Facet > Juxtapose: Linked views: Multidirectional linking



Buckets, http://buckets.peterbeshai.com/

Linked Highlighting with React, D3.js and Reflux

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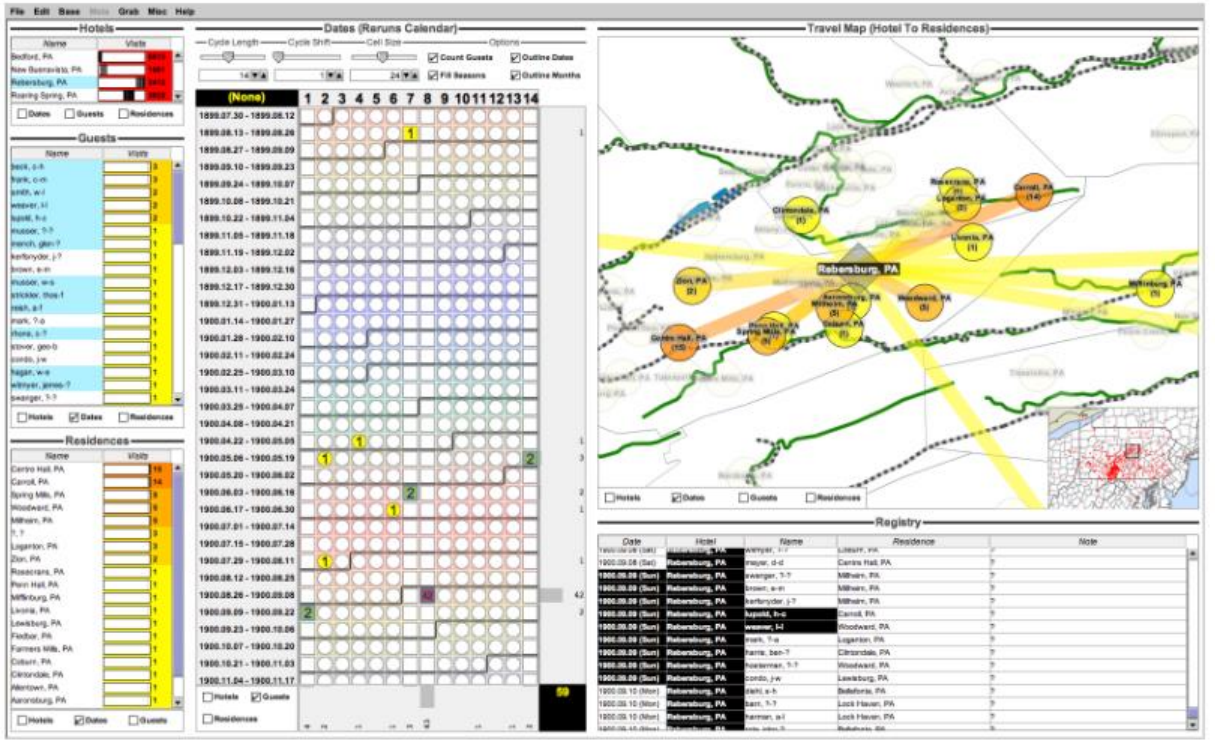
Facet > Juxtapose: coordinated multiple views

- Visual Analysis of Historical Hotel Visitation Patterns



Improvise
http://www.cs.ou.edu/~weaver/improvise/examples/hotels/

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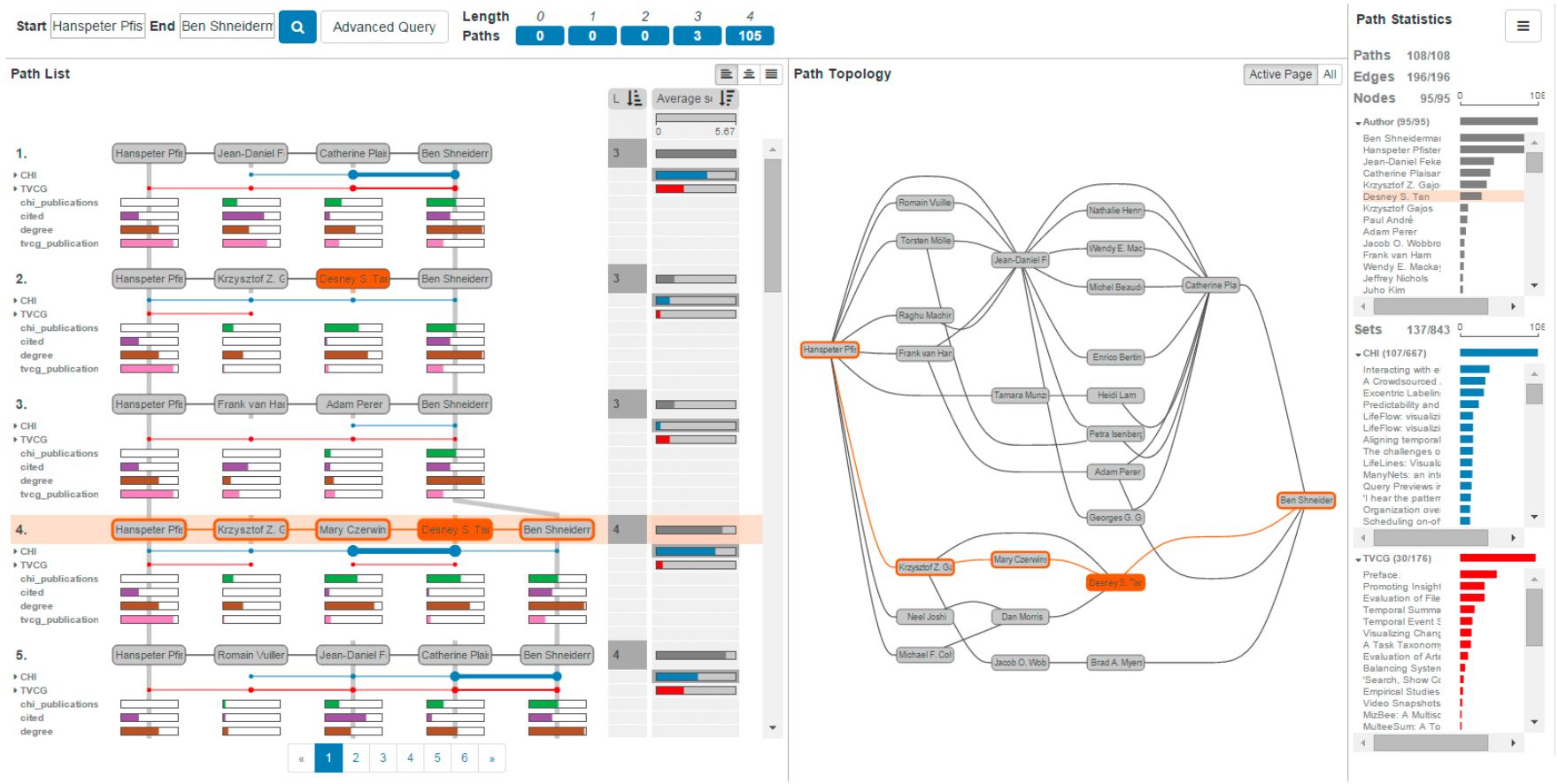
Facet > Juxtapose: Complex linked multiform views

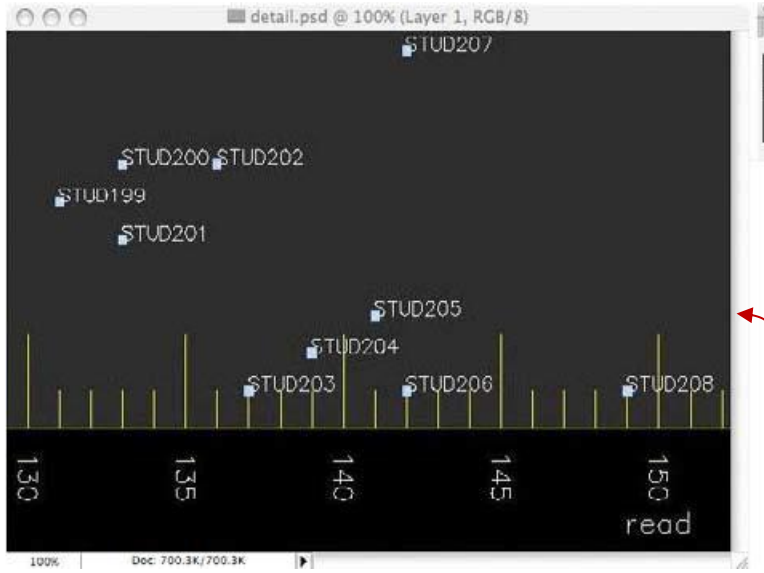


Pathfinder

slide by Tamara Munzner

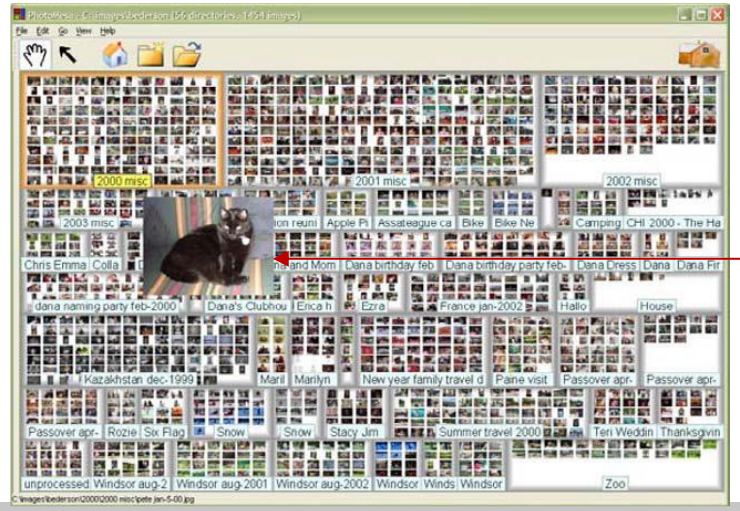
Facet > Overview-detail views

- Examples of overview – detail (non infoviz)



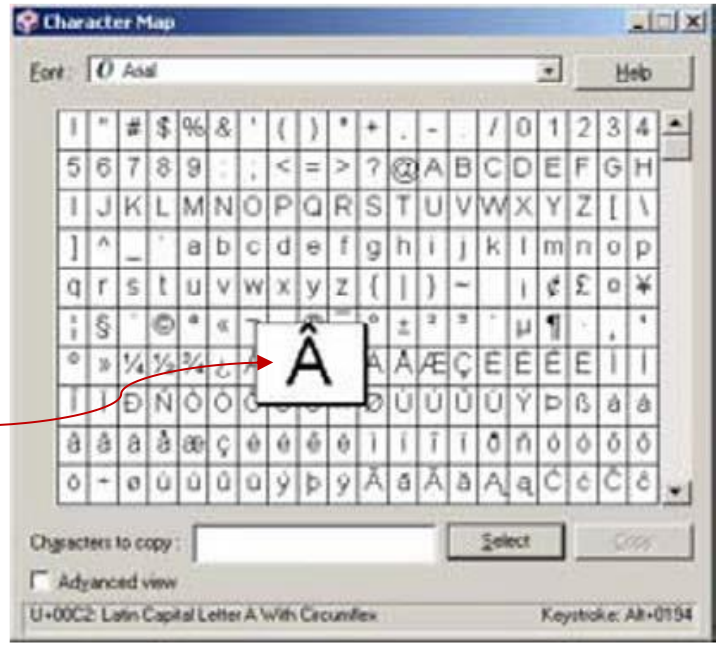
overview

detail



detail

overview



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Facet > Overview-detail views

- a subset of data shared
- navigation shared (bidirectional linking

- differences
  - viewpoint
  - (size)

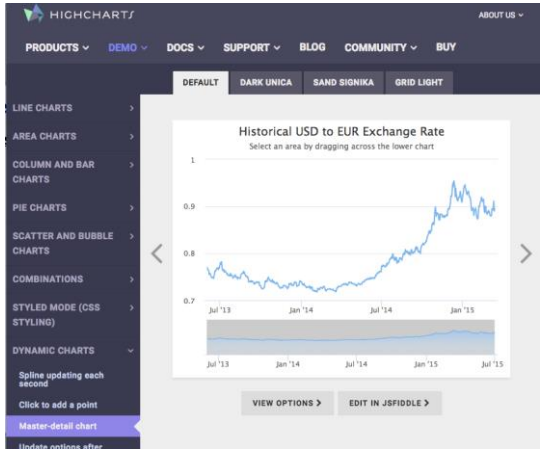
- special case:
  birds-eye map

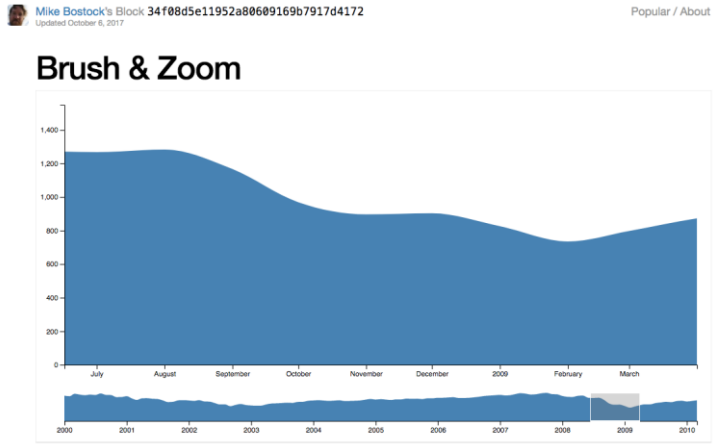
A Review of Overview+Detail, Zooming, and Focus+Context Interfaces.
Cockburn, Karlson, and Bederson. ACM Computing Surveys 41:1 (2008), 1–31.

slide by Tamara Munzner

Facet > Overview-detail navigation

- encoding: same
- data: subset shared
- navigation: shared
  - unidirectional linking
  - select in small overview
  - change extent in large detail view





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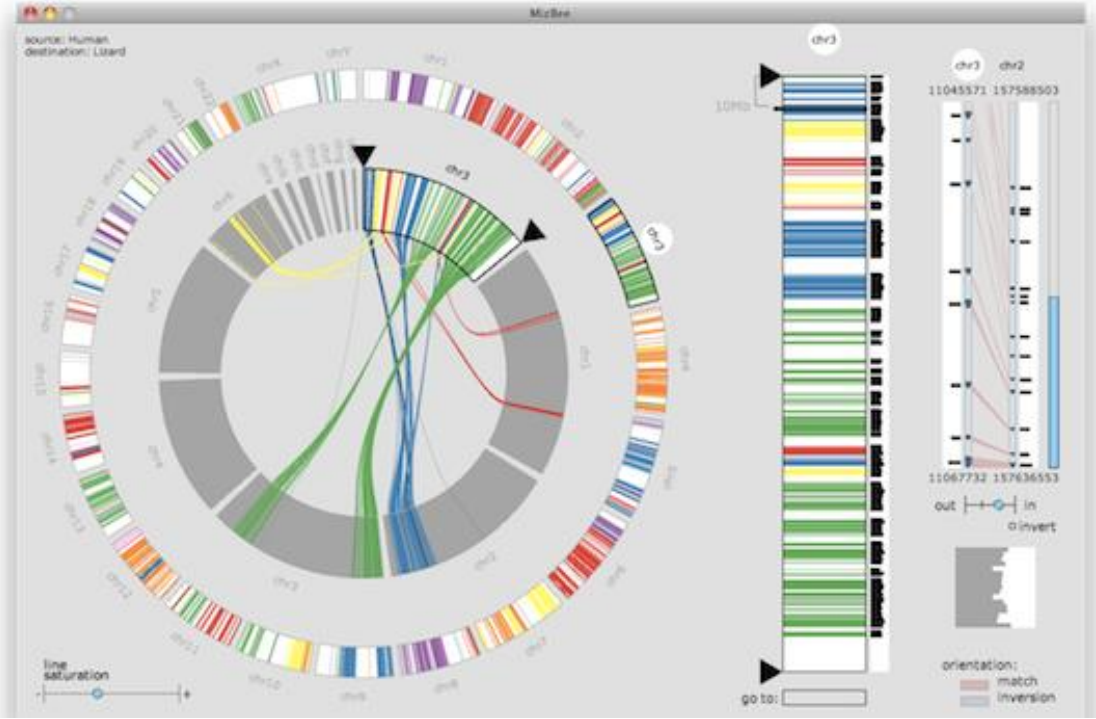
Facet > Overview-detail

- multiscale: three viewing levels side-by-side
  - linked views
  - dynamic filtering
  - tooling: processing (modern version: p5js.org)



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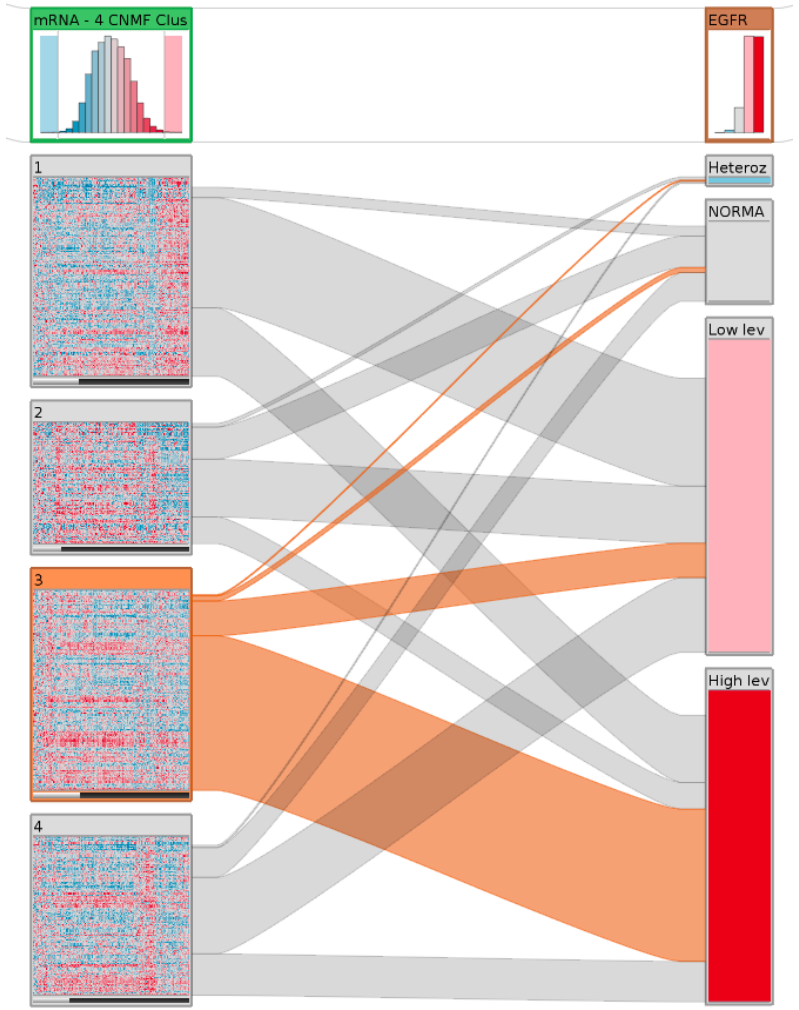
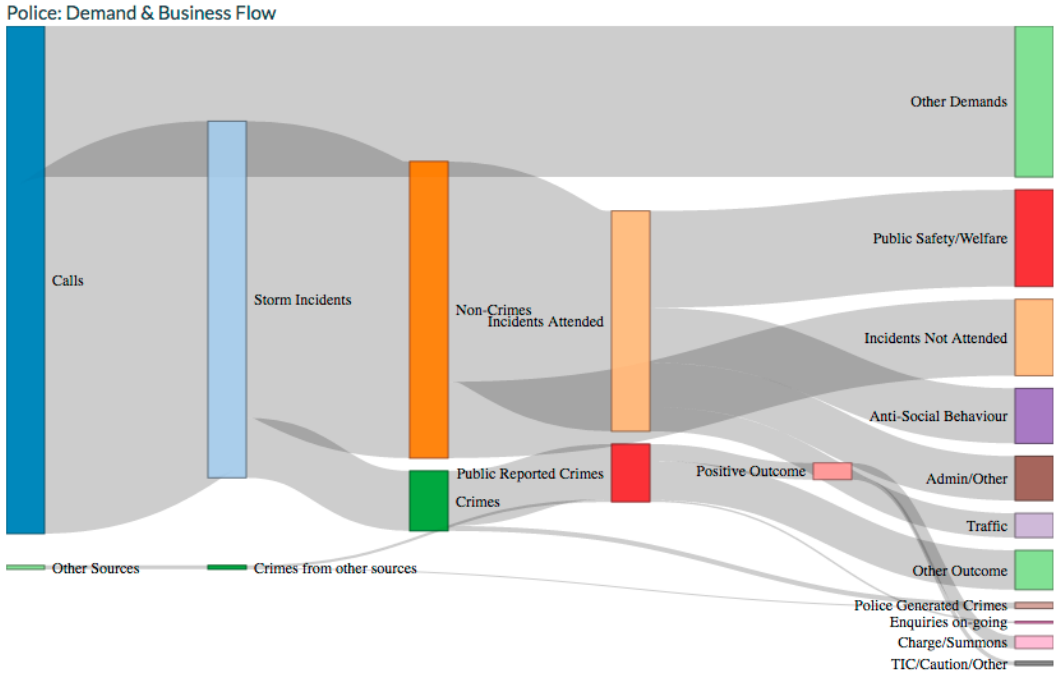
Facet > Overview-detail



https://www.youtube.com/watch?v=UcKDbGqHsdE

slide by Tamara Munzner

Facet > Flows: R/Shiny



https://gallery.shinyapps.io/TSupplyDemand/

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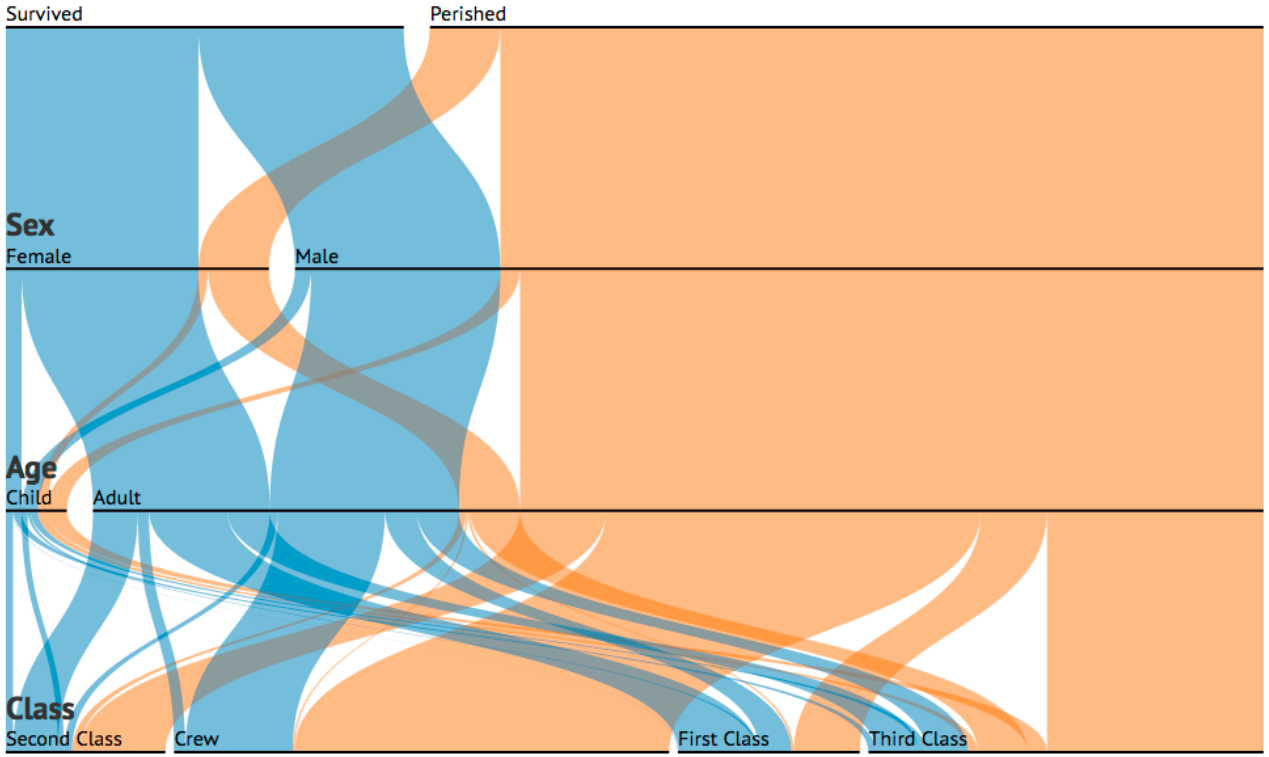
Facet > Parallel sets



https://www.jasondavies.com/parallel-sets/

https://eagereyes.org/parallel-sets

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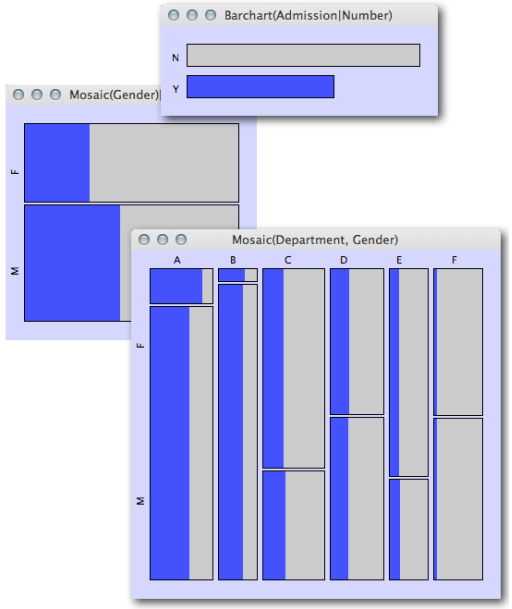
Facet > Mosaic plots



http://www.theusrus.de/blog/understanding-mosaic-plots/

http://www.theusrus.de/Mondrian/

http://www.theusrus.de/blog/making-movies/

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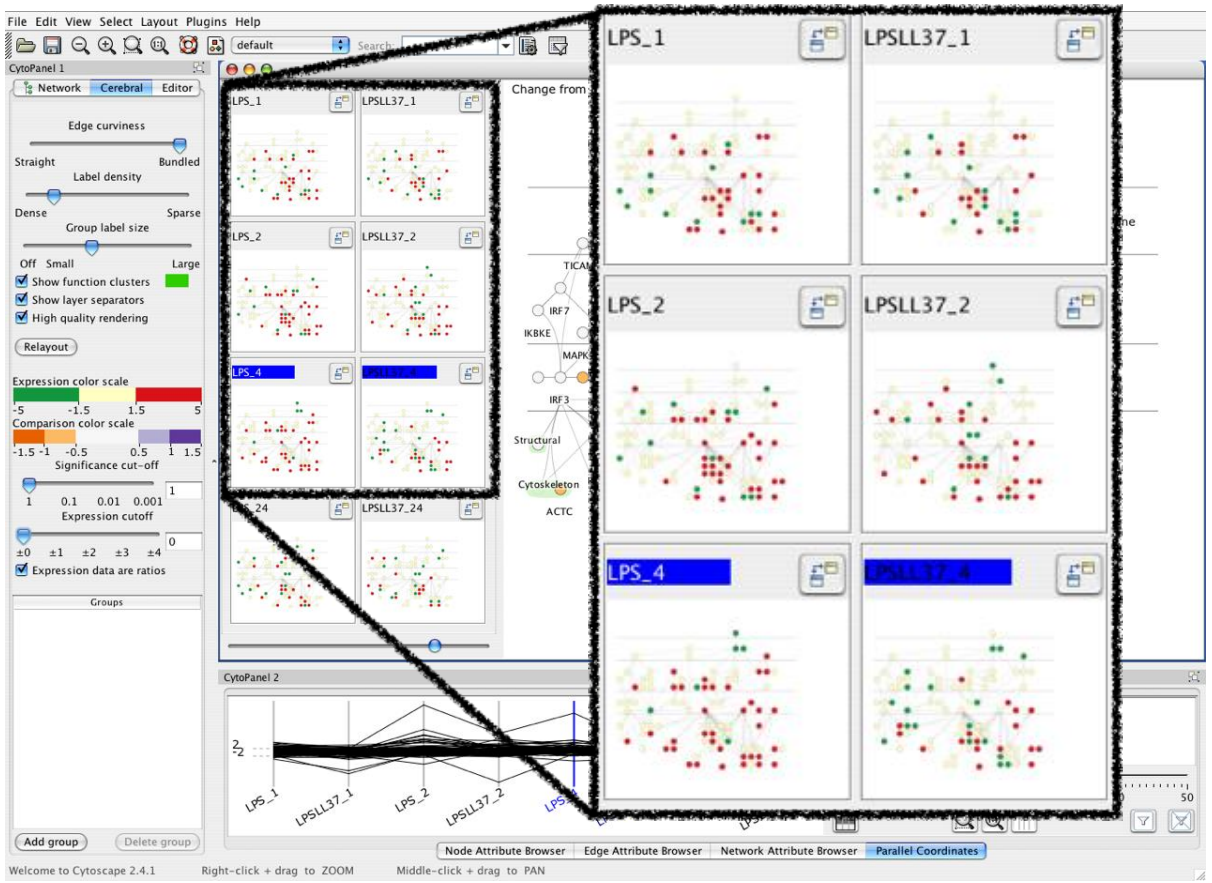
Facet > Small multiples

- encoding: same
- no shared data
  - different attributes for node colors
  - (same network layout)
- shared navigation



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.

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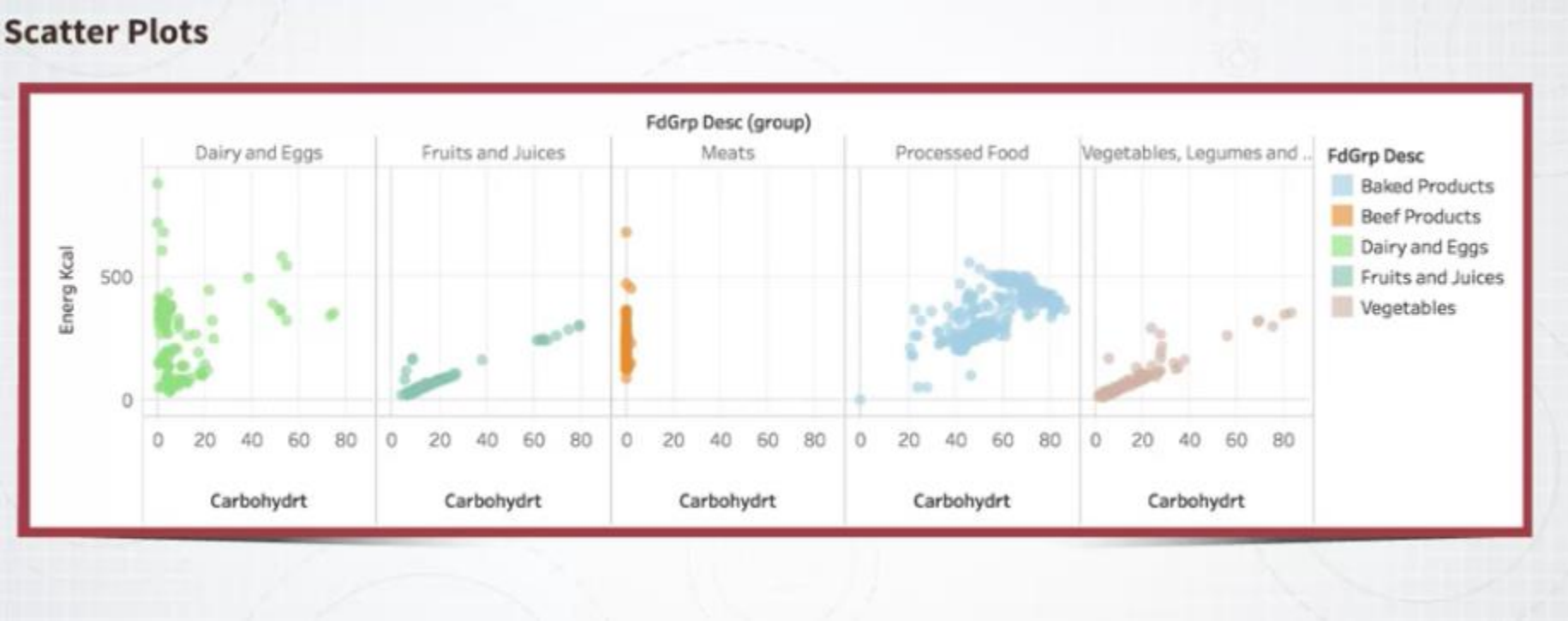
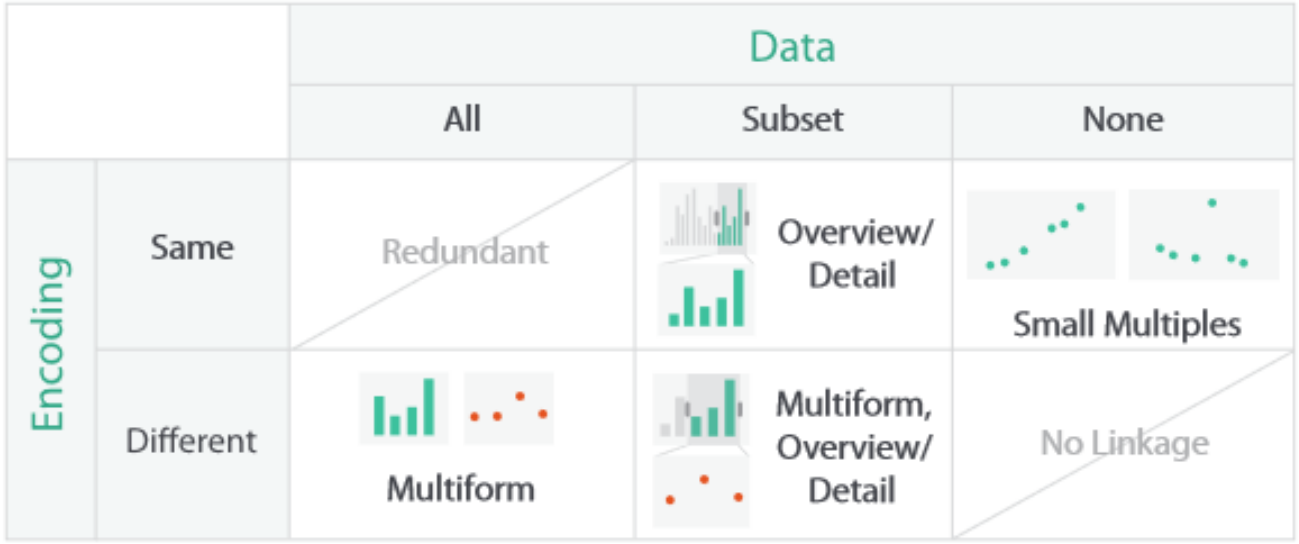
Facet > Small multiples

Facet > Small multiples



Facet > Coordinate views: Design choice interaction

- 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



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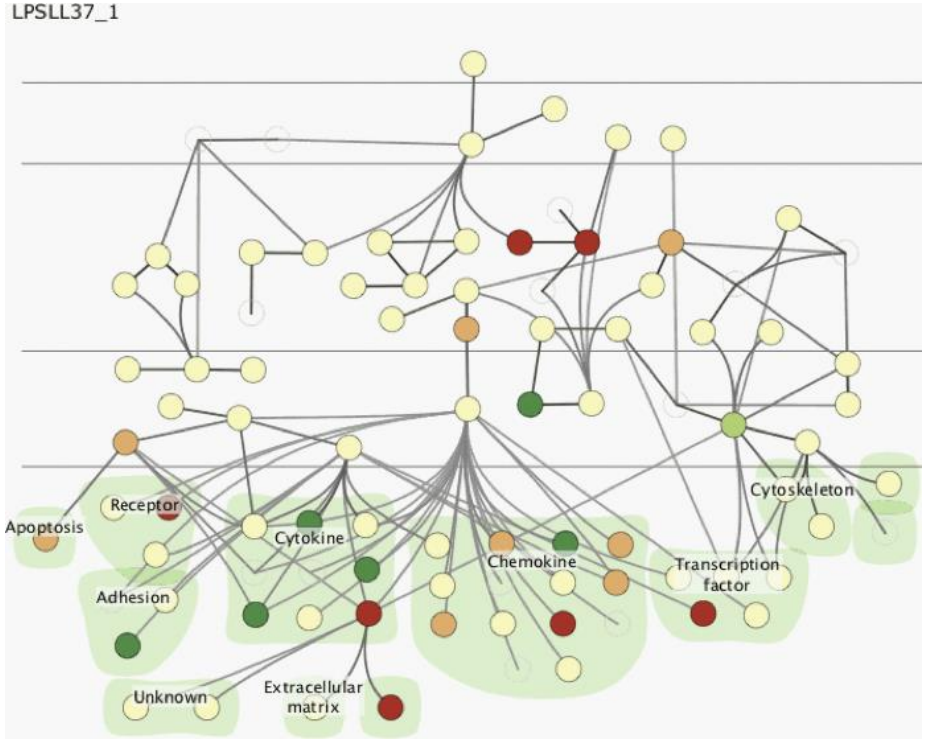
Facet > Why not animation?

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



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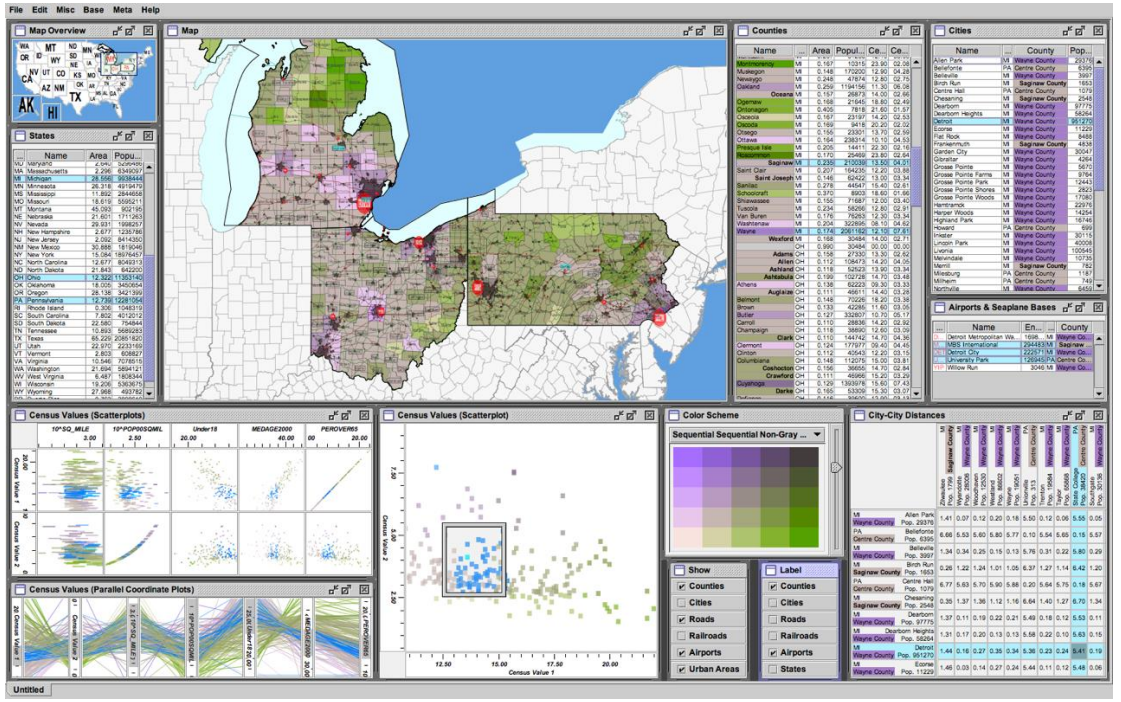
Facet > Improvise

- 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.]

slide by Tamara Munzner

Facet > Partition into views

- how to divide data between 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

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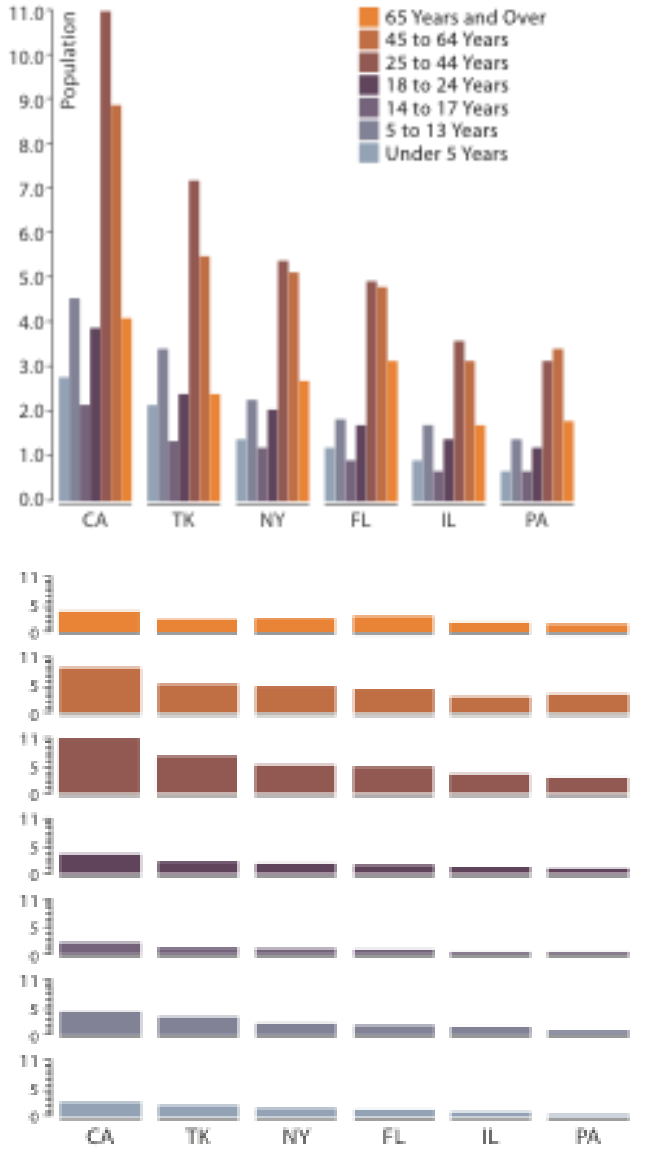
Facet > Partitioning: List alignment

- 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



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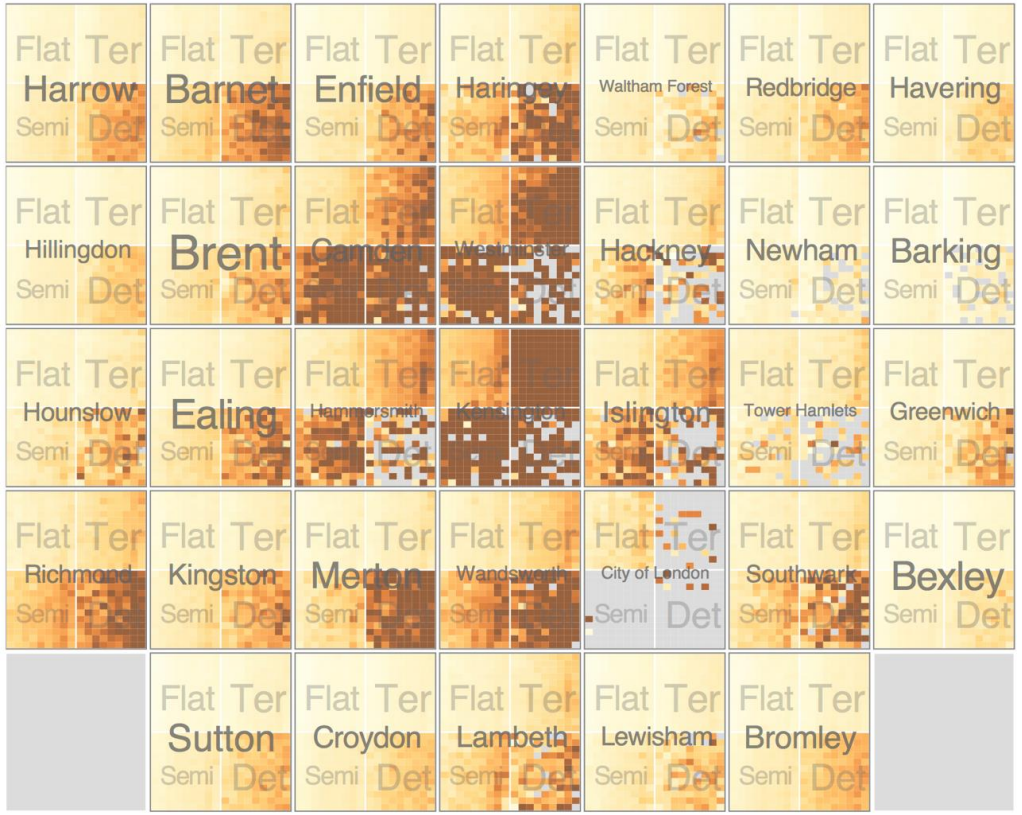
Facet > Partitioning: Recursive subdivision

- split by
  - neighborhood
  - type
  - 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.

slide by Tamara Munzner

Facet > Partitioning: Recursive subdivision

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

HIVE

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.

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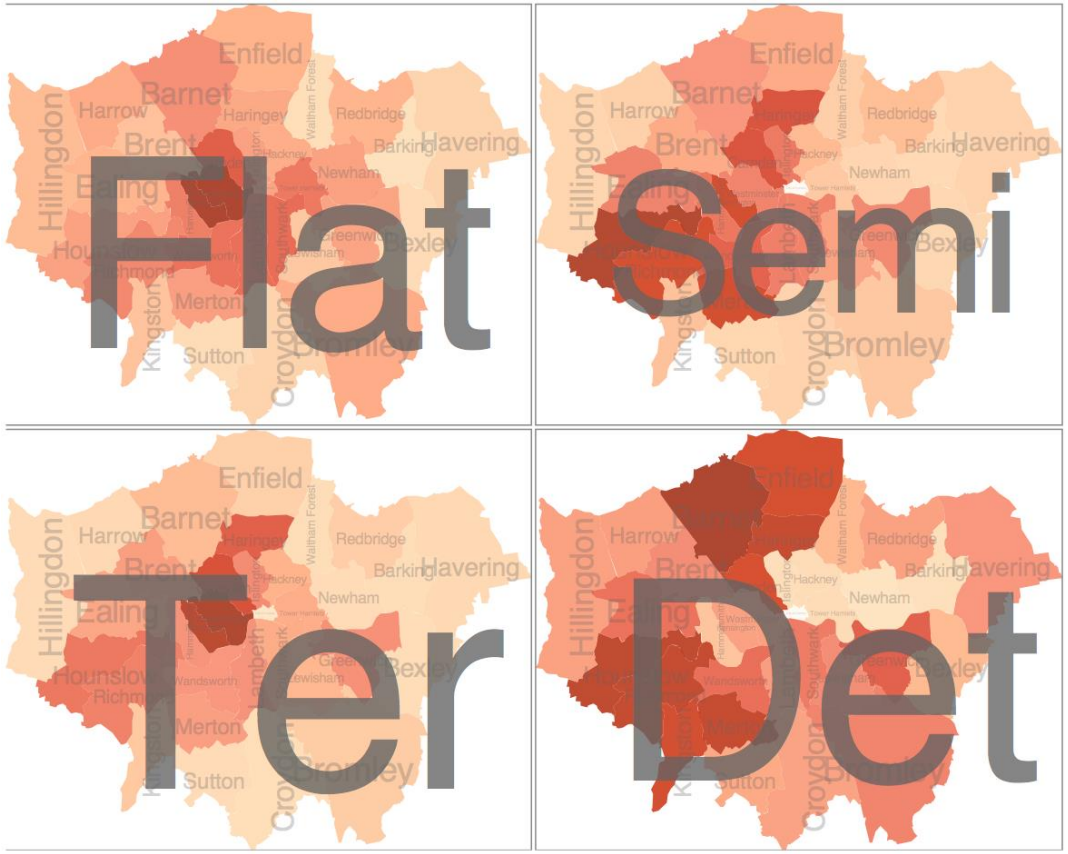
Facet > Partitioning: Recursive subdivision

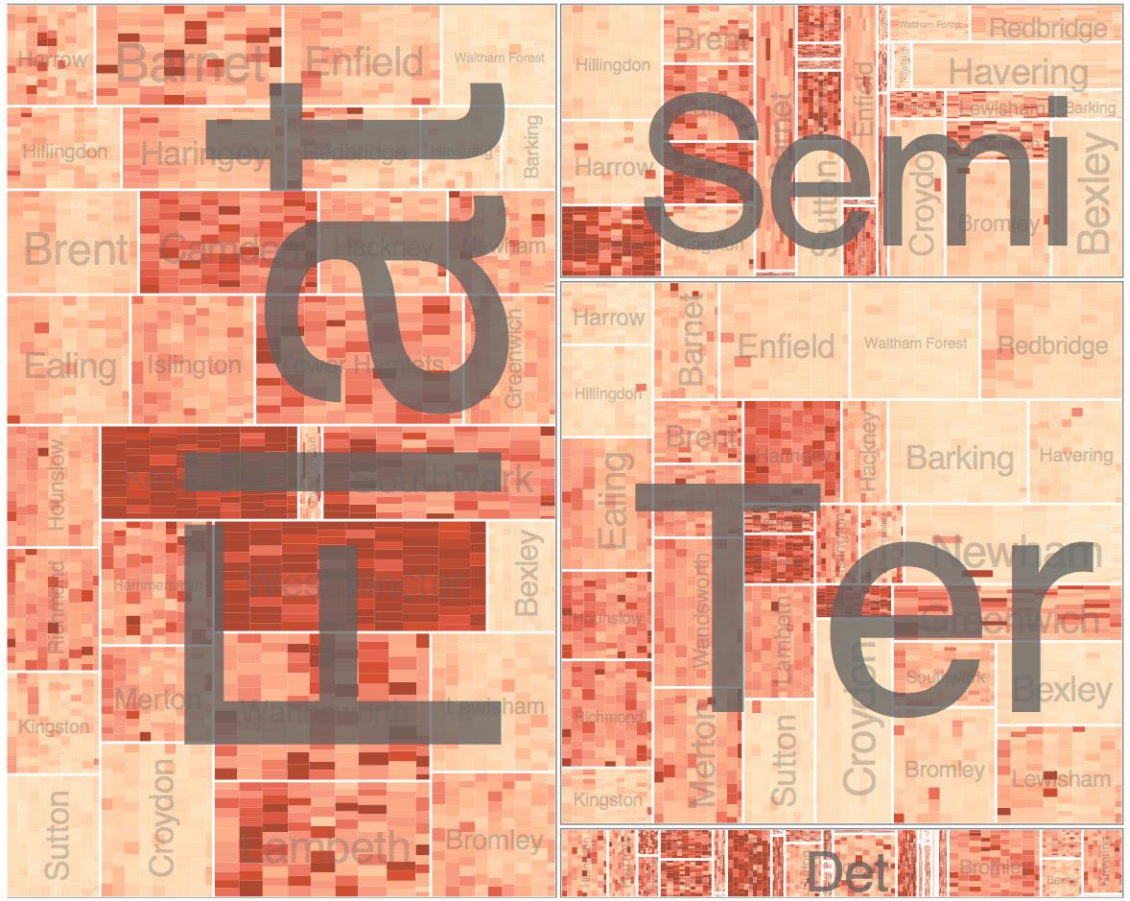
- different encoding for second-level regions
  - choropleth maps



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.

Facet > Partitioning: Recursive subdivision

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

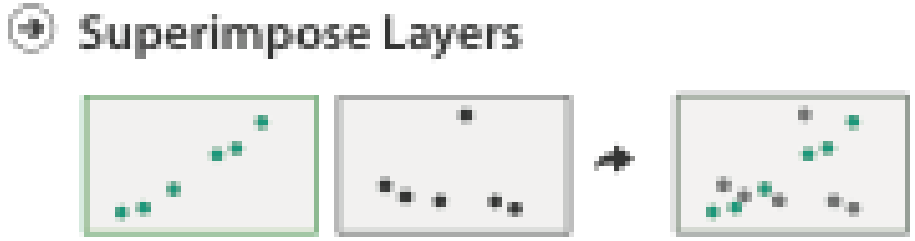


HIVE

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

Facet > 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?

slide by Tamara Munzner

Facet > Static visual layering

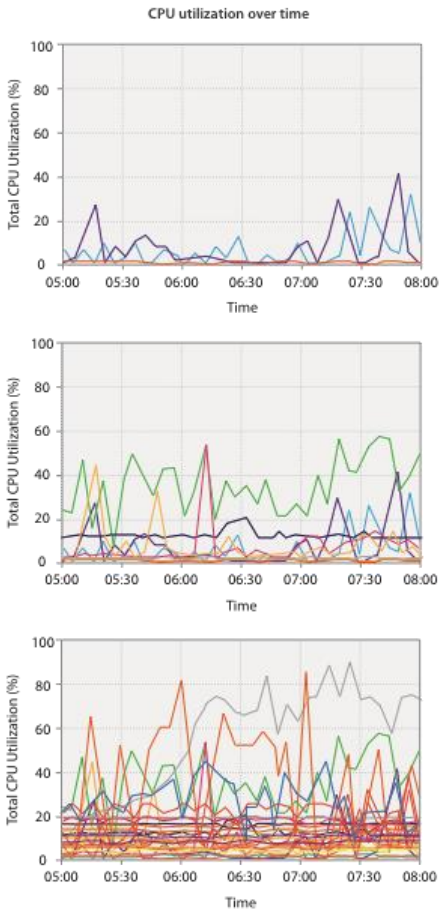
- foreground layer: roads
  - hue, size distinguishing main from minor
  - high luminance contrast from background
- background layer: regions
  - desaturated colors for water, parks, land areas
- user can selectively focus attention
- "get it right in black and white"
  - check luminance contrast with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

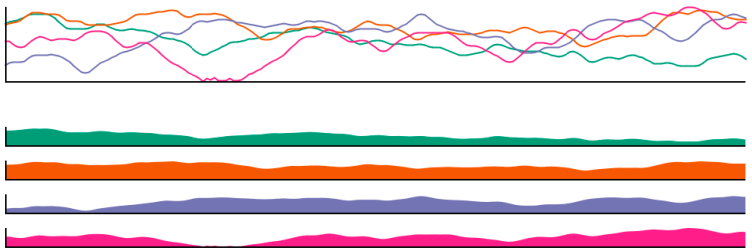
Get it right in black and white, Stone 2010.

slide by Tamara Munzner

Facet > 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



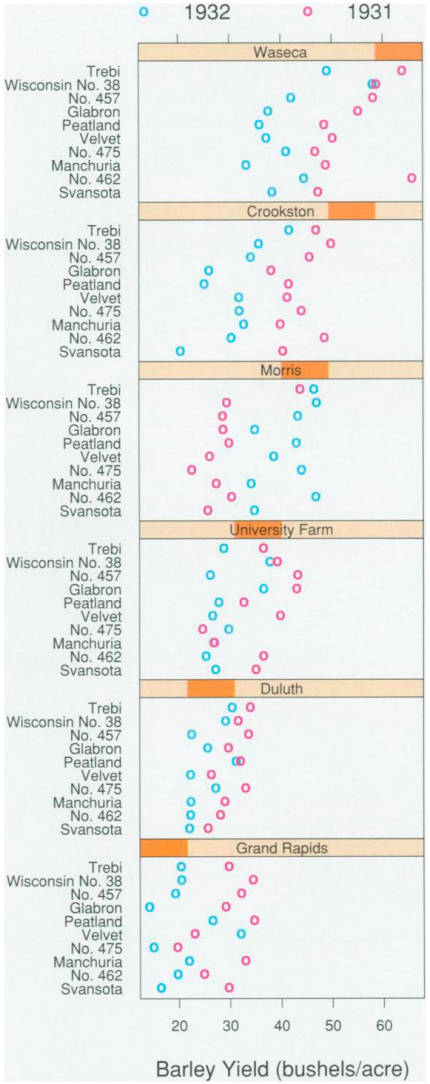


[Graphical Perception of Multiple Time Series. Javed, McDonnel, and Elmqvist. IEEE Transactions on Visualization and Computer Graphics (Proc. IEEE InfoVis 2010) 16:6 (2010), 927–934.]

slide by Tamara Munzner

Facet > Trellis plots

- superimpose within same frame
  - color code by year
- partitioning
  - split by site, rows are wheat varieties
- main-effects ordering
  - derive value of median for group, use to order
  - order rows within view by variety median
  - order views themselves by site median



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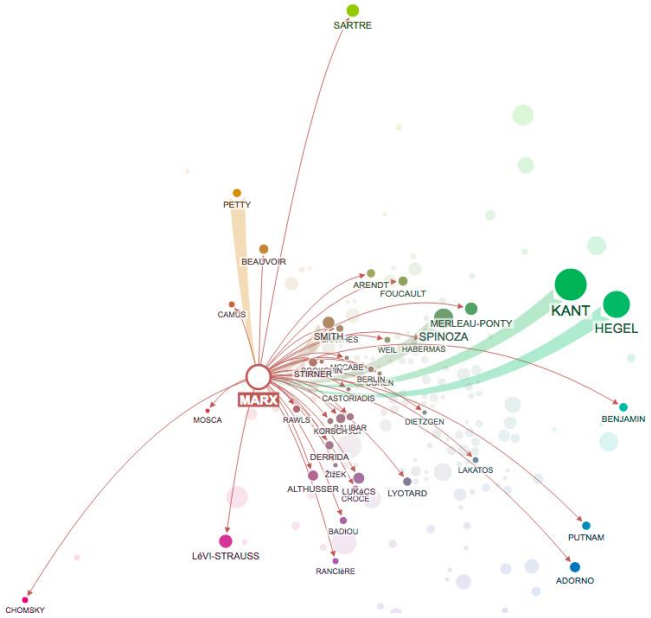
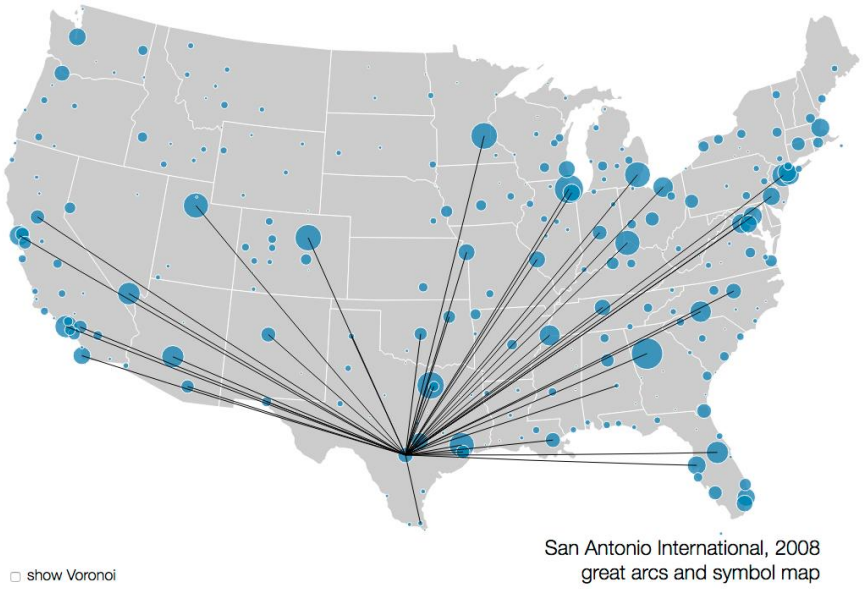
Facet > Dynamic visual layering

- interactive based on selection
- one-hop neighbor highlighting demos: click vs hover (lightweight)





http://mariandoerk.de/edgemaps/demo/ http://mbostock.github.io/d3/talk/20111116/airports.html

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Facet > multiple views example

NASA earth observatory

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

slide by Tamara Munzner

Interaction taxonomy (Munzner)

- How to handle complexity: 1 + 3 strategies

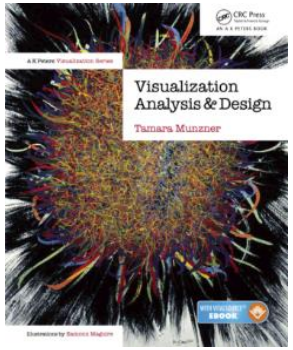
derive new data to show within view

change view over time

facet across multiple views

reduce items/attributes within single view

→ *Derive*



Tamara Munzner

Manipulate

- Change

- Select

- Navigate

Facet

- Juxtapose

- Partition

- Superimpose

Reduce

- Filter

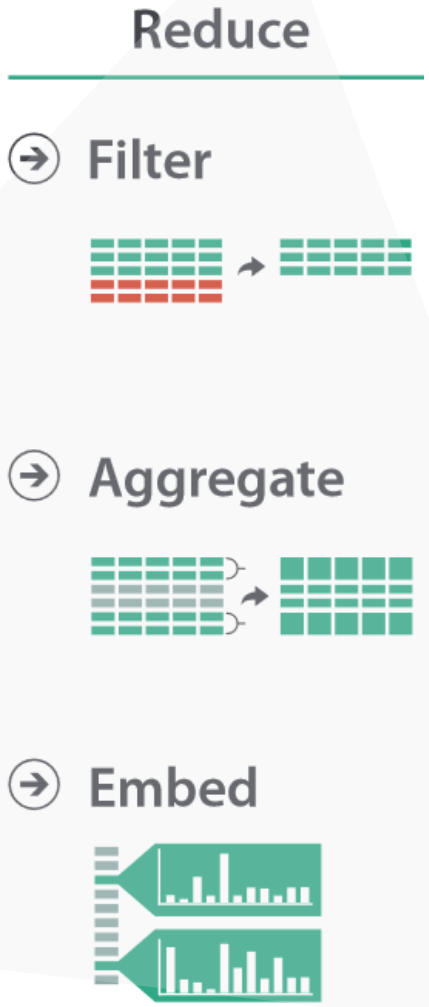
- Aggregate

- Embed

slide by Tamara Munzner

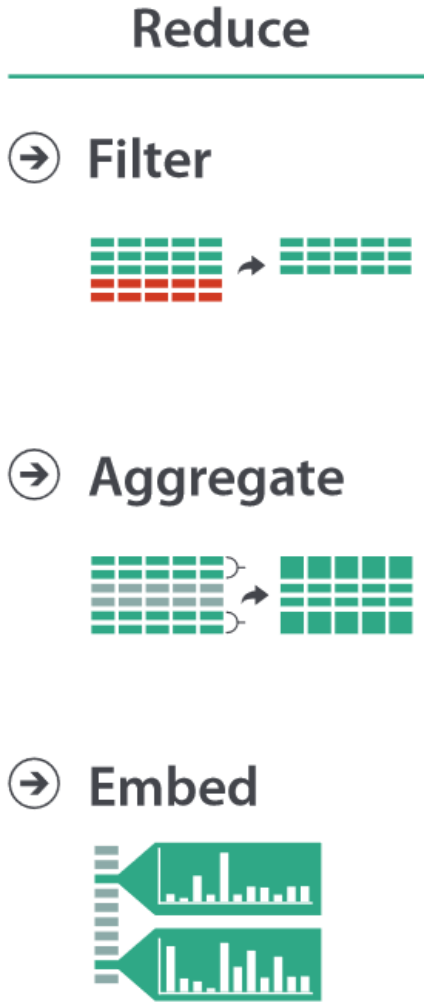
Interaction taxonomy (Munzner)

- Manipulate
  - Change
  - Select
  - Navigate
- Facet
  - Juxtapose
  - Partition
  - Superimpose
- **Reduce**
  - Filter
  - Aggregate
  - Embed



Reduce items and attributes

- Filter
  - straightforward and intuitive to understand and compute
  - …but, out of sight = out of mind
- Aggregation
  - inform about whole set
  - …but difficult to avoid losing signal
- not mutually exclusive
  - combine filter, aggregate
  - combine reduce, change, facet



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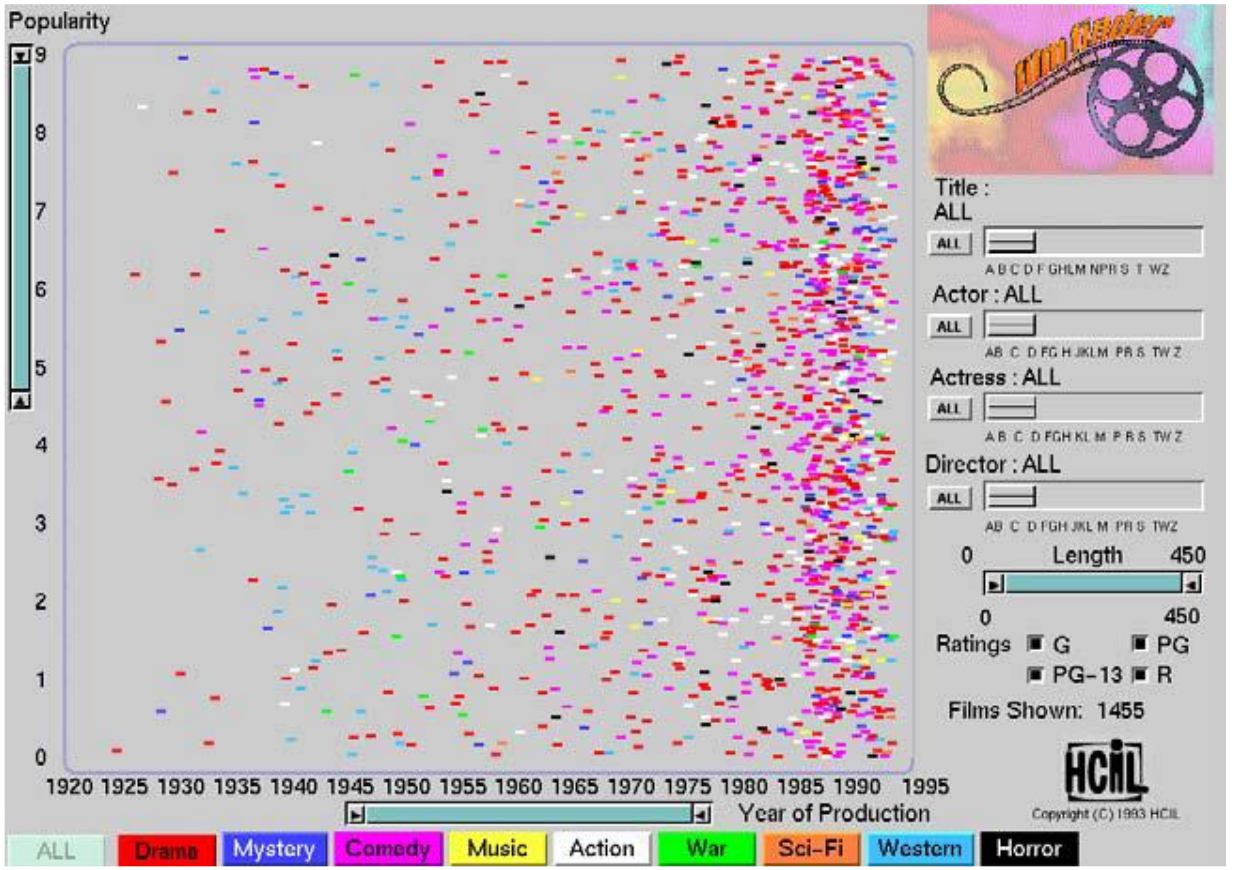
Reduce > Filter

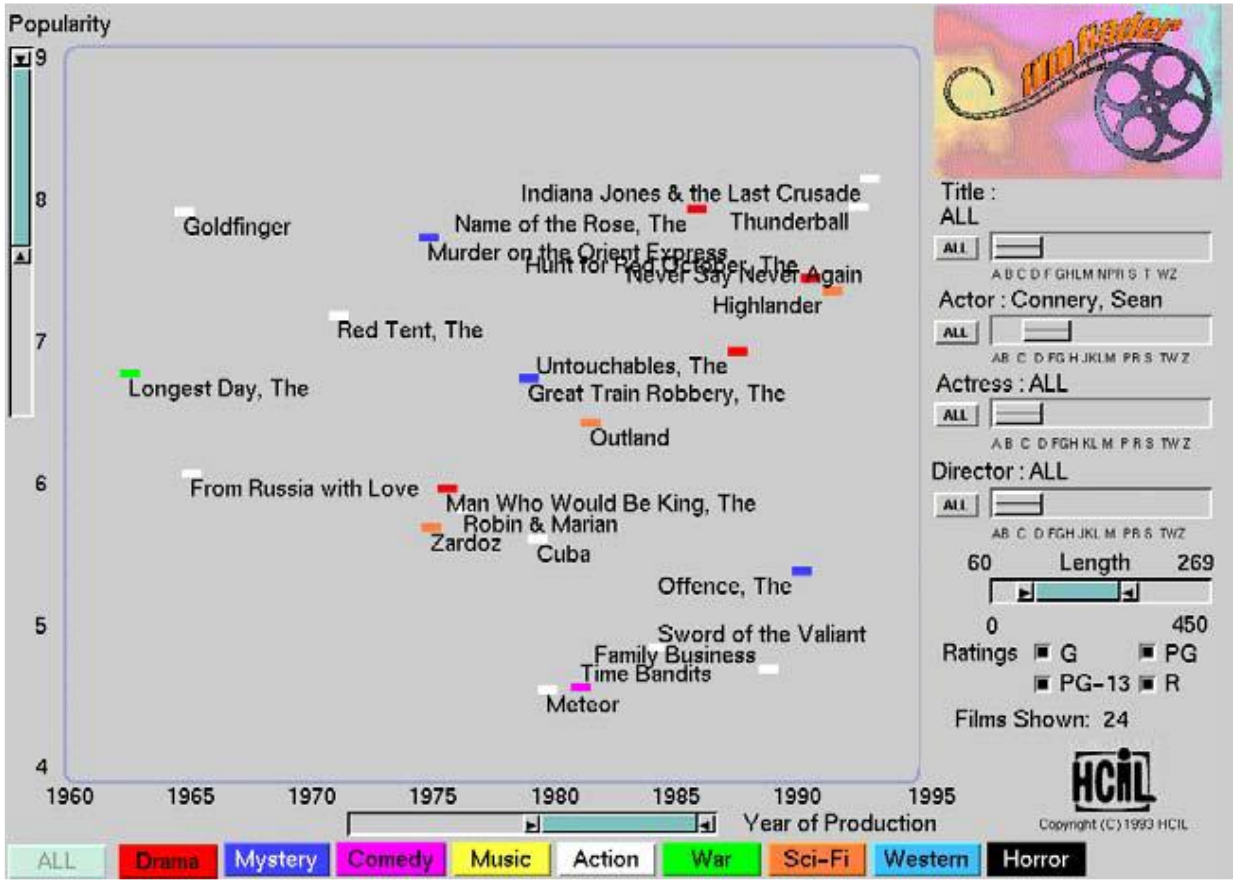
- FilmFinder (overview, filtering, and detail)



University of Maryland, 1994

Reduce > Filter

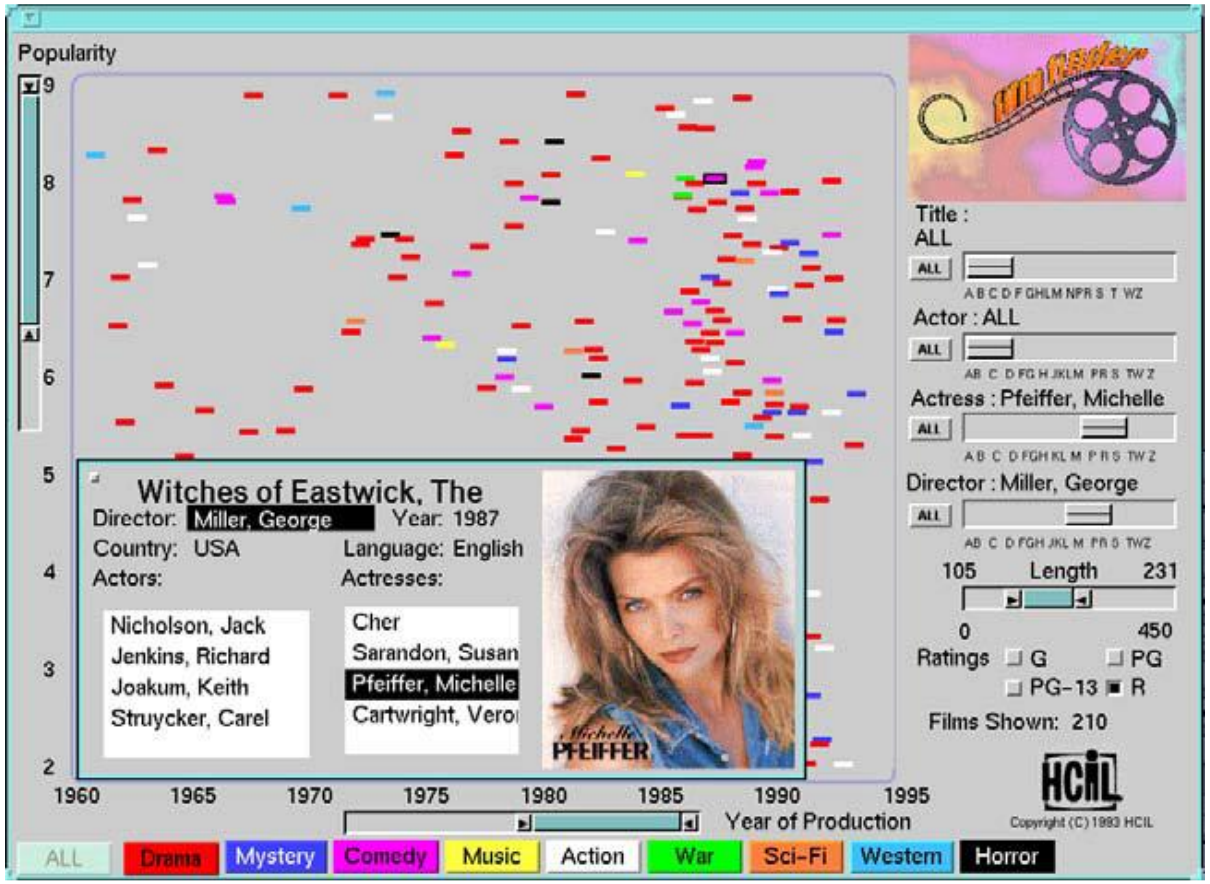
- FilmFinder (overview, filtering, and detail)



University of Maryland, 1994

Reduce > Filter

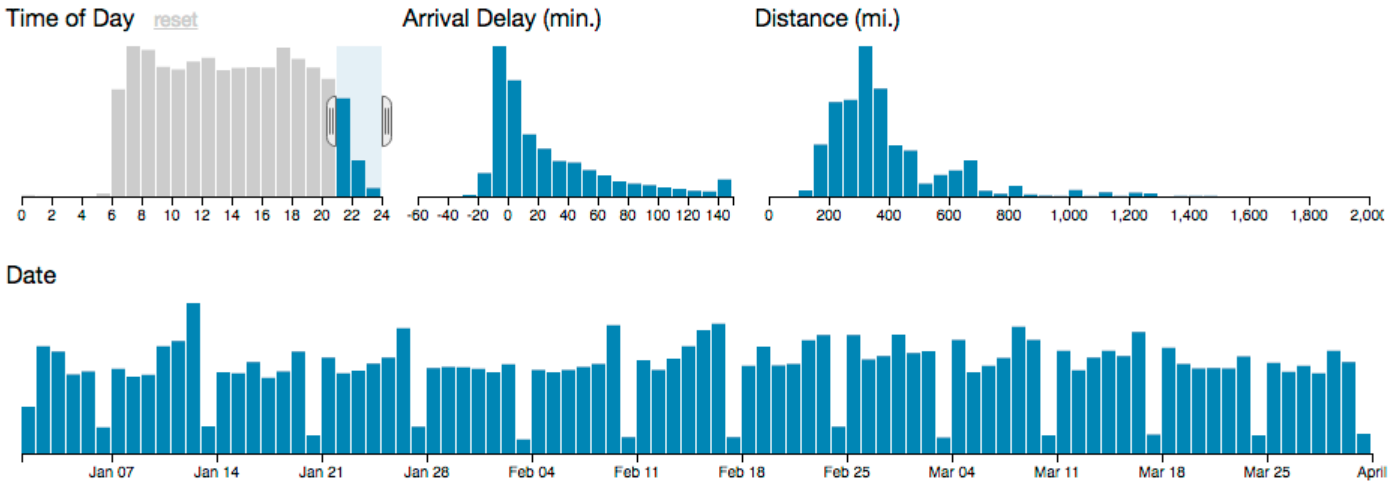
- FilmFinder (overview, filtering, and detail)



University of Maryland, 1994

Reduce > Filter: cross filtering

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



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

slide by Tamara Munzner

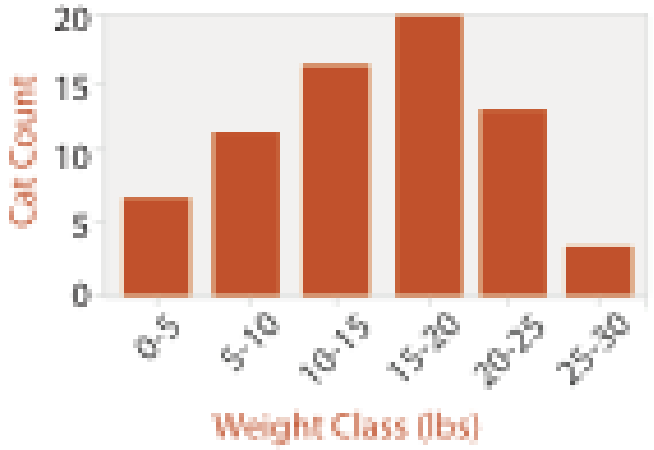
Reduce > Filter: cross filtering

https://www.nytimes.com/interactive/2014/upshot/buy-rent-calculator.html?_r=0

slide by Tamara Munzner

Reduce > Aggregate: histogram

- task: find distribution
- data: table
- derived data
  - new table: keys are bins, values are counts

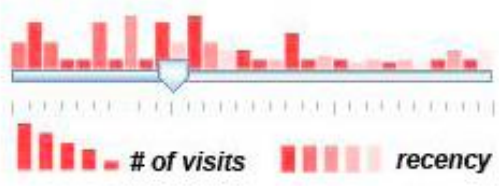


- bin size crucial
  - pattern can change dramatically depending on discretization
  - opportunity for interaction: control bin size on the fly

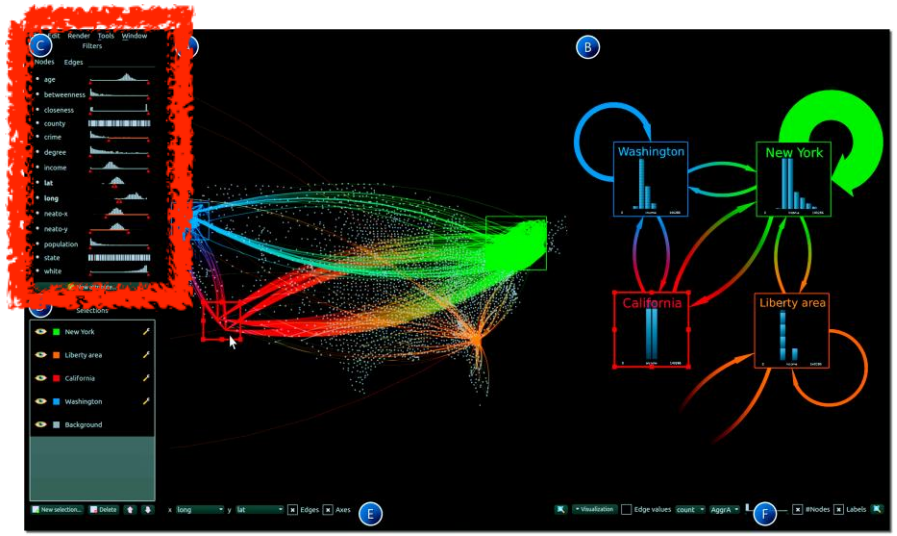
slide by Tamara Munzner

Reduce > Aggregate: scented widgets

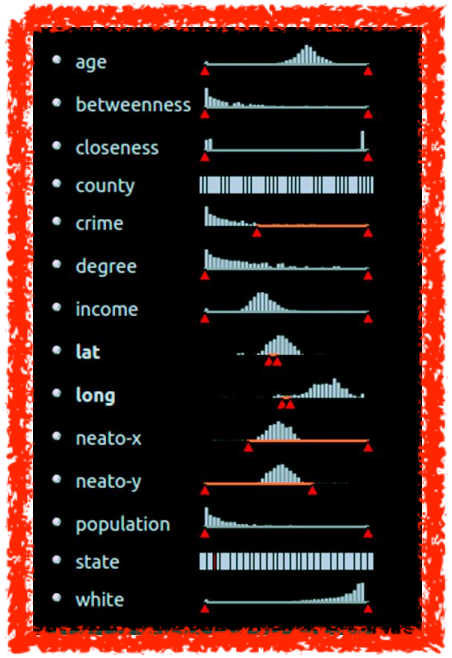
- augmented widgets show information scent
  - cues to show whether value in drilling down further vs looking elsewhere
- concise use of space: histogram on slider



[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).]



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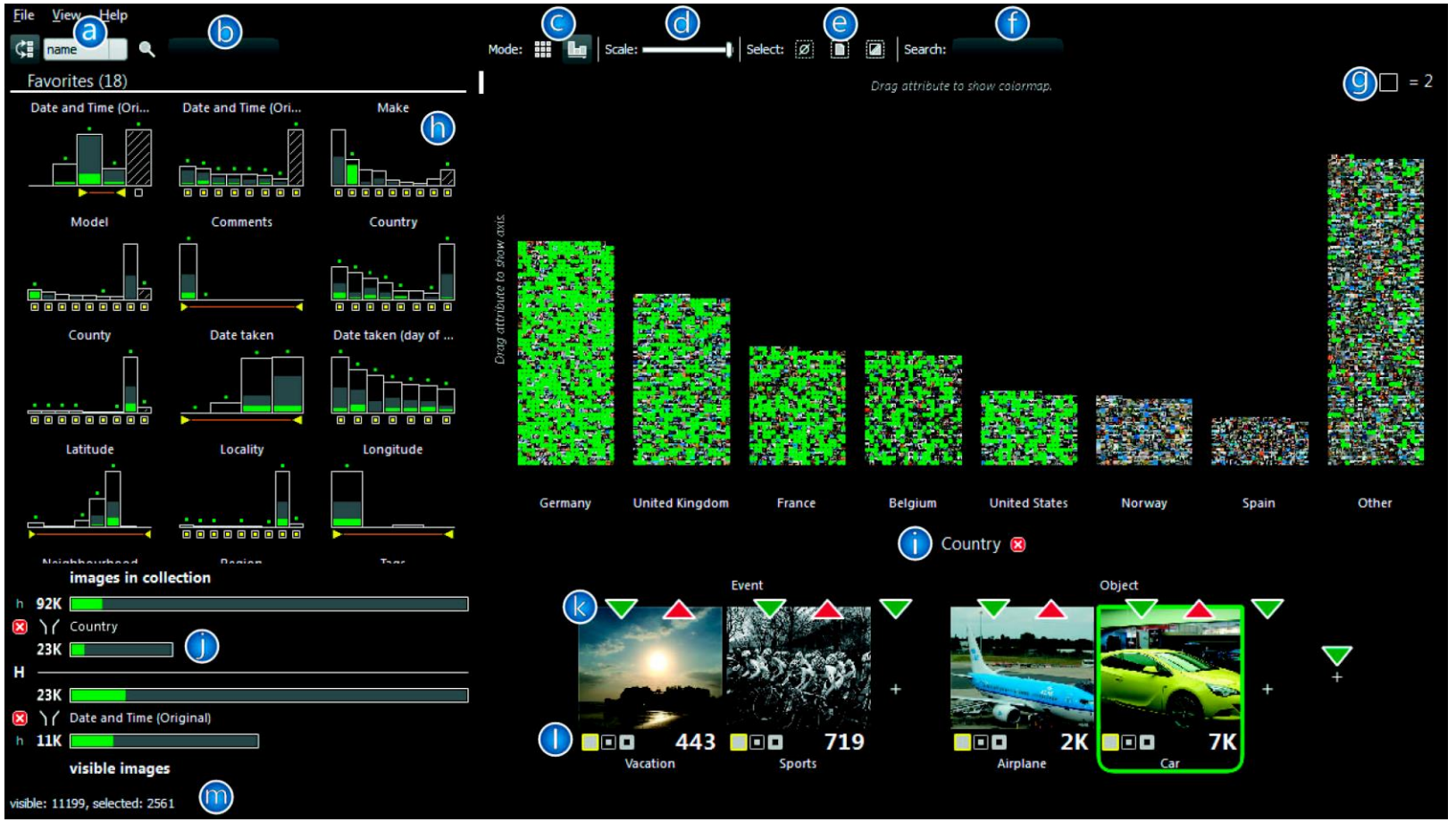
Reduce > Aggregate: Scented histogram bisliders: detailed

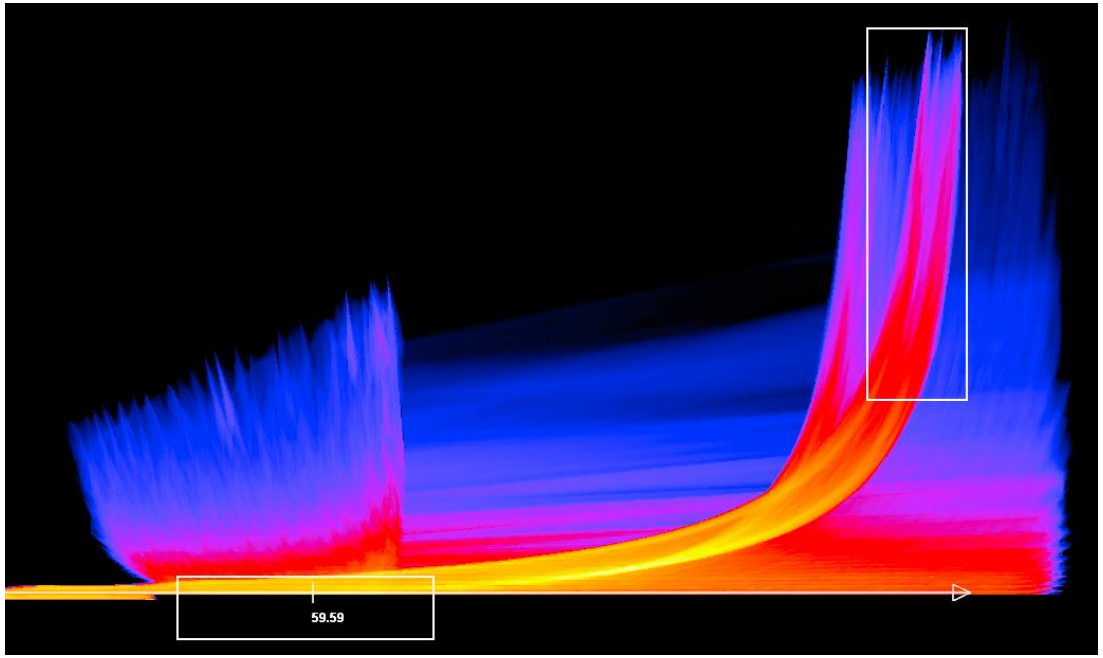


ICLIC: Interactive categorization of large image collections. van der Corput and van Wijk. Proc. PacificVis 2016.

slide by Tamara Munzner

Reduce > Aggregate: Continuous scatterplot

- data: table
- derived data: table
  - key attribs x,y for pixels
  - quant attrib:
    overplot density



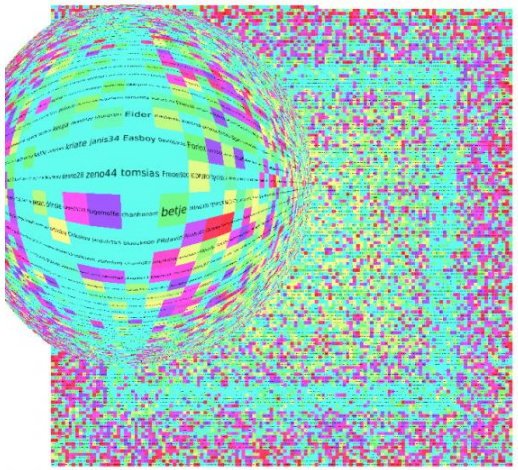
- dense space-filling 2D matrix
- color: sequential categorical hue + ordered luminance colormap

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

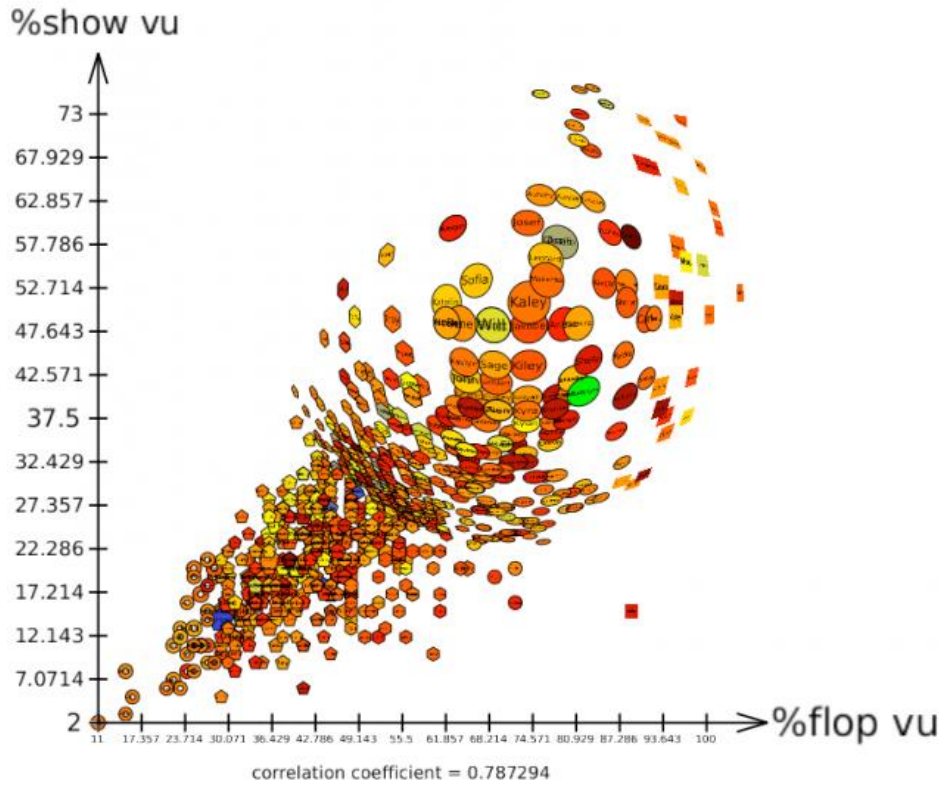
slide by Tamara Munzner

Reduce > Fisheye Lens

- distort geometry
  - shape: radial
  - focus: single extent
  - extent: local
  - metaphor: draggable lens



http://tulip.labri.fr/TulipDrupal/?q=node/351
http://tulip.labri.fr/TulipDrupal/?q=node/371



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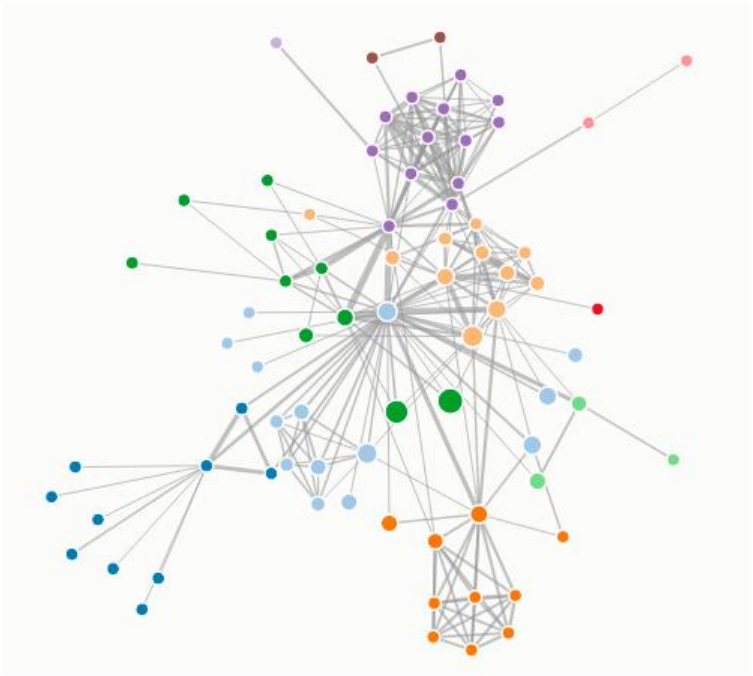
Reduce > Fisheye Lens



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

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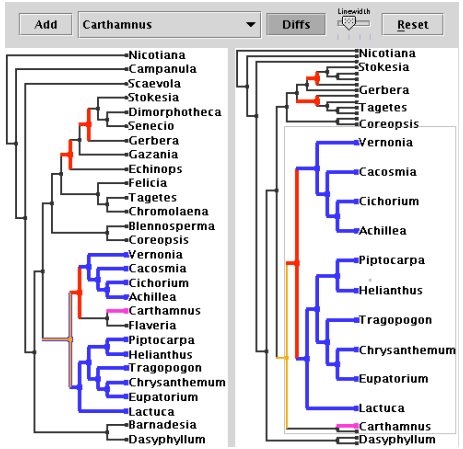
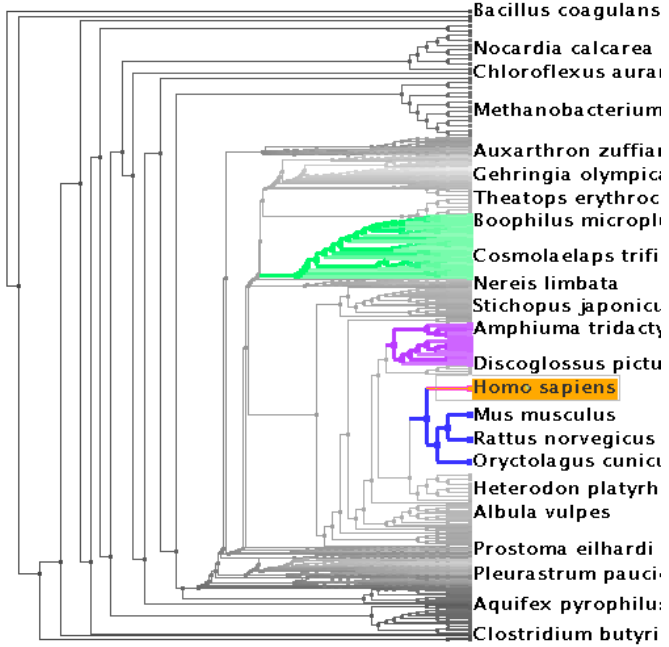
Reduce > Stretch and Squish Navigation

- distort geometry
  - shape: rectilinear
  - foci: multiple
  - impact: global
  - metaphor: stretch and squish, borders fixed





[https://youtu.be/GdaPj8a9QEo]

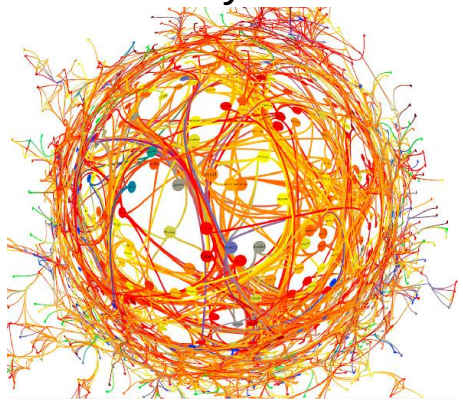
[TreeJuxtaposer: Scalable Tree Comparison Using Focus+Context With Guaranteed Visibility. Munzner, Guimbretiere, Tasiran, Zhang, and Zhou. ACM Transactions on Graphics (Proc. SIGGRAPH) 22:3 (2003), 453– 462.]

slide by Tamara Munzner

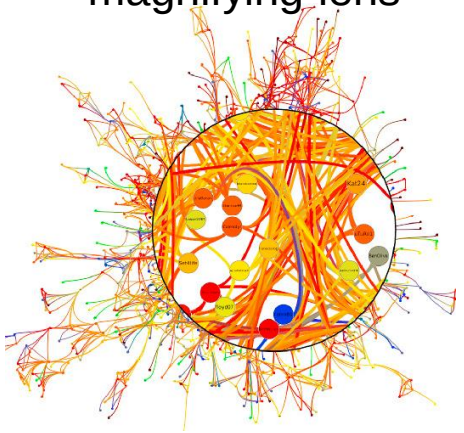
Reduce > Distortion costs and benefits

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

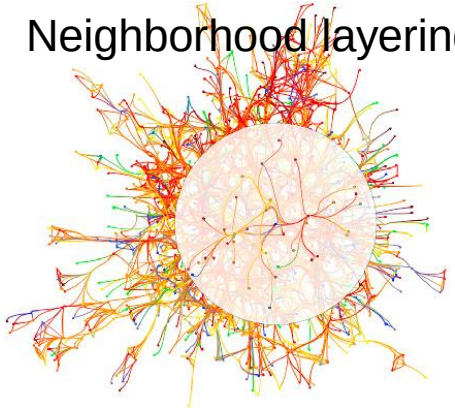
fisheye lens



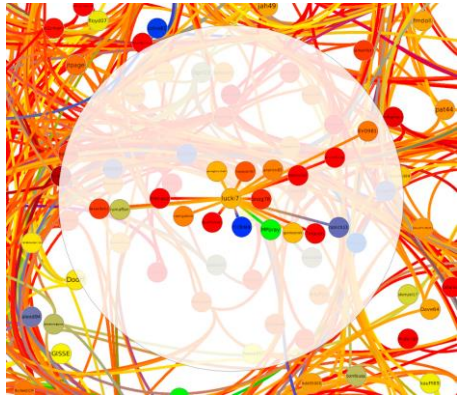
magnifying lens



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.

Further reading

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Thank you!

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