UNIVERSITÀ DI TORINO

Analisi e Visualizzazione di Reti Complesse

DV08 - Interactive Views

Prof. Rossano Schifanella

How to handle complexity: 1 previous strategy

➔ *Derive*

derive new data to show within the view

How to handle complexity: 1 previous strategy + 2 more

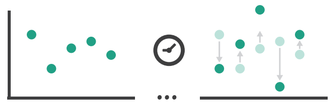
→ *Derive*

derive new data to show within the view

change view over time
facet across multiple views

Manipulate

→ **Change**



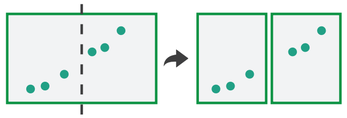
→ **Select**

→ **Navigate**

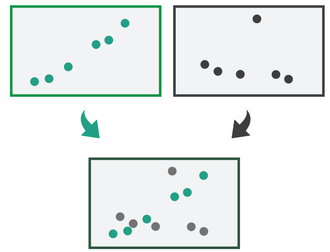
Facet

→ **Juxtapose**

→ **Partition**



→ **Superimpose**



Manipulate

Change over Time

Change over time

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

  - interaction entails **change**

- **powerful & flexible**

Idiom: 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

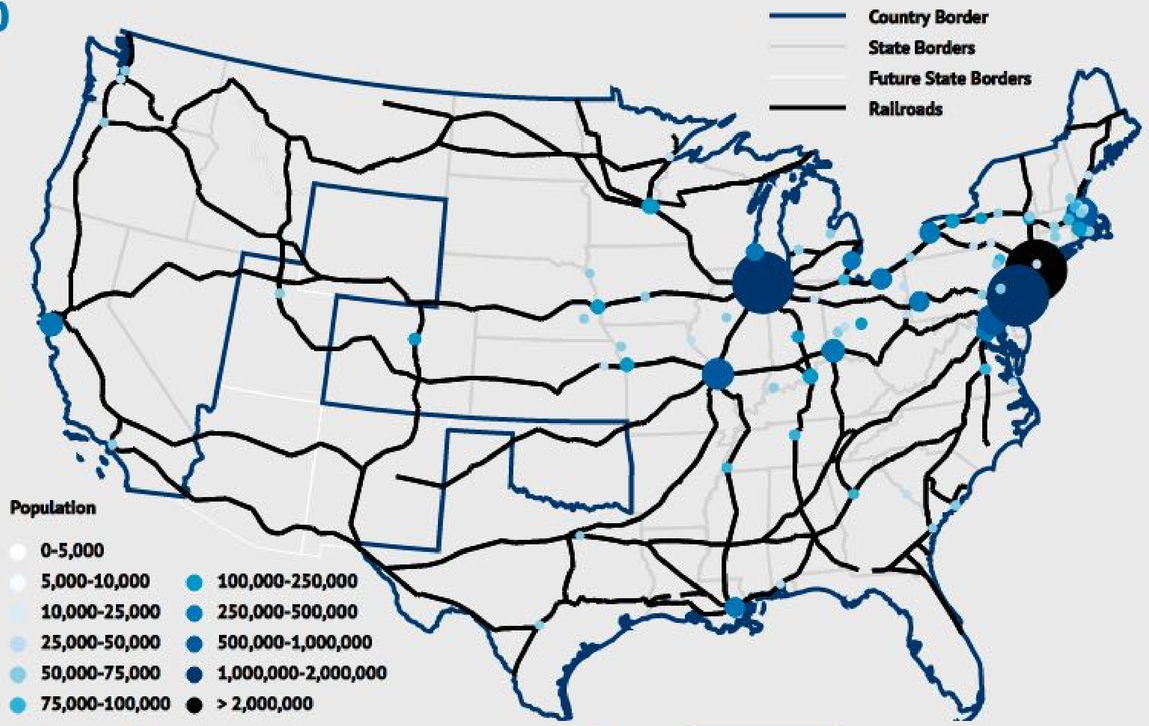
The Growth of a Nation

Or....how the railroads changed the face of America in the 1800's

The following visualization shows land, population and railroad growth in 19th Century America.

The Year 1890

By 1890, there were more than 165,000 miles of railroad tracks across the US. The massive railroad corporations had paved the way for other corporations that grew out of the industrial revolution of that time such as the Oriental Telephone and Standard Oil Companies. New technologies such as the telephone, light bulb and motion pictures were invented and became more mainstream.



Display population by: County City Display Railroads Select Year: Play Sequence

Numbers by the Decade

Miles of Railroad Tracks:

Land Area:

Population:

States: Delaware, 1787 · New Jersey, 1787 · Pennsylvania, 1787 · Connecticut, 1788 · Georgia, 1788 · Maryland, 1788 · Massachusetts, 1788 · New Hampshire, 1788 · New York, 1788 · South Carolina, 1788 · Virginia, 1788 · West Virginia, 1788 · North Carolina, 1789 · Rhode Island, 1790 · Vermont, 1791 · Kentucky, 1792 · Tennessee, 1796 · Ohio, 1803 · Louisiana, 1812 · Indiana, 1816 · Mississippi, 1817 · Illinois, 1818 · Alabama, 1819 · Maine, 1820 · Missouri, 1821 · Arkansas, 1836 · Michigan, 1837 · Florida, 1845 · Texas, 1845 · Iowa, 1846 · Wisconsin, 1848 · California, 1850 · Minnesota, 1858 · Oregon, 1859 · Kansas, 1861 · Nevada, 1864 · Nebraska, 1867 · Colorado, 1876 · Montana, 1889 · North Dakota, 1889 · South Dakota, 1889 · Washington, 1889

Legend: 1800 1810 1820 1830 1840 1850 1860 1870 1880 1890 1900

Largest cities

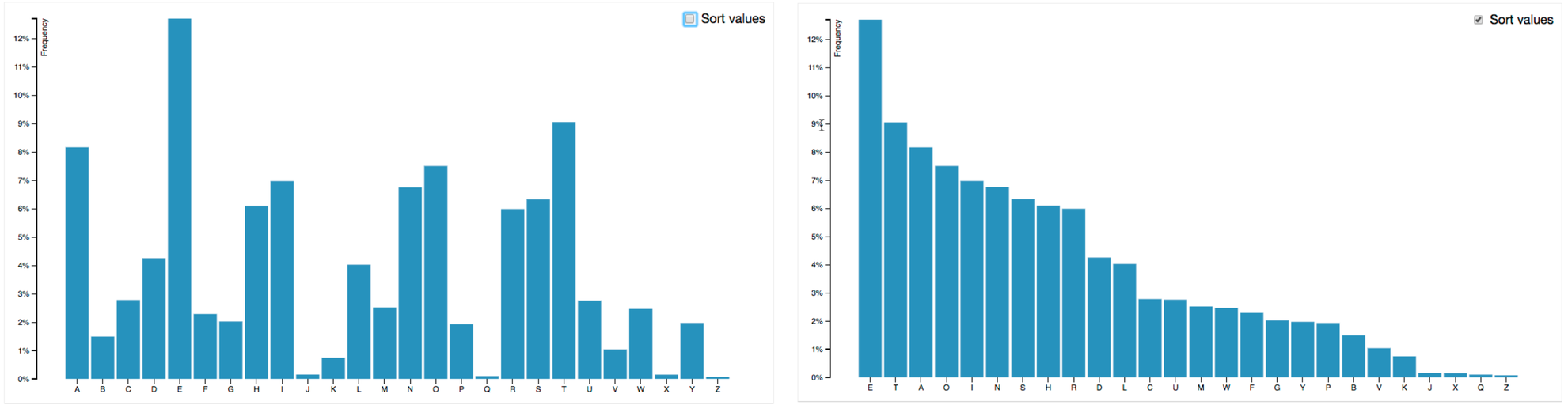
New York, NY
Chicago, IL
Philadelphia, PA
Brooklyn, NY
St. Louis, MO
Boston, MA
Baltimore, MD
San Francisco, CA
Cincinnati, OH
Cleveland, OH
Buffalo, NY
New Orleans, LA
Pittsburgh, PA
Washington, VA
Detroit, MI
Milwaukee, WI
Newark, NJ
Minneapolis, MN
Jersey City, NJ
Louisville, KY
Omaha, NE
Rochester, NY
St. Paul, MN
Kansas City, MO
Providence, RI
Denver, CO
Indianapolis, IN
Allegheny, PA
Albany, NY
Columbus, OH
Syracuse, NY
New Haven, CT
Worcester, MA
Toledo, OH
Richmond, VA
Paterson, NJ
Lowell, MA
Nashville, TN
Scranton, PA
Fall River, MA
Cambridge, MA
Atlanta, GA
Memphis, TN
Wilmington, DE
Dayton, OH
Troy, NY
Grand Rapids, MI
Reading, PA
Camden, NJ
Trenton, NJ
Lynn, MA
Lincoln, NE
Charleston, SC
Hartford, CT
St. Joseph, MO
Evansville, IN
Los Angeles, CA
Des Moines, IA
Bridgeport, CT
Oakland, CA
Portland, OR
Saginaw, MI
Salt Lake City, UT
Lawrence, MA
Springfield, MA
Manchester, NH
Utica, NY
Hoboken, NJ
Savannah, GA
Seattle, WA
Peoria, IL
New Bedford, MA
Erie, PA
Somerville, MA
Harrisburg, PA
Kansas City, KS
Dallas, TX
Sioux City, IA
Elizabeth, NJ

200,000 400,000 600,000 800,000 1,000,000 1,200,000 1,400,000

Population State County

Idiom: Change order/arrangement

- what: simple table
- how: data-driven reordering
- why: find extreme values, trends

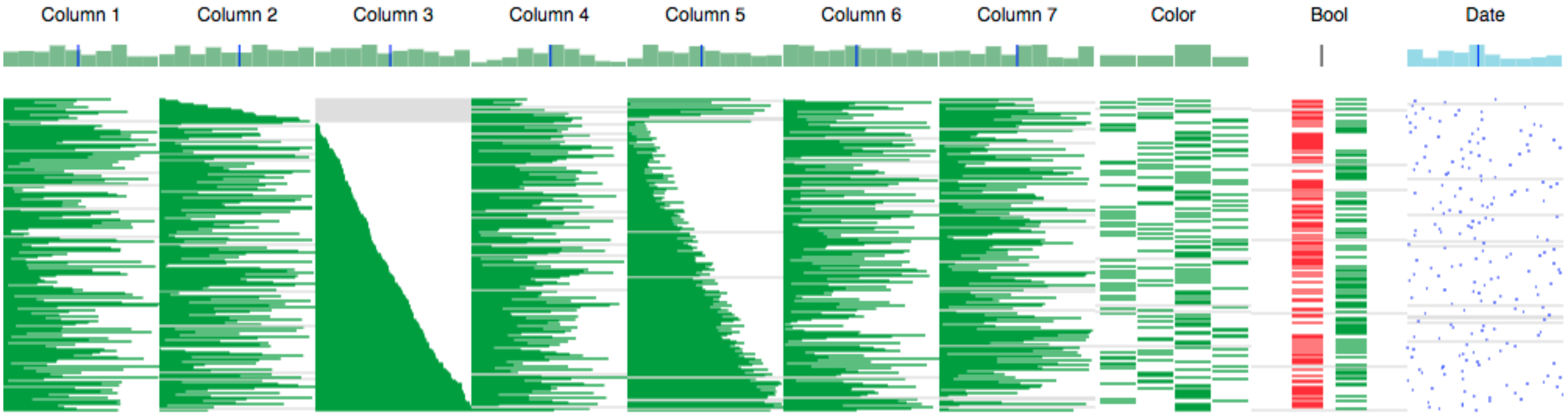


[Sortable Bar Chart]

made with D3

Idiom: Reorder

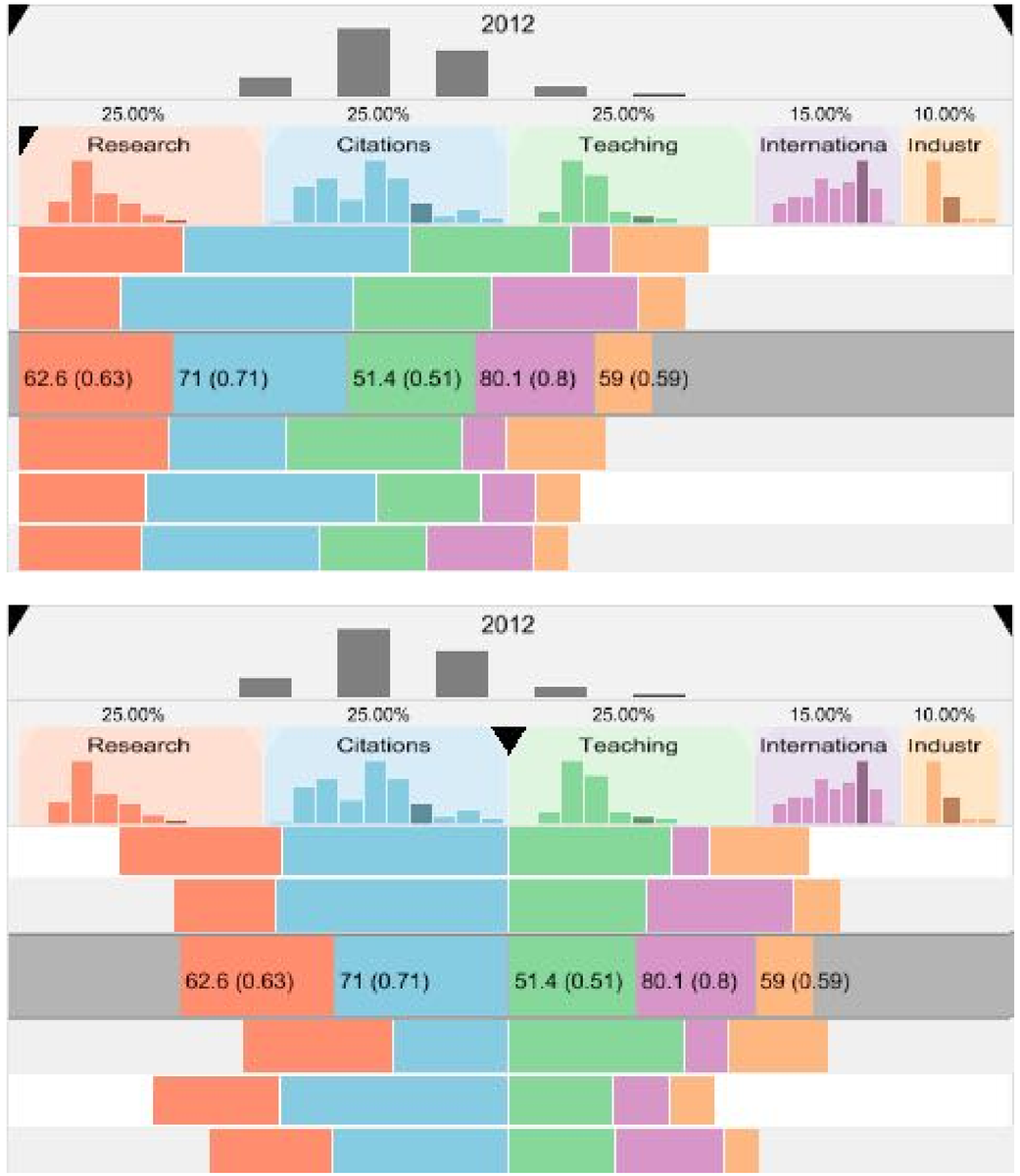
- what: table with many attributes
- how: data-driven reordering by selecting column
- why: find correlations between attributes



Idiom: Change alignment

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

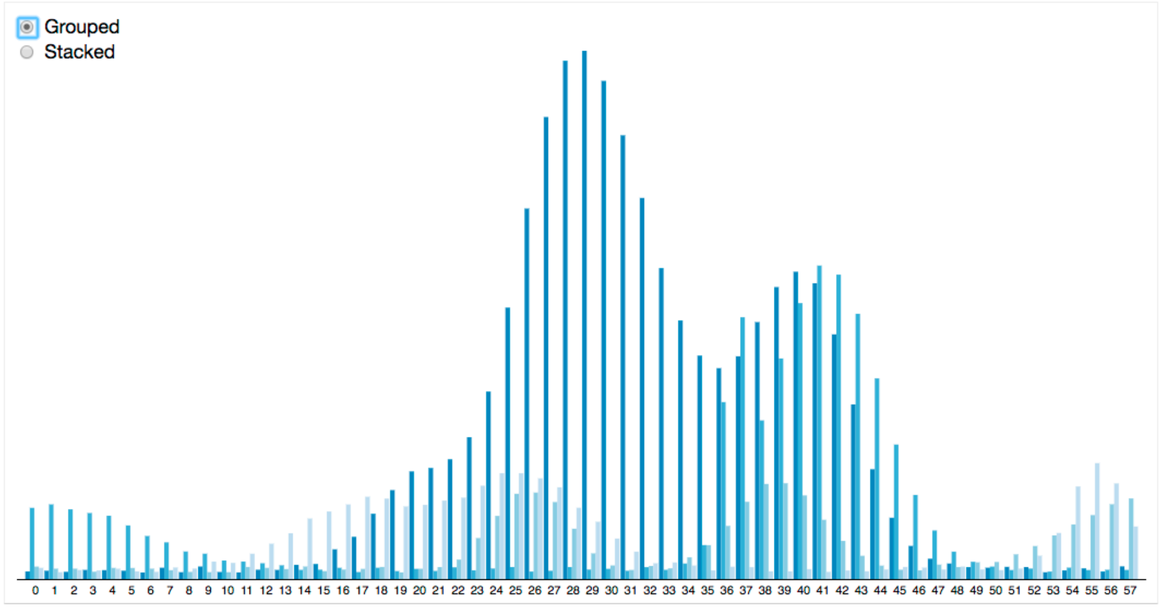
System: LineUp

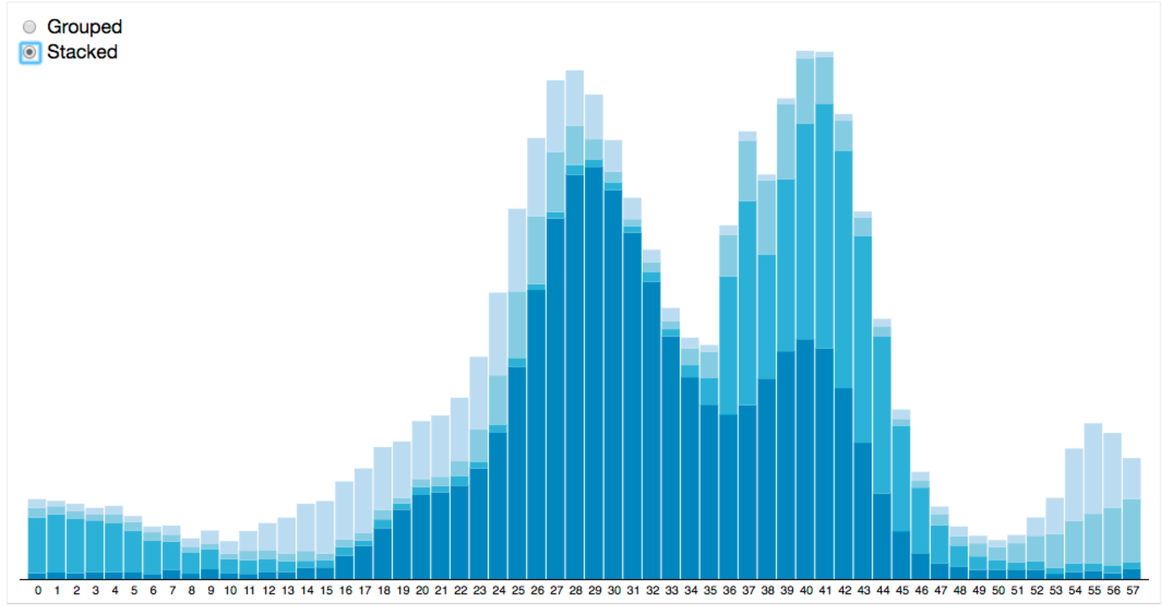


[LineUp: Visual Analysis of Multi-Attribute Rankings.Gratzl, Lex, Gehlenborg, Pfister, and Streit. IEEE Trans. Visualization and Computer Graphics

Idiom: Animated transitions - visual encoding change

- smooth transition from one state to another
  - alternative to jump cuts, supports item tracking
    - best case for animation
  - staging to reduce cognitive load

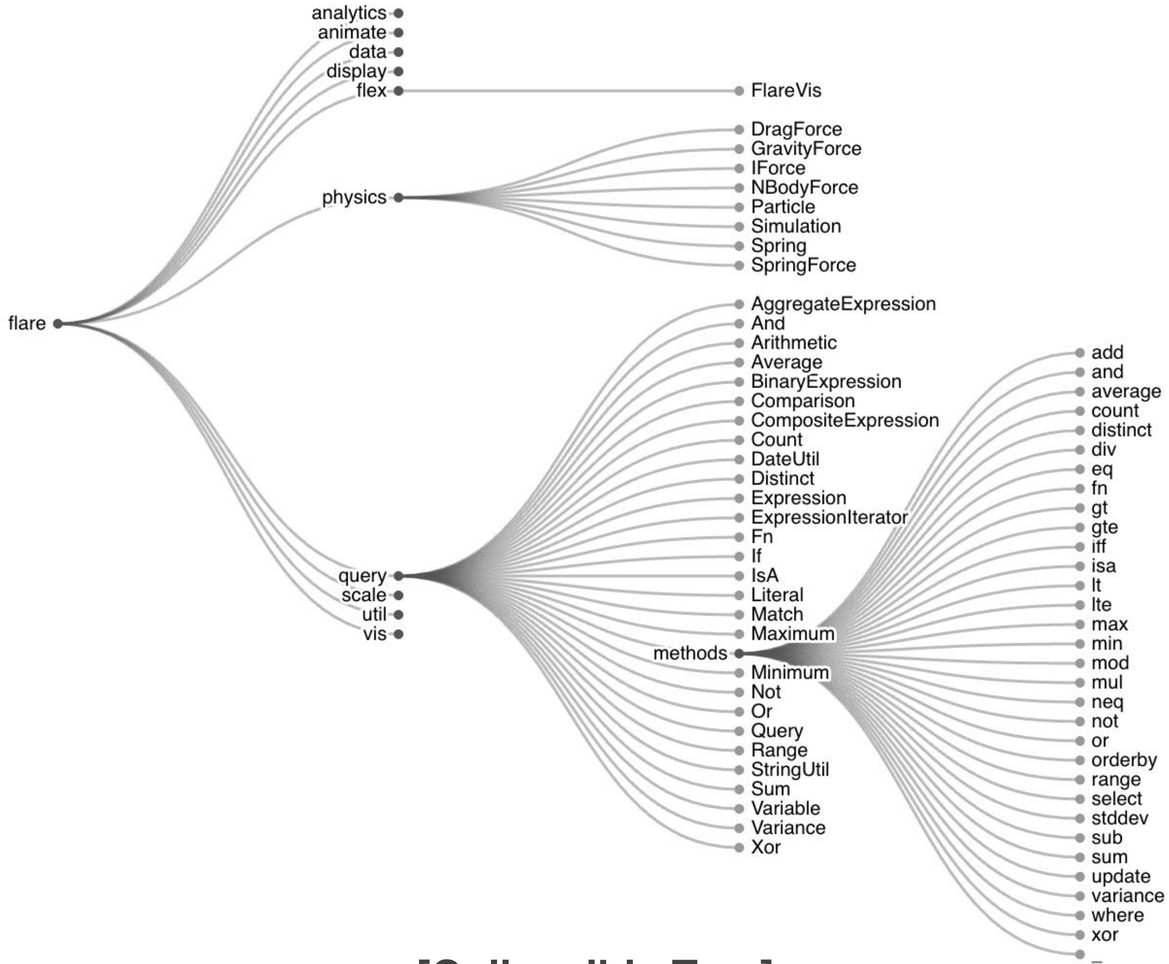




[Stacked to Grouped Bars]

Idiom: Animated transition - tree detail

- animated transition
  - network drilldown/rollup

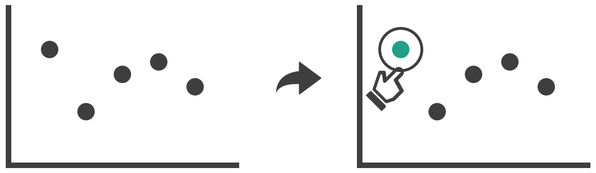


[Collapsible Tree]

Manipulate

- Change over Time

- Select



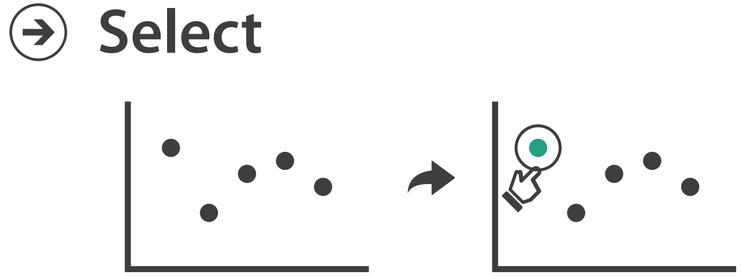
Interaction technology

- what do you 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)
vimeo.com/182590214

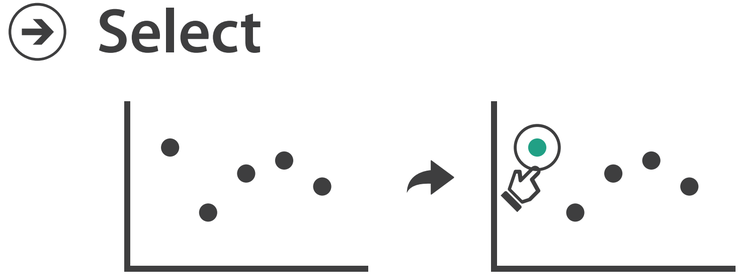
I Hate Tom Cruise - Alex Kauffmann (5 min)
www.youtube.com/watch?v=QXLfT9sFcbc

Selection



- **selection**: basic operation for most interaction
- design choices: how many selection types?
  - **interaction modalities**
    - **click/tap** (heavyweight) vs **hover** (lightweight but not available on most touchscreens)
    - **multiple click types** (shift-click, option-click, …)
    - **proximity** beyond click/hover (touching vs nearby vs distant)
- **application semantics**
  - **adding** to selection set vs **replacing** selection
  - can selection be **null**?
    - ex: toggle so nothing selected if click on background
  - **primary** vs **secondary** (ex: source/target nodes in network)
  - **group membership** (add/delete items, name group, …)

Highlighting

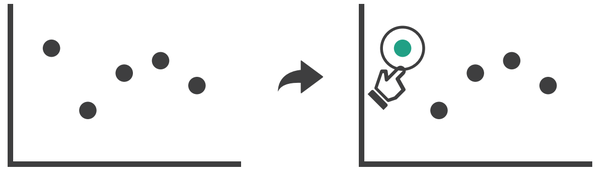


- **highlight:** change visual encoding for selection targets
  - visual feedback closely tied to but separable from selection (interaction)
- design choices: **typical visual channels**
  - change **item color**
    - but hides existing color coding
  - add **outline mark**
  - **change size** (ex: increase outline mark linewidth)
  - **change shape** (ex: from solid to dashed line for link mark)
- unusual channels: motion
  - motion: usually avoid for single view
    - with multiple views, could justify to draw attention to other views

Manipulate

Change over Time

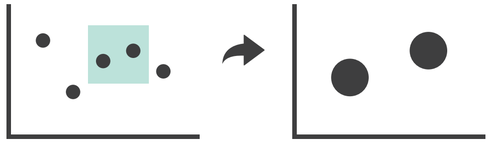
Select



Navigate

Item Reduction

- *Zoom*
  Geometric or *Semantic*



- *Pan/Translate*

- *Constrained*

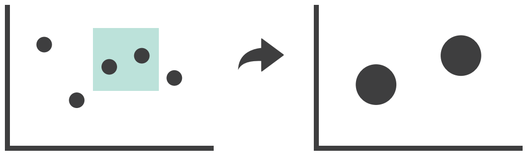
Navigate: Changing viewpoint/visibility

- **change viewpoint**
  - changes which items are visible within view
- **camera metaphor**
  - pan/translate/scroll
    - move up/down/sideways

➔ **Navigate**

➔ Item Reduction

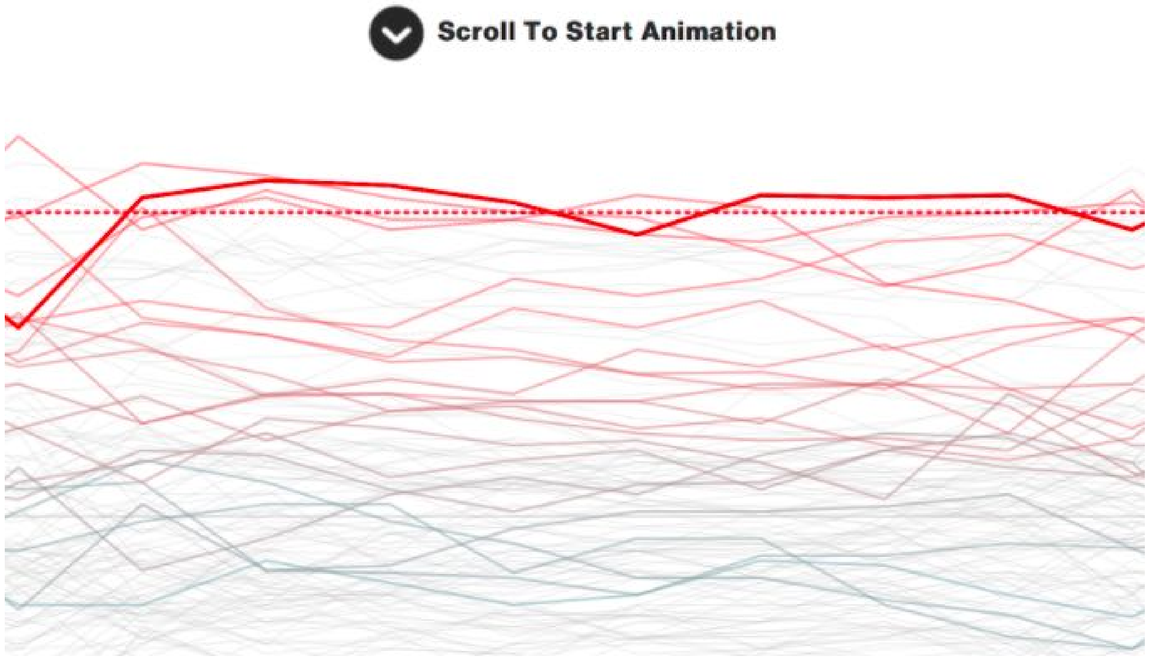
➔ *Zoom*
Geometric or *Semantic*



➔ *Pan/Translate*

Idiom: Scrollytelling

- **how**: **navigate page by scrolling** (panning down)
- **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



[A visual introduction to Machine Learning]

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

https://www.vev.design/blog/scrollytelling-examples/

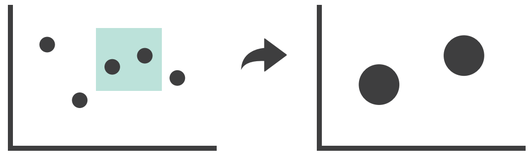
Navigate: Changing viewpoint/visibility

- **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

Navigate

→ Item Reduction

→ *Zoom*
Geometric or *Semantic*



→ *Pan/Translate*

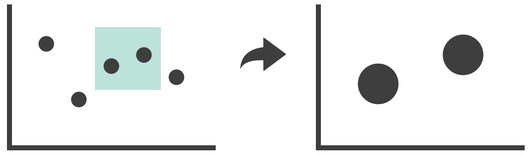
Navigate: Unconstrained vs constrained

- **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

➔ Navigate

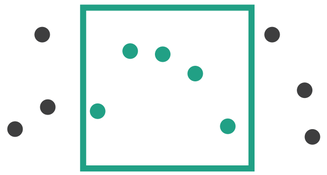
➔ Item Reduction

➔ *Zoom*
Geometric or *Semantic*



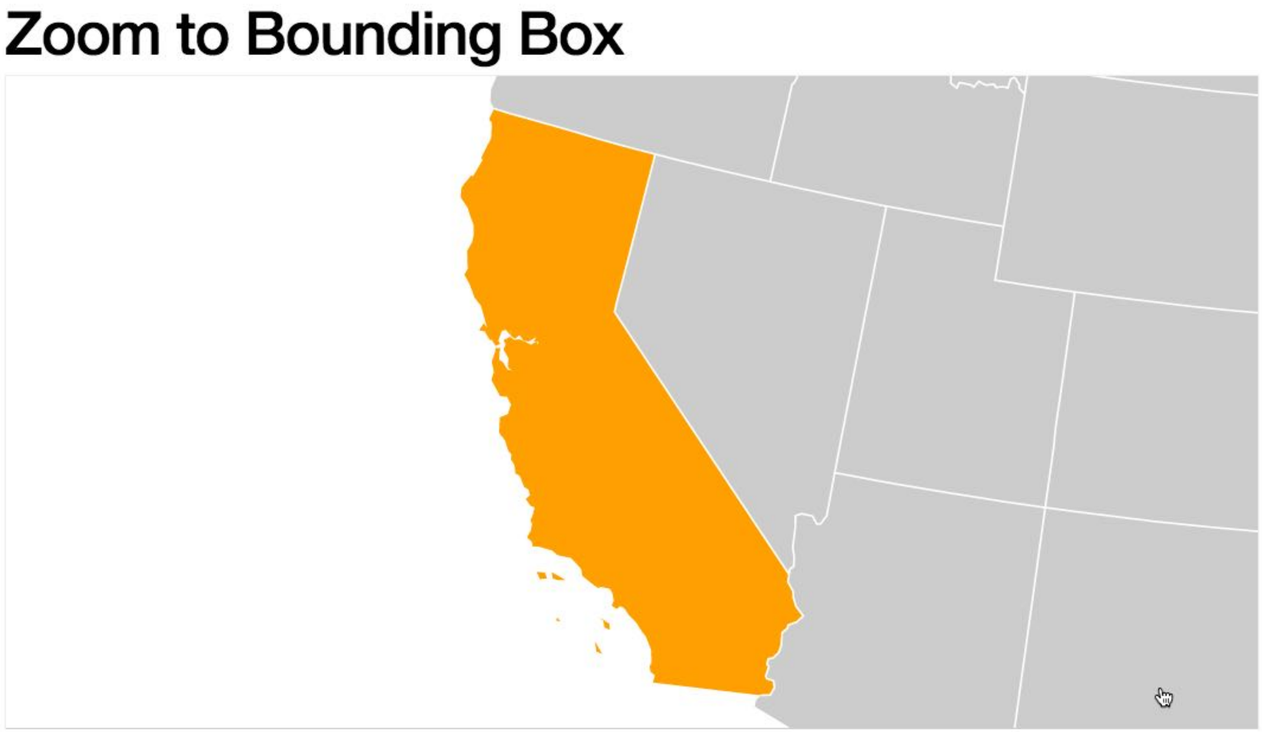
➔ *Pan/Translate*

➔ *Constrained*



Idiom: Animated transition + constrained navigation

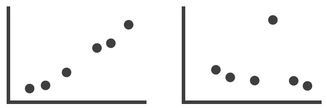
- example: **geographic map**
  - simple zoom, only viewport changes, shapes preserved



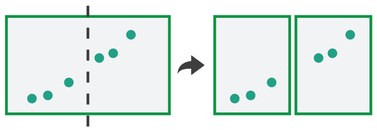
[Zoom to Bounding Box]

Facet (multiple views)

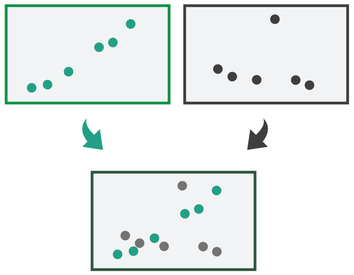
- Juxtapose



- Partition



- Superimpose



Juxtapose and coordinate views

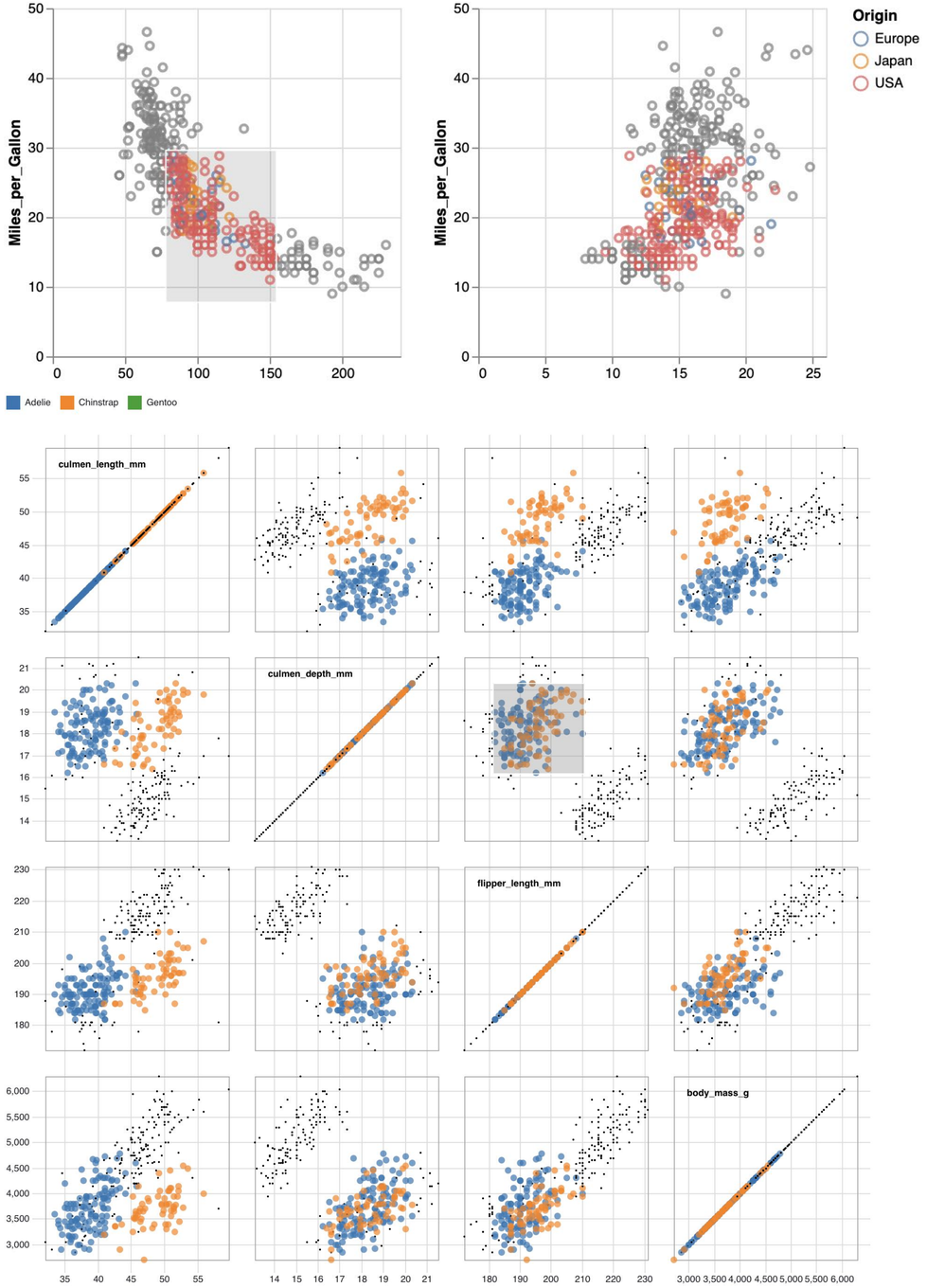
- Share Encoding: Same/Different
  - *Linked Highlighting*

- Share Data: All/Subset/None

- Share Navigation

Idiom: Linked highlighting

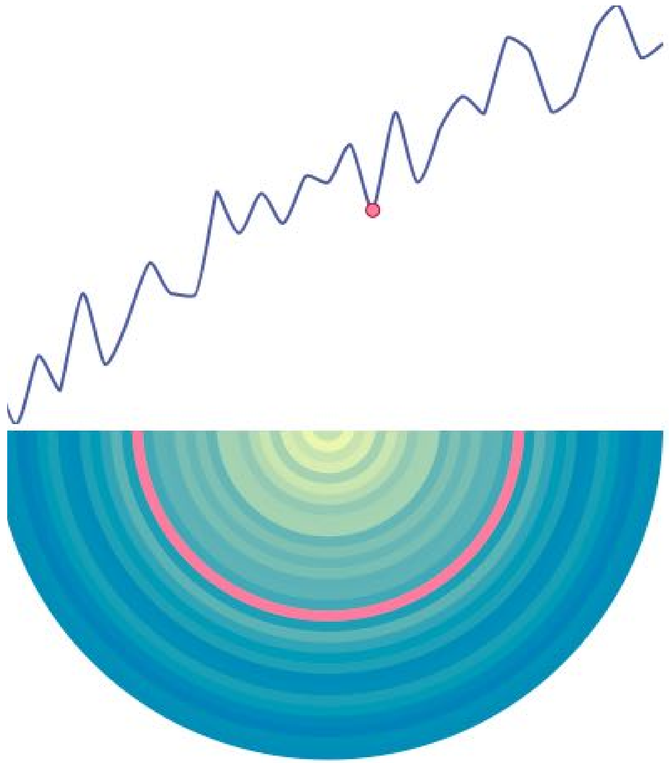
- see how regions contiguous in one view are distributed within another
  - powerful and pervasive interaction idiom
- encoding: different
  - multiform
- data: all shared
  - all items shared
  - different attributes across the views
- aka: **brushing** and **linking**



[example 1]
[example 2]

Linked views: Directionality

- **unidirectional** vs **bidirectional** linking
  - **bidirectional almost always better!**



http://pbeshai.github.io/linked-highlighting-react-vega-redux/

Idiom: Overview-detail views

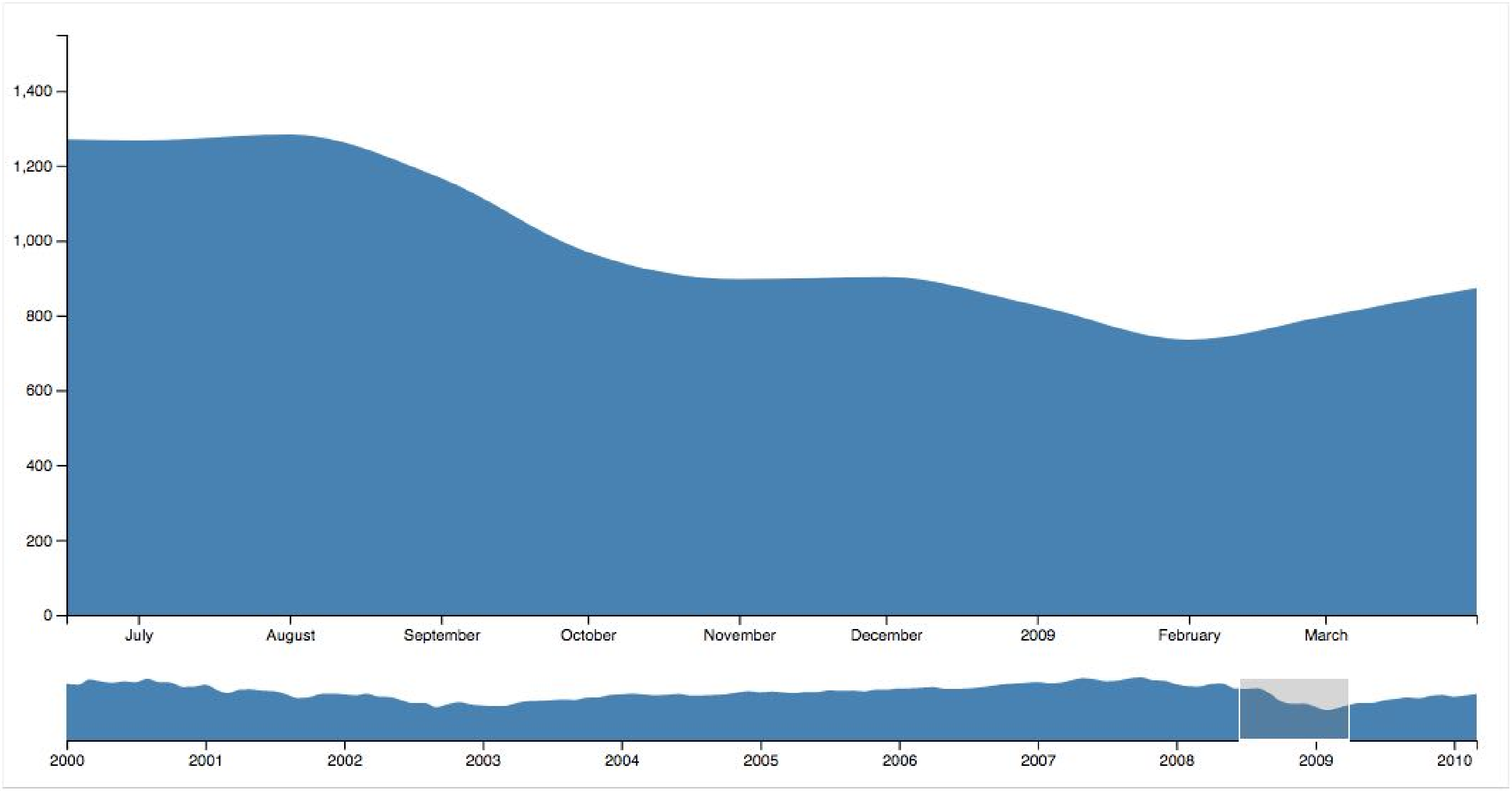
- encoding: **same** or **different**
  - ex: same (birds-eye map)
- data: subset shared
  - viewpoint differences: subset of data items
- navigation: shared
  - **bidirectional** linking
- other differences
  - (window size)

System: Google Maps

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

Idiom: Overview-detail navigation

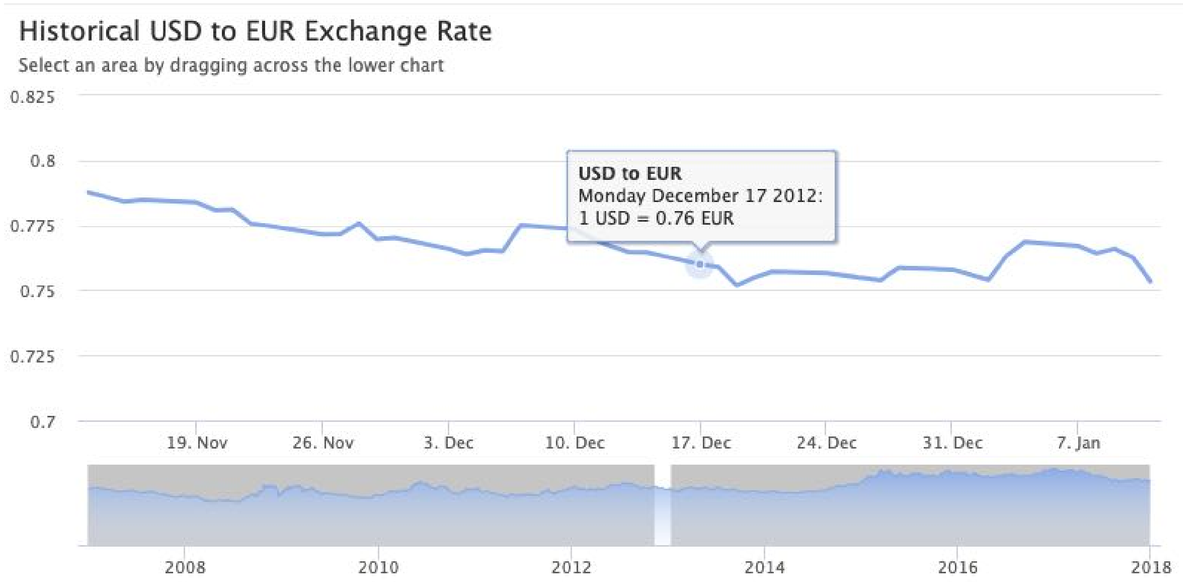
- encoding: **same** or **different**
- data: subset shared
- navigation: **shared**
  - **unidirectional** linking
  - select in small overview, change extent in large detail view



[example 1]

Idiom: Tooltips

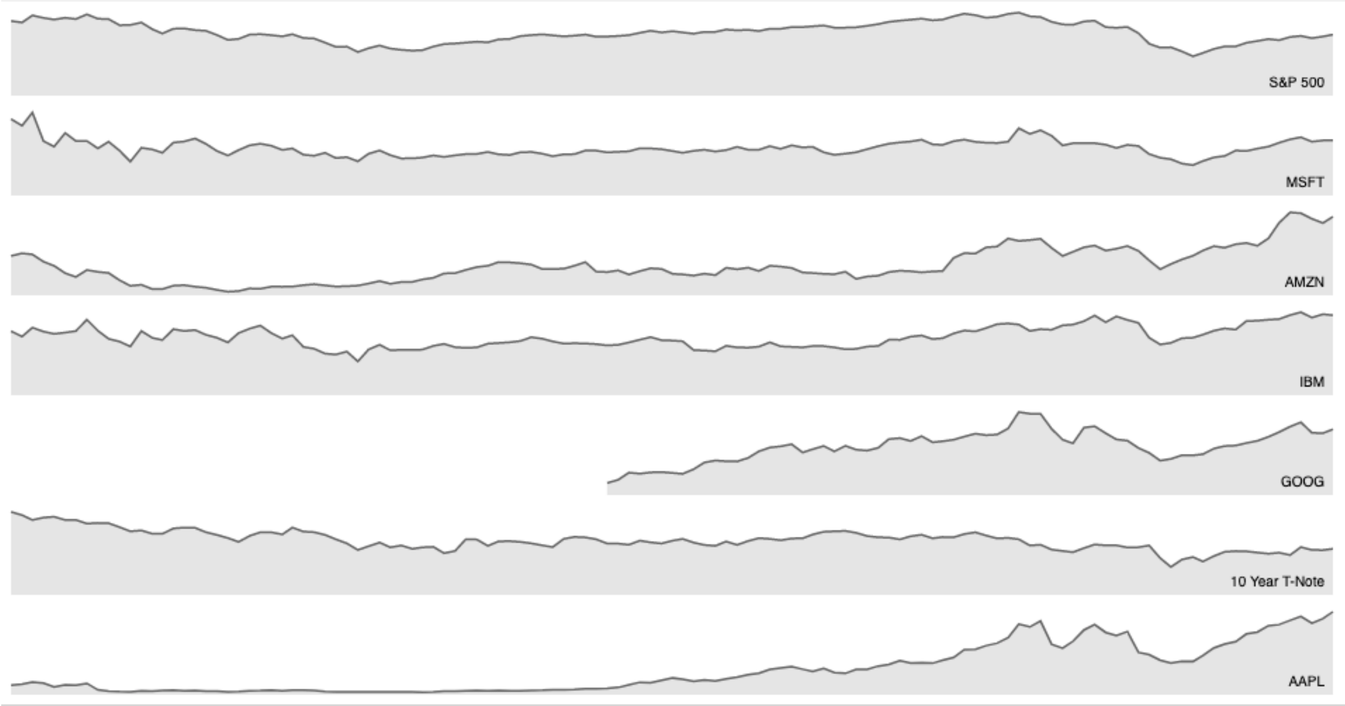
- **popup information for selection**
  - **hover** or **click**
  - specific case of detail view:
    provide useful additional detail on demand
  - beware: does not support overview!
    - always consider if there's a way to visually encode directly to provide overview
    - "If you make a rollover or tooltip, assume nobody will see it. If it's important, make it explicit. "
      - Gregor Aisch, NYTimes



[https://www.highcharts.com/demo/dynamic-master-detail]

Idiom: Small multiples

- encoding: same
  - ex: line charts
- data: none shared
  - different slices of dataset
    - items or attributes
    - ex: stock prices for different companies

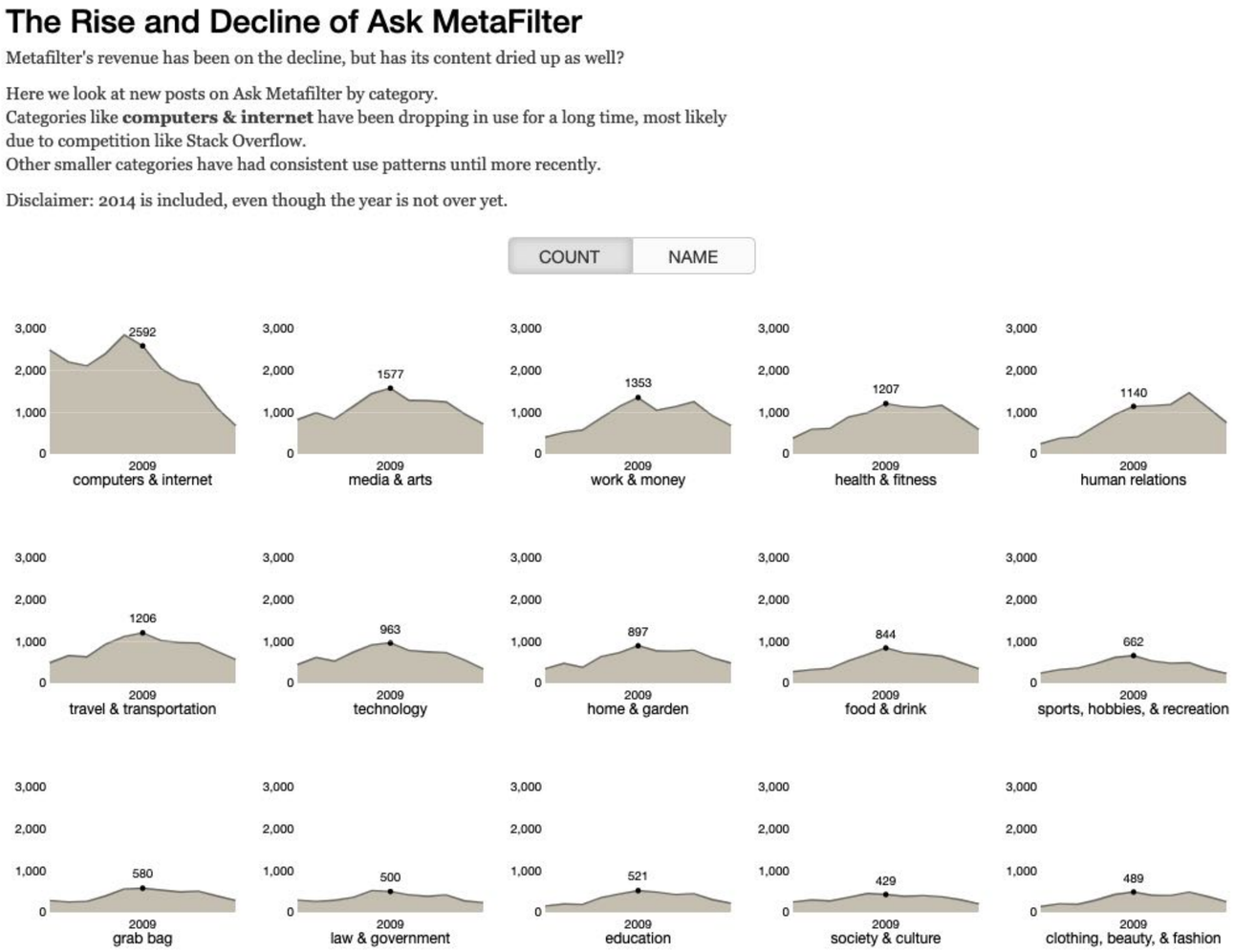


[example 1]

[example 2]

Interactive small multiples

- **linked highlighting:** analogous item/attribute across views
  - same year highlighted across all charts if hover within any chart



[example 1]

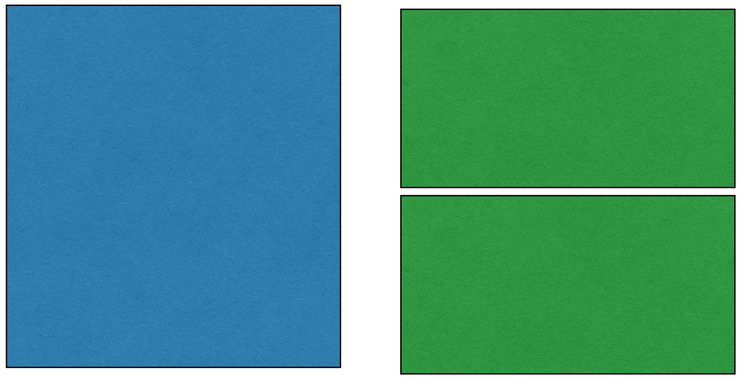
[example 2]

Example: Combining many interaction idioms

- multiform
- multidirectional linked highlighting of small multiples
- tooltips

http://buckets.peterbeshai.com/

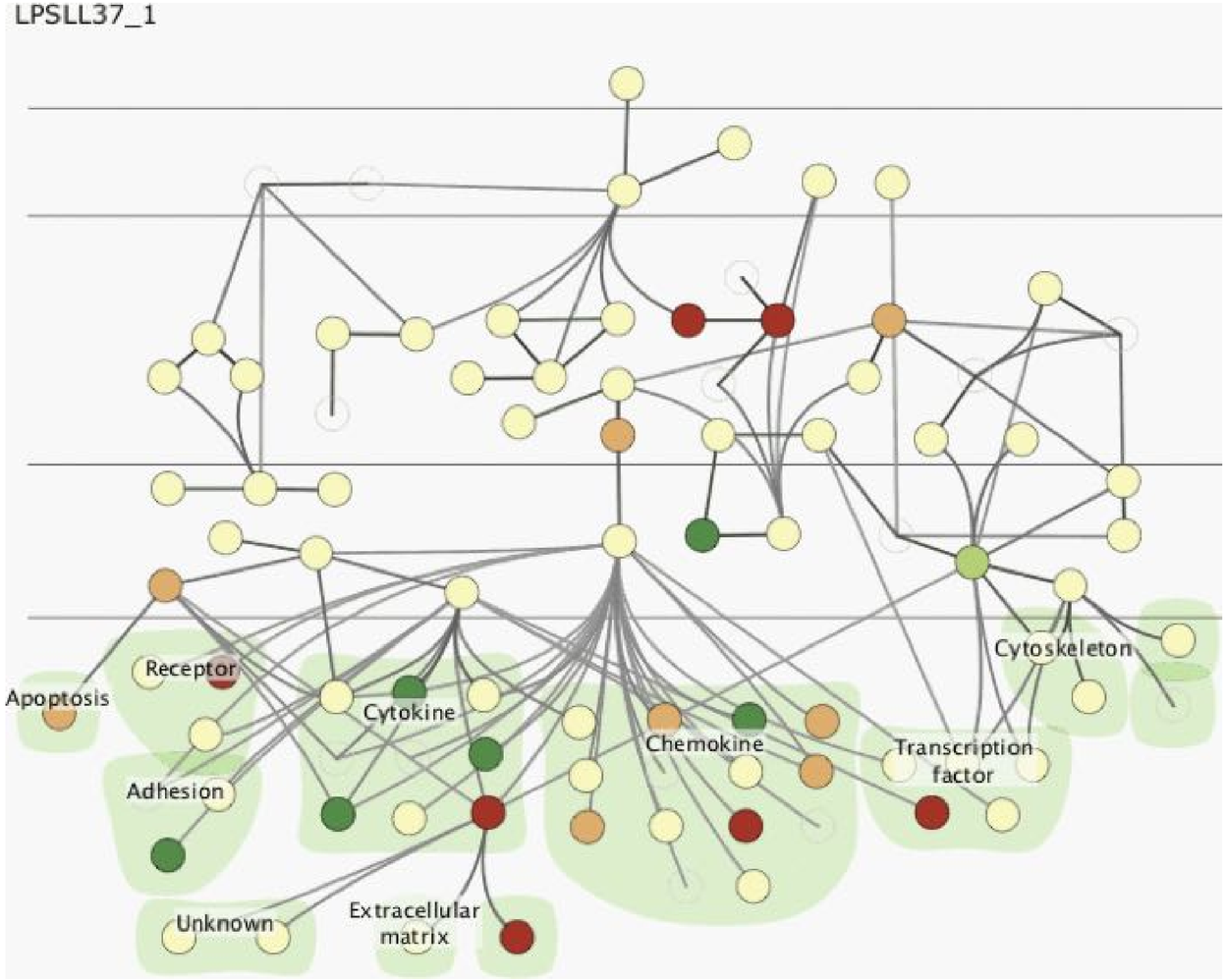
Juxtapose views: tradeoffs



- juxtapose costs
  - display area
    - 2 views side by side: each has only half the area of one view
- juxtapose benefits
  - cognitive load: eyes vs memory
    - lower cognitive load: move eyes between 2 views
    - higher cognitive load: compare single changing view to memory of previous state

Juxtapose vs animate

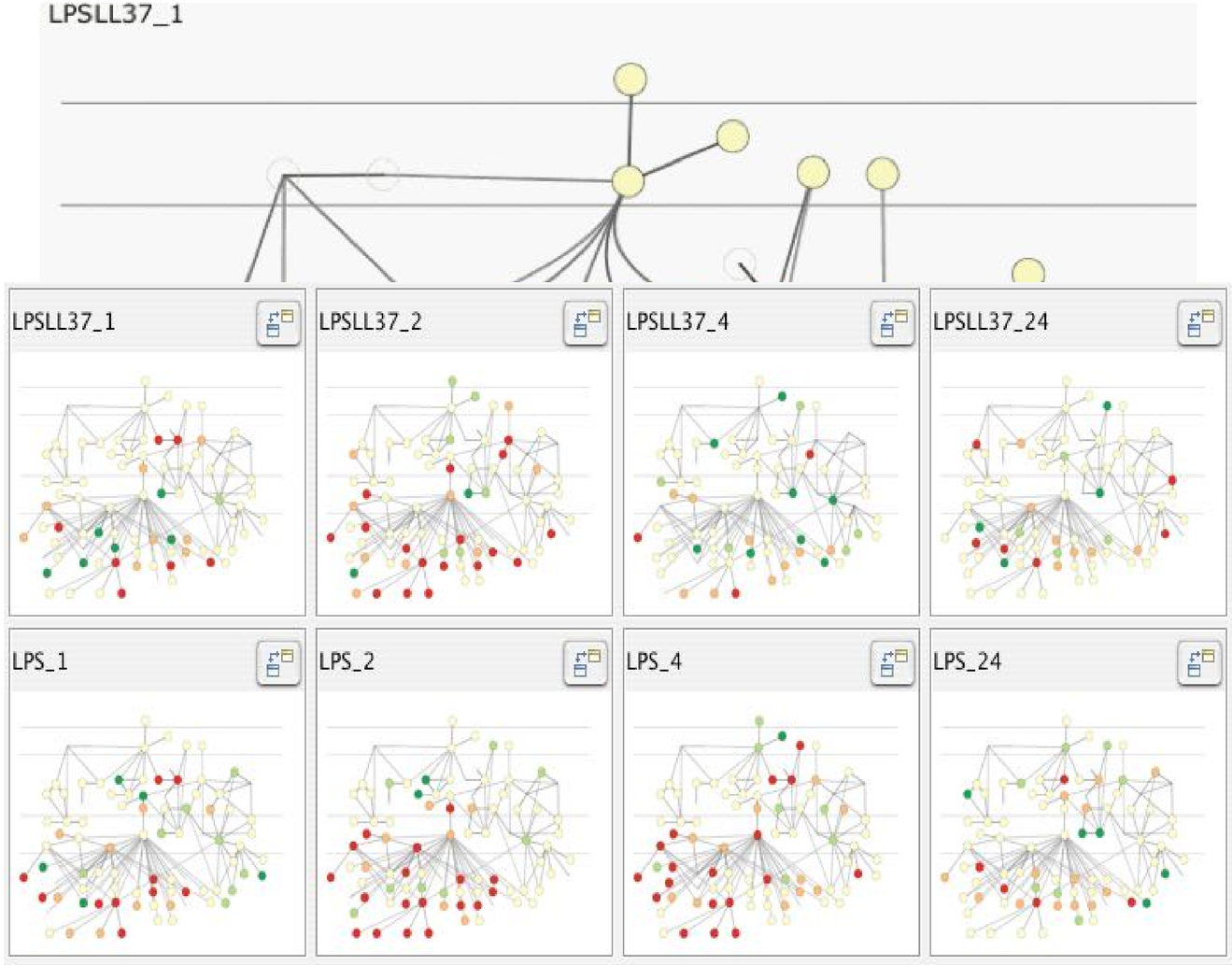
- **animate**: **hard to follow** if many scattered changes or many frames
  - vs **easy special case: animated transitions**



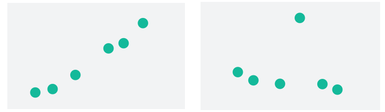
Cerebral: Visualizing Multiple Experimental Conditions on a Graph with Biological Context. Barsky, Munzner, Gardy, and Kincaid. IEEE Trans. Visualization and Computer Graphics

Juxtapose vs animate

- animate: hard to follow if many scattered changes or many frames
  - vs easy special case: animated transitions
- juxtapose: easier to compare across small multiples
  - different conditions (color), same gene (layout)



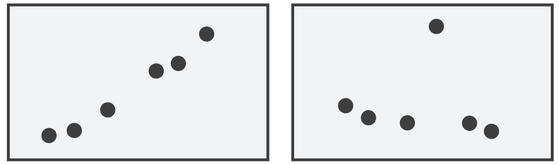
View coordination: Design choices

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

Partition into views

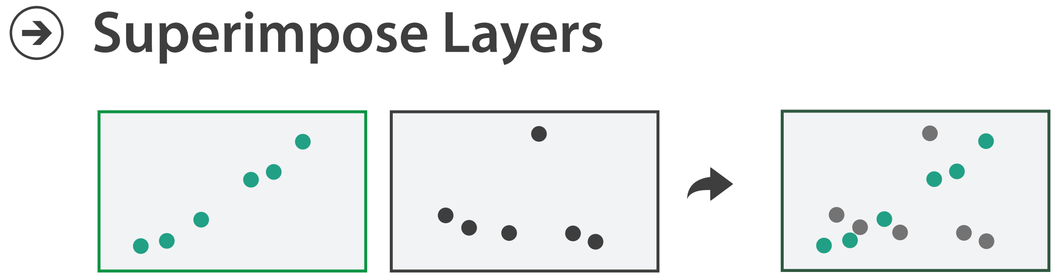
- how to **divide data between views**
  - **split** into regions by attributes
  - encodes association between items using **spatial proximity**
  - **order of splits** has major implications for what patterns are visible

Partition into Side-by-Side Views



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 achievable, three with careful design
  - small static set, or dynamic from many possible?



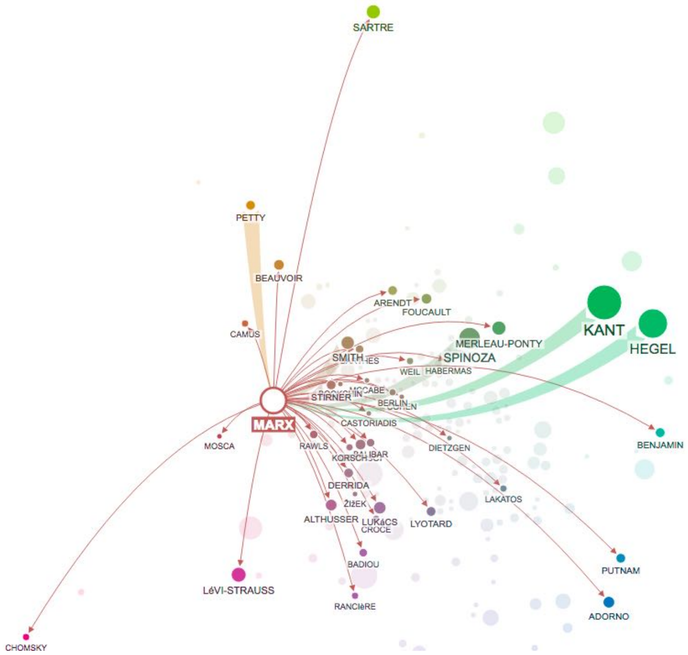
Static visual layering

- **foreground layer:** roads
  - hue, size distinguishing main from minor
  - high luminance contrast from background
- **background layer:** regions
  - desaturated colors for water, parks, land areas
- user can **selectively focus attention**

Dynamic visual layering

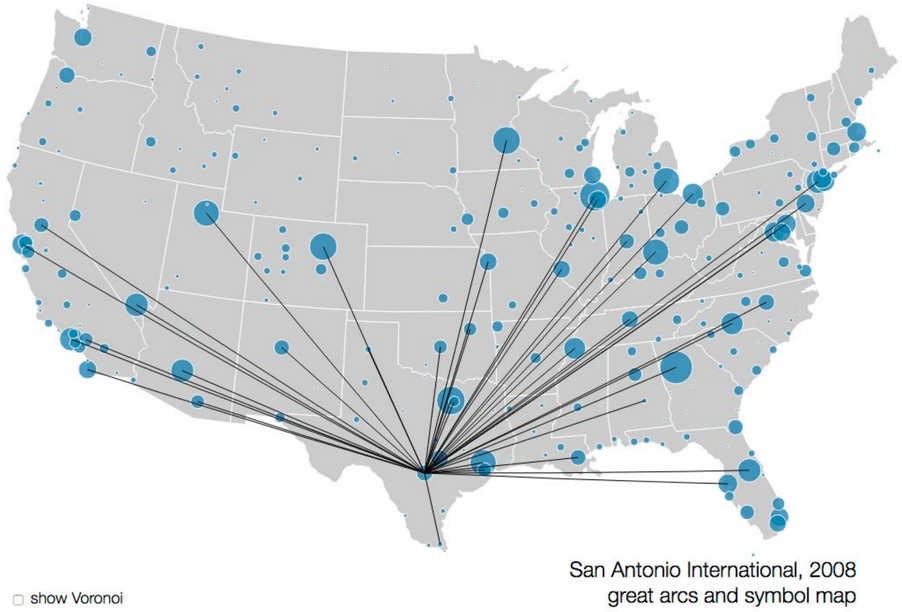
- **interactive, based on selection**
  - **one-hop neighbour highlighting**

click (heavyweight)



[example]

hover (fast)



[example]

How: Idiom design choices

Encode

- Arrange
  - Express
  - Separate
  - Order
  - Align
  - Use

Manipulate

- Change
- Select
- Navigate

Facet

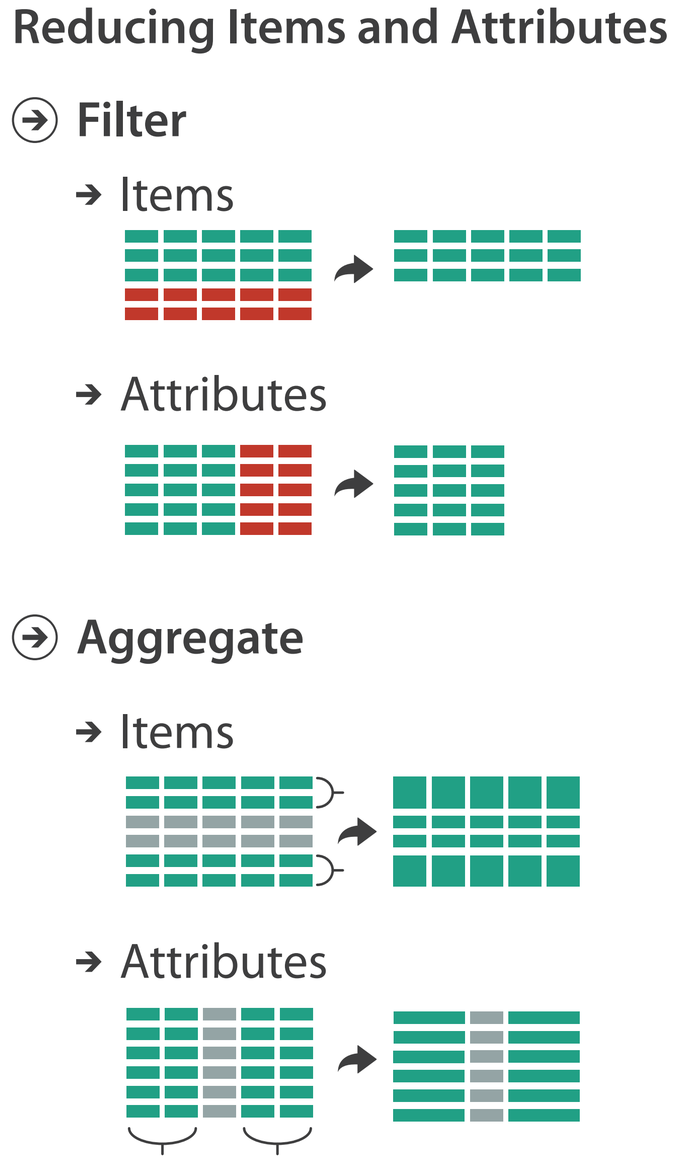
- Juxtapose
- Partition
- Superimpose

Reduce

- Filter
- Aggregate
- Embed

Reduce items and attributes

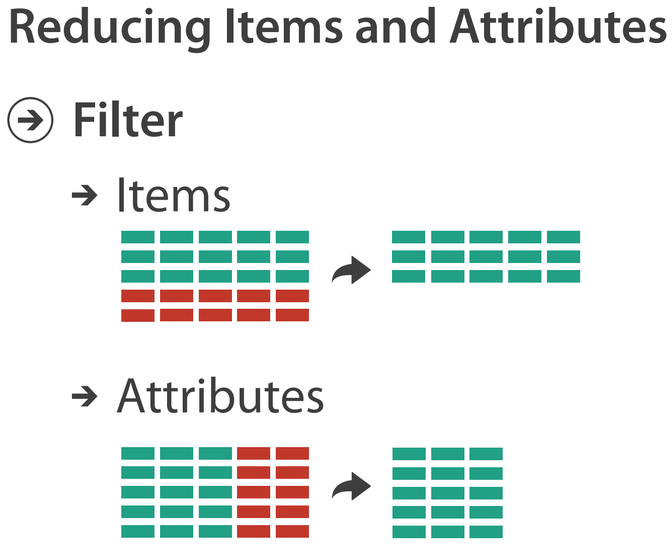
- **reduce/increase: inverses**
- **filter**
  - pro: straightforward and intuitive
    - to understand and compute
  - con: out of sight, out of mind
- **aggregation**
  - pro: inform about whole set
  - con: difficult to avoid losing signal
- **not mutually exclusive**
  - combine filter, aggregate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



Filter

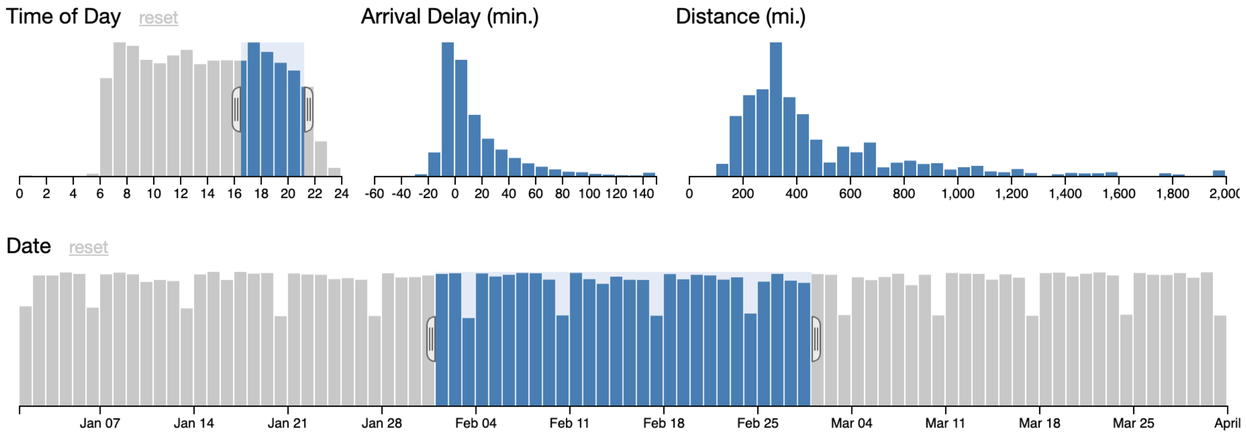
- **eliminate some elements**
  - either items or attributes
- according to **what**?
  - any possible function that partitions dataset into two sets
  - attribute values bigger/smaller than x
  - noise/signal

- **filters vs queries**
  - **query**: start with nothing, add in elements
  - **filters**: start with everything, remove elements
  - **best approach depends on dataset size**



Idiom: cross filtering

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



February 28, 2001

20,701 of 231,083 flights selected.

09:11 PM	MDW	IND	162 mi.	+44 min.
09:11 PM	TUS	LAX	451 mi.	+167 min.
09:11 PM	HRL	SAT	233 mi.	+120 min.
09:10 PM	MCI	HOU	666 mi.	+9 min.
09:10 PM	SMF	BUR	358 mi.	+88 min.
09:10 PM	DAL	SAT	248 mi.	+18 min.
09:10 PM	BWI	TPA	842 mi.	-1 min.
09:10 PM	SMF	LAX	373 mi.	+110 min.
09:10 PM	HOU	AUS	148 mi.	-2 min.
09:10 PM	ELP	HOU	677 mi.	-10 min.

[example 1]
[example 2]

Interaction benefits

- **interaction pros**
  - major advantage of **computer-based** vs paper-based visualization
  - **flexible**, **powerful**, **intuitive**
    - **exploratory data analysis**: change as you go during 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

Interaction limitations

- interaction has a **time cost**
  - sometimes minor, sometimes significant
  - degenerates to human-powered search in worst case
- **remembering** previous state imposes **cognitive load**
- 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

Questions?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