

Information Visualization

Interactive Views

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Lect 8/9/10, 30 Jan & 4/6 Feb 2020

<https://www.cs.ubc.ca/~tmm/courses/436V-20>

Upcoming

- Foundations 3: out Thu Jan 30, due Wed Feb 5 6pm
- Programming 2: out Thu Jan 30, due Wed Feb 12 6pm
- D3 videos/readings week 4
 - The General Update Pattern of D3.js [60 min]
 - Interaction with Unidirectional Data Flow [16 min]
 - Read: Reusable D3 Components
- Quiz 4, due by Fri Jan 31, 8am

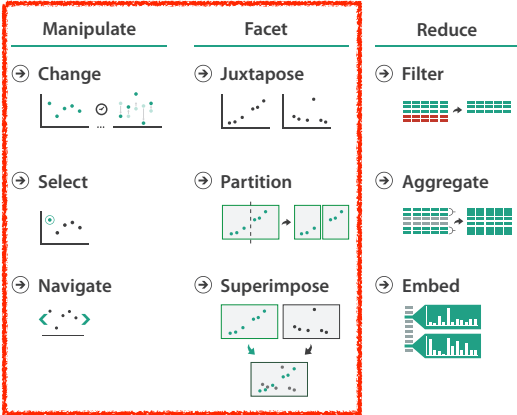
Interactive Views

How to handle complexity: 1 previous strategy + 3 more

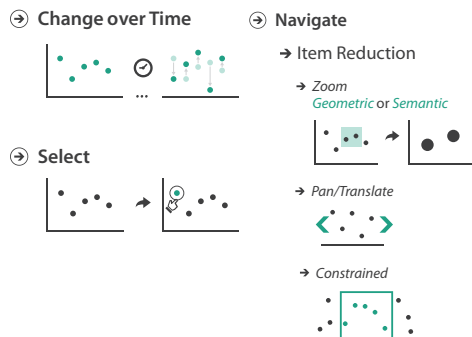
→ Derive



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



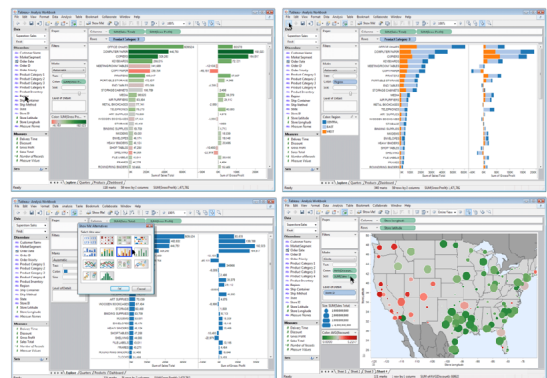
Manipulate



Change over time

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

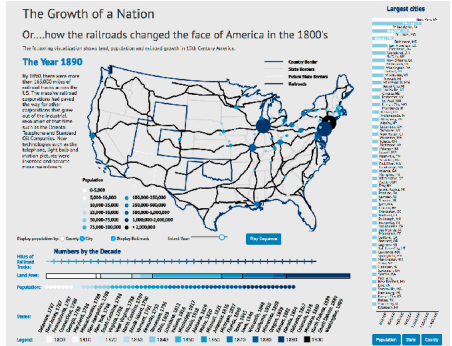
Idiom: Re-encode



made using Tableau, <http://tableausoftware.com>

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

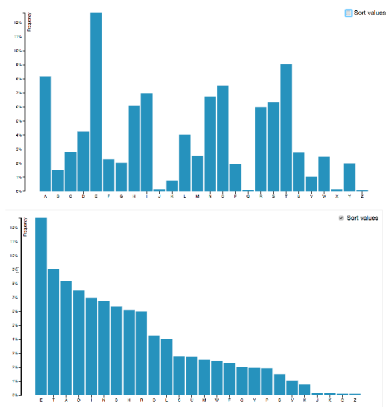


[Growth of a Nation](<http://laurenwood.github.io/>)

slide inspired by: Alexander Lex, Utah

Idiom: Change order/arrangement

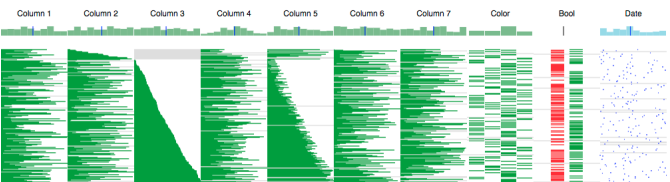
- what: simple table
- how: data-driven reordering
- why: find extreme values, trends



[Sortable Bar Chart](<https://bl.ocks.org/mbostock/3885705>)

Idiom: Reorder

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

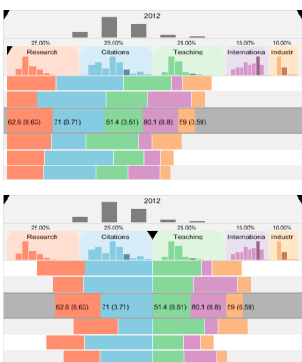


[<http://carlmanaster.github.io/datastripes/>]

System: DataStripes

Idiom: Change alignment

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

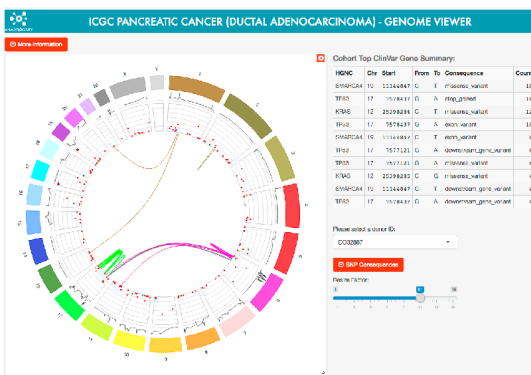


[LineUp: Visual Analysis of Multi-Attribute Rankings, Gratzl, Lex, Gehlenborg, Pfister, and Streit. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2013) 19:12 (2013), 2277–2286.]

System: LineUp

Shiny example

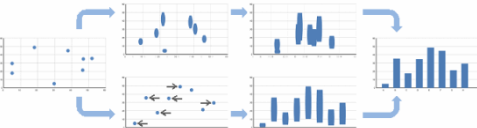
- APGI genome browser
 - tooling: R/Shiny
 - interactivity
 - tooltip detail on demand on hover
 - expand/contract chromosomes
 - expand/contract control panes



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

Idiom: 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

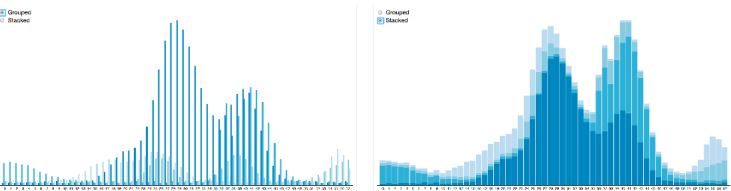


video: vimeo.com/19278444

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

Idiom: Animated transitions - visual encoding change

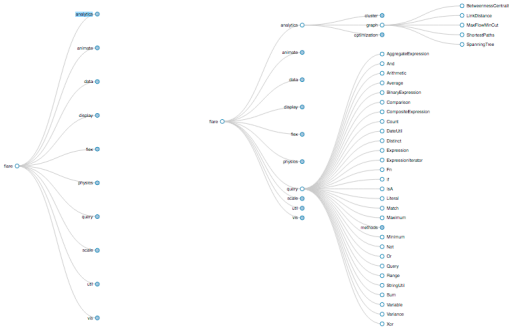
- smooth transition from one state to another
 - alternative to jump cuts, supports item tracking
 - best case for animation
 - staging to reduce cognitive load



[Stacked to Grouped Bars](<http://bl.ocks.org/mbostock/3943967>)

Idiom: Animated transition - tree detail

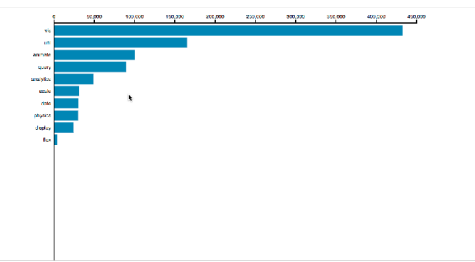
- animated transition
 - network drilldown/rollup



[Collapsible Tree](<https://bl.ocks.org/mbostock/4339083>)

Idiom: Animated transition - bar detail

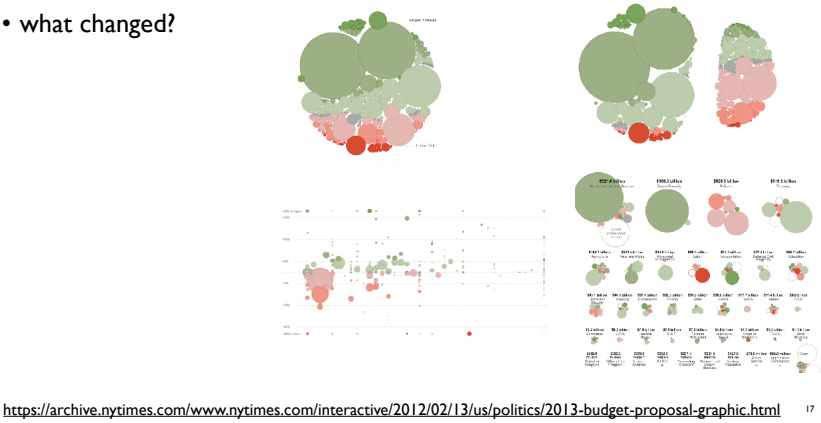
- example: hierarchical bar chart
 - add detail during transition to new level of detail



[Hierarchical Bar Chart](<https://bl.ocks.org/mbostock/1283663>)

Interactive transitions quiz: 4 Ways Budget

- what changed?



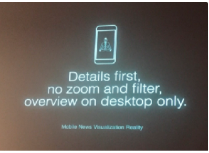
<https://archive.nytimes.com/www.nytimes.com/interactive/2012/02/13/us/politics/2013-budget-proposal-graphic.html>

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?

slide inspired by: Alexander Lex, Utah



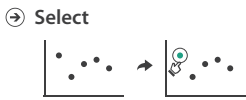
Data visualization and the news - Gregor Aisch (37 min)
vimeo.com/182590214



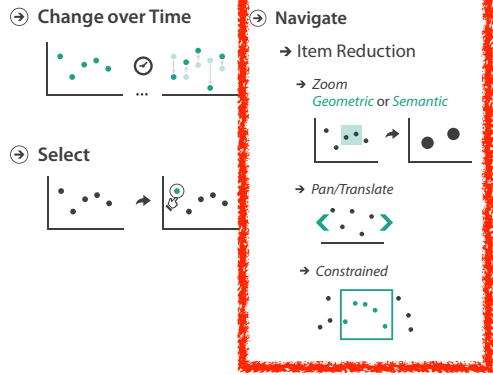
I Hate Tom Cruise - Alex Kauffmann (5 min)
www.youtube.com/watch?v=QXLtT9sFcbc

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, ...)

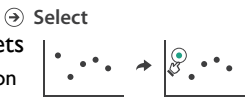


Manipulate



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



Tooltips

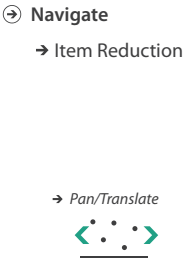
- popup information for selection
 - hover or click
 - can provide useful additional detail on demand
 - beware: does not support overview!
 - always consider if there's a way to visually encode directly to provide overview
 - “If you make a rollover or tooltip, assume nobody will see it. If it's important,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

Rule of thumb: Responsiveness is required

- visual feedback: three rough categories
 - 0.1 seconds: perceptual processing
 - subsecond response for mouseover highlighting - ballistic motion
 - 1 second: immediate response
 - fast response after mouseclick, button press - Fitts' Law limits on motor control
 - 10 seconds: brief tasks
 - bounded response after dialog box - mental model of heavyweight operation (file load)
- scalability considerations
 - highlight selection without complete redraw of view (graphics frontbuffer)
 - show hourglass for multi-second operations (check for cancel/undo)
 - show progress bar for long operations (process in background thread)
 - rendering speed when item count is large (guaranteed frame rate)

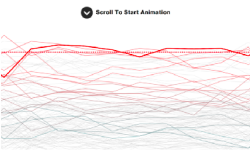
Navigate: Changing viewpoint/visibility

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



Idiom: Scrollytelling

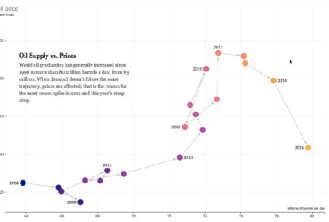
- how: navigate page by scrolling (panning down)
- pros:
 - familiar & intuitive, from standard web browsing
 - linear (only up & down) vs possible overload of click-based interface choices
- cons:
 - full-screen mode may lack affordances
 - scrollytelling, no direct access
 - unexpected behaviour
 -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



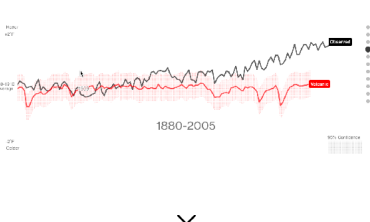
<https://eagereyes.org/blog/2016/the-scrollytelling-scourge>
[How to Scroll, Bostock] (<https://bost.ocks.org/mike/scroll/>)

slide inspired by: Alexander Lex, Utah

Scrollytelling examples



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

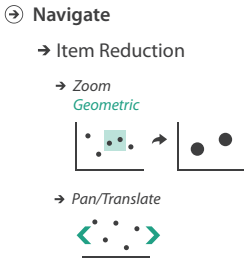


<https://www.bloomberg.com/graphics/2015-whats-warming-the-world/>

slide inspired by: Alexander Lex, Utah

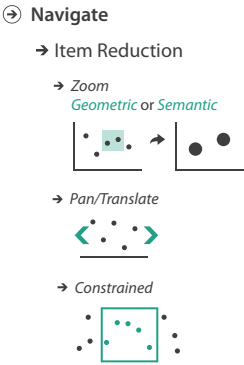
Navigate: Changing viewpoint/visibility

- 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: 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



Idiom: Animated transition + constrained navigation

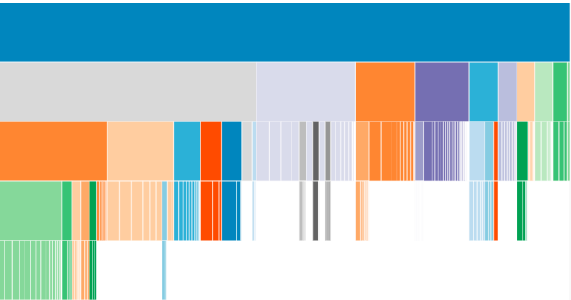
- example: geographic map
 - simple zoom, only viewport changes, shapes preserved



[Zoom to Bounding Box] (<https://bl.ocks.org/mbostock/4699541>)

Idiom: Animated transition + constrained navigation

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



[Zoomable Icicle] (<https://bl.ocks.org/mbostock/1005873>)

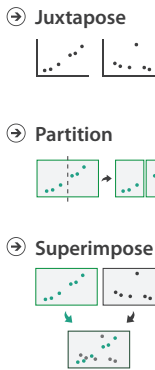
Interaction benefits

- 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

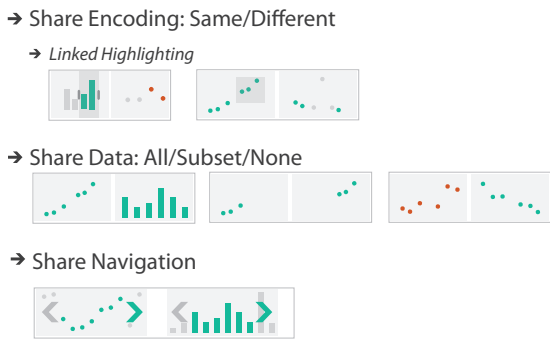
Interaction limitations

- 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

Facet

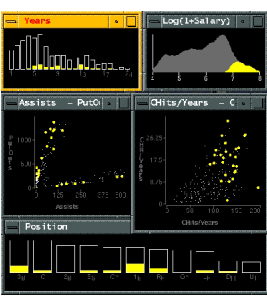


Juxtapose and coordinate views



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
- aka: brushing and linking

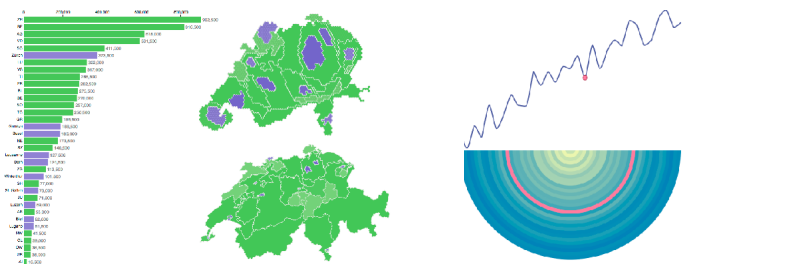


[Visual Exploration of Large Structured Datasets. Wills. Proc. New Techniques and Trends in Statistics (NTTS), pp. 237–246. IOS Press, 1995.]

System: **EDV**

Linked views

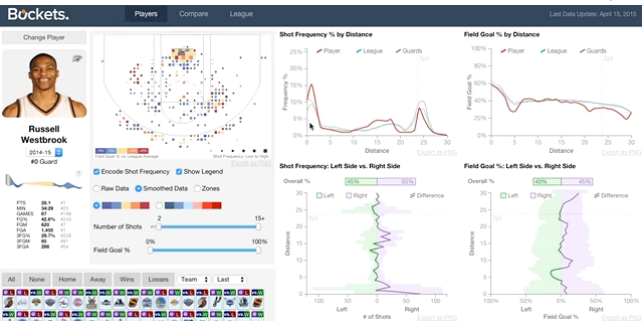
- unidirectional vs bidirectional linking



<http://www.ralphstraumann.ch/projects/swiss-population-cartogram/> <http://peterbeshai.com/linked-highlighting-react-d3-reflux/>

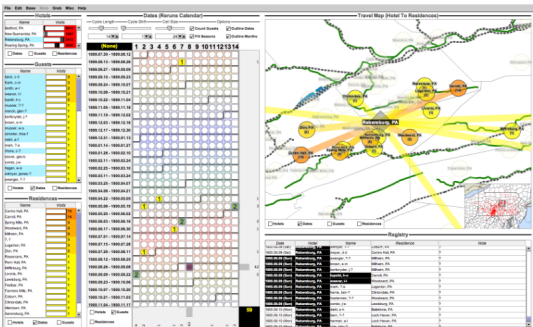
Linked views: Multidirectional linking

System: **Buckets**



<http://buckets.peterbeshai.com/>
<https://medium.com/@pbesh/linked-highlighting-with-react-d3-js-and-reflux-169c0b7210b>

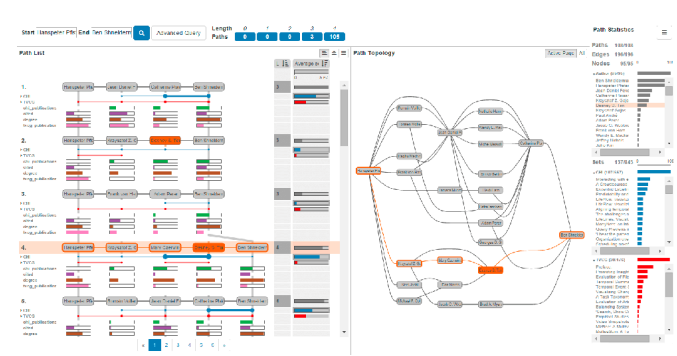
Video: Visual Analysis of Historical Hotel Visitation Patterns



<https://www.youtube.com/watch?v=Tzsv6wkZoiQ>
<http://www.cs.ou.edu/~weaver/improvise/examples/hotels/>

Complex linked multiform views

System: **Pathfinder**



<https://www.youtube.com/watch?v=aZF7AC8aNXo>

Idiom: **Overview-detail views**

System: **Google Maps**

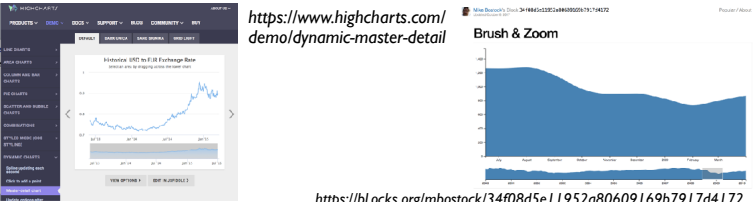
- encoding: same
- data: subset shared
- navigation: shared
 - bidirectional linking
- differences
 - viewpoint
 - (size)
- special case:
birds-eye map



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

Idiom: **Overview-detail navigation**

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

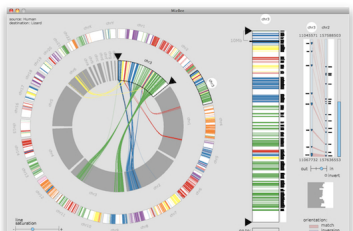


<https://bl.ocks.org/mbostock/34f08d5e11952a80609169b7917d4172>

Overview-detail

System: **MizBee**

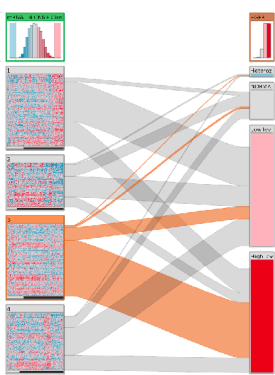
- multiscale: three viewing levels
 - linked views
 - dynamic filtering
 - tooling: processing (modern version: p5js.org)



<https://www.youtube.com/watch?v=86p7brwuz2g>

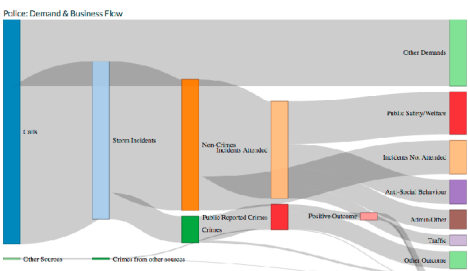
Overview-detail

System: **StratomeX**



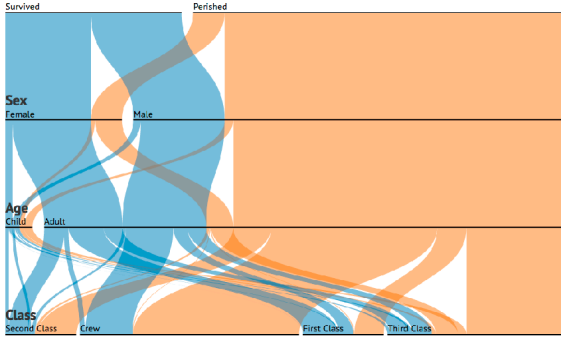
<https://www.youtube.com/watch?v=UcKDbGqHsdE>

Flows: R/Shiny



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

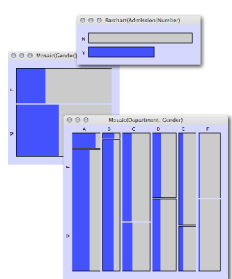
Idiom: **Parallel sets**



<https://www.jasondavies.com/parallel-sets/>
<https://eagereyes.org/parallel-sets>

Idiom: **Mosaic plots**

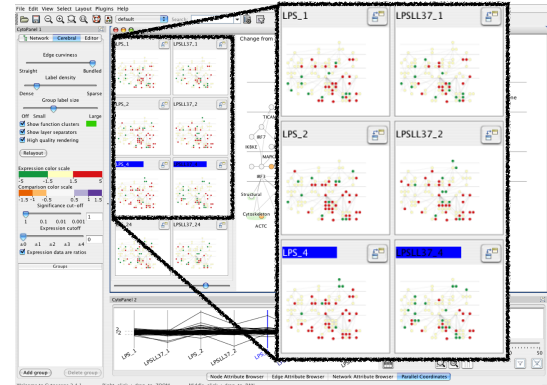
System: **Mondrian**



<http://www.theusrus.de/blog/understanding-mosaic-plots/>
<http://www.theusrus.de/Mondrian/>
<http://www.theusrus.de/blog/making-movies/>

Idiom: **Small multiples**

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



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

System: **Cerebral**

Coordinate views: Design choice interaction

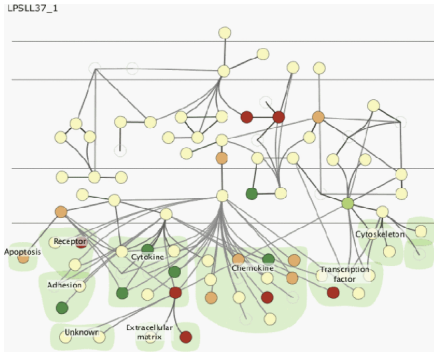
		Data		
		All	Subset	None
Encoding	Same	Redundant	Overview/Detail	Small Multiples
	Different	Multiform	Multiform, Overview/Detail	No Linkage

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

Why not animation?

- disparate frames and regions: comparison difficult
 - vs contiguous frames
 - vs small region
 - vs coherent motion of group

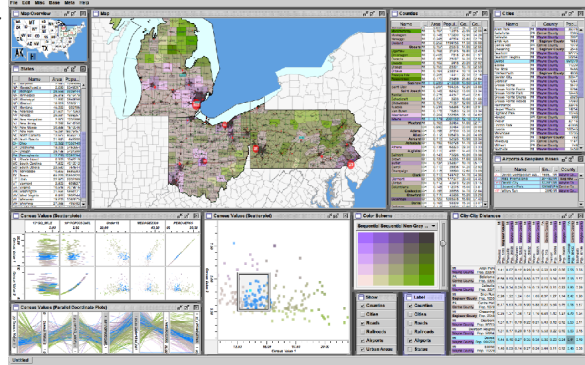
- safe special case
 - animated transitions



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System: **Improvise**

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

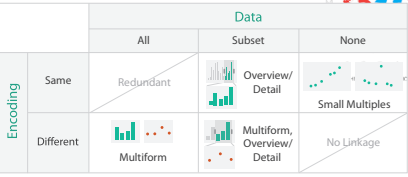


[Building Highly-Coordinated Visualizations In Improvise. Weaver. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 159–166, 2004.]

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Quiz: Multiple views

- gerrymandering

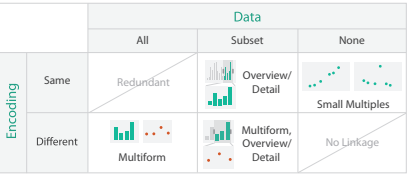


<http://www.statmapsnpix.com/2018/05/the-shape-of-american-democracy-v1.0.html>

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Quiz: Multiple views

- terrain

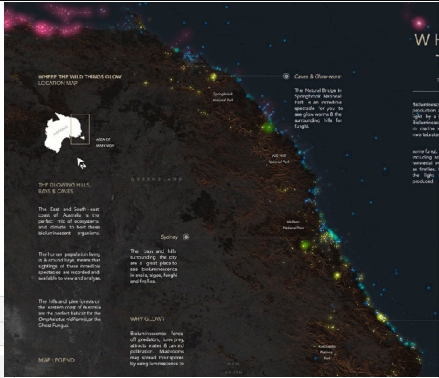


<https://earthobservatory.nasa.gov/images/144367/taking-measure-of-antarctic-terrain>

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Quiz: Multiple views

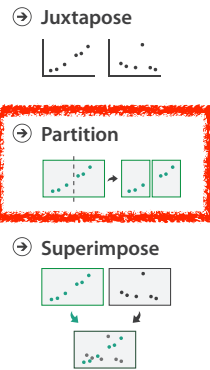
- where the wild things glow



<https://public.tableau.com/profile/jeonni.walker#!/vizhome/WhereTheWildThingsGlow/Tester>

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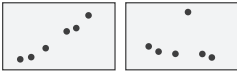
Facet



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Partition into views

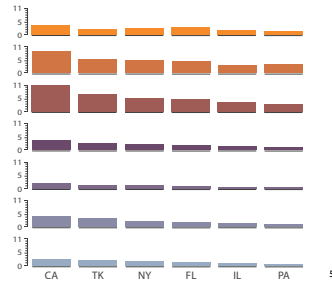
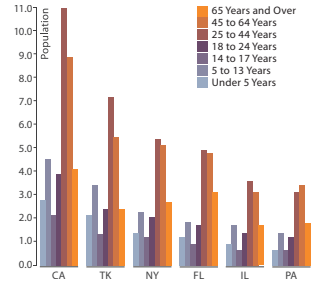
- how to divide data between views → Partition into Side-by-Side Views
 - split into regions by attributes
 - encodes association between items using spatial proximity
 - order of splits has major implications for what patterns are visible



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Partitioning: List alignment

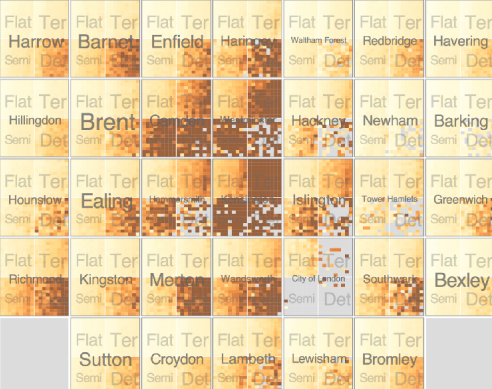
- single bar chart with grouped bars
 - split by state into regions
 - complex glyph within each region showing all ages
 - compare: easy within state, hard across ages
- small-multiple bar charts
 - split by age into regions
 - one chart per region
 - compare: easy within age, harder across states



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Partitioning: Recursive subdivision

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



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

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Partitioning: Recursive subdivision

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

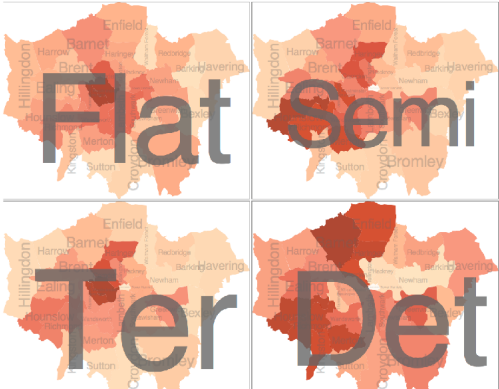


[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

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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.]

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Partitioning: Recursive subdivision

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

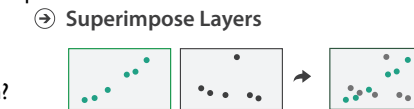


[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

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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?



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Static visual layering

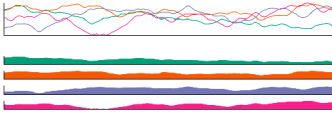
- foreground layer: roads
 - hue, size distinguishing main from minor
 - high luminance contrast from background
- background layer: regions
 - desaturated colors for water, parks, land areas
- user can selectively focus attention
- “get it right in black and white”
 - check luminance contrast with greyscale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

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



Superimposing limits

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



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

Idiom: **Trellis plots**

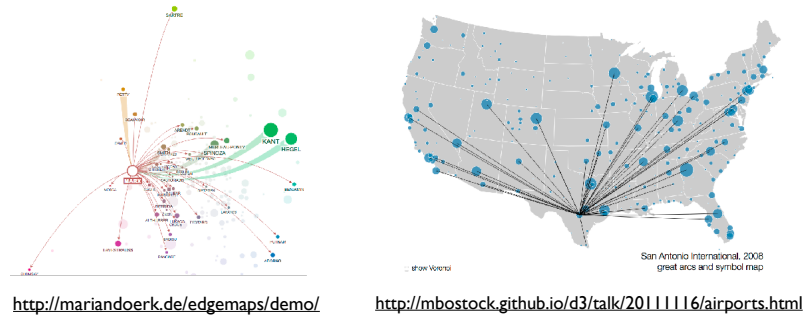
- superimpose within same frame
 - color code by year
- partitioning
 - split by site, rows are wheat varieties
- main-effects ordering
 - derive value of median for group, use to order
 - order rows within view by variety median
 - order views themselves by site median



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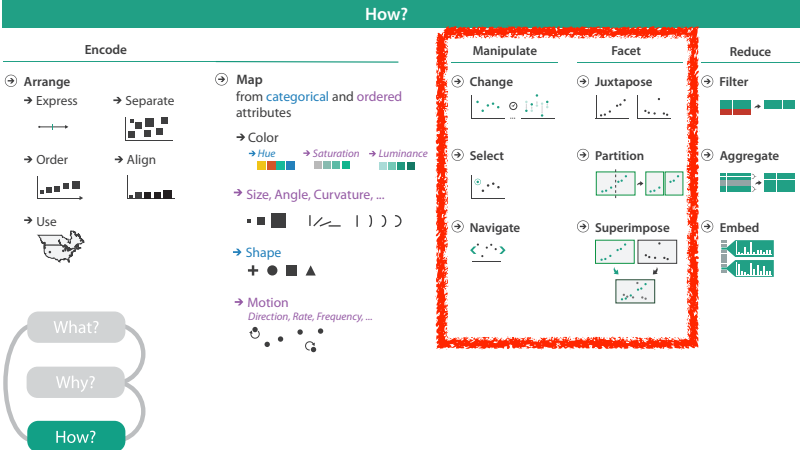
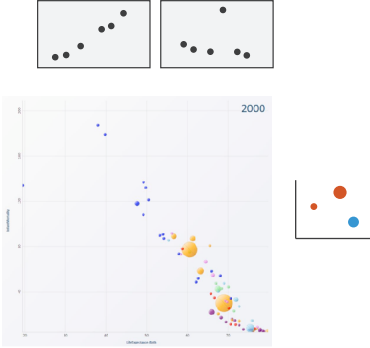
Dynamic visual layering

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



Partition into views

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



Credits

- Visualization Analysis and Design (Ch 11, 12)
- Alex Lex & Miriah Meyer, <http://dataviscourse.net/>
- Effectiveness of Animation in Trend Visualization. George Robertson, Roland Fernandez, Danyel Fisher, Bongshin Lee, and John Stasko. IEEE TVCG 14(6):1325-32 (Proc InfoVis 2008). <https://www.cc.gatech.edu/~stasko/papers/infovis08-anim.pdf>