Ch 11/12: Manipulate, Facet
Paper: Paramorama

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CPSC 547, Information Visualization
Week 7: 24 Oct 2017

www.cs.ubc.ca/~tmm/courses/547-17F

Today

- timing
  - presentation topics
  - projects
    - meetings timing
    - proposal expectation walkthrough
    - team (or potential team) sync-ups
  - today's reading discussion, Q&A
  - break
  - Matt Brehmer guest lecture 3:30
    - Timelines Revisited
    - ChartAccent
    - tools discussion

Presentations & Projects

Presentation topic choices

- presentation topic choices due this Friday (Oct 27) at noon
  - post your choice to discussion thread on Canvas: 1 or 2 topic choices
    - ok to have more than one person with same choice
  - timing: let me know if a specific day is bad for you ("veto day")
    - from this set: Nov 7, 14, 21, 28, Dec 5
  - I'll assign days soon
  - I'll assign papers (from this year's VIS conf) at least 1 week before your presentation
  - more on presentation expectations next time (Oct 31)

Presentation topics: Pick one or two

- data types
  - networks
  - trees
  - geographic data
  - high-dimensional data
  - text data
  - space & time (spatiotemporal data)
  - trajectories
  - sequences & events
  - multi-attribute tables
  - spatial fields
- domains
  - machine learning
  - genomics
  - medicine
  - sports
  - digital humanities
  - sense making
- topics
  - color
  - design
  - perception
  - uncertainty
  - analysis process
- techniques
  - parallel coordinates
  - dimensionality reduction
  - clustering
  - matrix views
  - multiple view coordination

Groups

- finalize by this Fri Oct 27 at latest
  - post to project matchup thread on discussion board to confirm your group
  - please post with current status report, even before that!
    - who's still looking, who's resolved

Meetings

- each group needs signoff: at least one meeting
  - in some cases followup meeting needed; in some cases you're already set
- meetings cutoff is 5pm Thu Nov 2
- major blocks of available time
  - Tue 10/24 5-6
  - Wed 10/25 4-6:30
  - Thu 10/26 3:30-6:30
  - Fri 10/27 5-6
  - Mon 10/30 flexible all day
  - Tue 10/31 5-7
  - Wed 11/1 5:30-6:30
  - The 11/2 3:30-5

Projects overall schedule

- Pitches: Tue Oct 17 in class
- Groups finalized: Fri Oct 27 5pm
- Meetings cutoff: Thu Nov 2 at 5pm
- Proposals due: Mon Nov 5 at 10pm
  - (no readings due Tue Nov 6)
- Peer Project Reviews 1: Tue Nov 20 in class
- Peer Project Reviews 2: Tue Dec 5 in class
- Final presentations: Tue Dec 12 1-5pm
- Final papers due: Fri Dec 15 at 11:59pm

Proposals

- projects: written proposals due Mon Nov 5 10pm
  - (no readings due Tue Nov 6)
- heading
  - project title (real title, not just "CPSC 547 proposal" - can change later)
  - name & email of every person on team (do not include student numbers)
- intro: brief description of what you're proposing to do, at high level
  - include personal expertise in this area (for each group member)
- for design studies: domain, data, task
  - definitely in domain terms
  - get started on abstraction (even if preliminary)
    - do discuss scale of data: # items, # levels in each categorical attrib, range of ordered attribs
- for technique projects: explain proposed context of use

Proposals II

- proposed infovis solution (what you know so far)
  - do include illustration of what interface might look like, could be hand drawn sketch or mockup made with drawing program
  - do include scenario of use (how user would use solution to address task)
- implementation plan (high-level: platform, language, libraries)
  - clarify your scope/goal: building on work of others to enable more ambitious project, vs rolling your own to learn tool. amount of work depends on your existing expertise
- milestones
  - break into meaningful smaller pieces. specific to your project, in addition to generic
  - for each, estimate target date of completion *and* hours of work
  - be explicit about who will do what: work breakdown between group members
  - time scope: 70 hrs per person across whole project
  - very typical to structure as possibilities: after A&B, decide on C and do 2 of D-G

Proposals III

- http://www.cs.ubc.ca/~tmm/courses/547-17F/projectdesc.html#proposals
- also, consult final report structure to have future goal in mind http://www.cs.ubc.ca/~tmm/courses/547-17F/projectdesc.html#final

Paper: Paramorama

Paramorama: Visualization of Parameter Space for Image Analysis

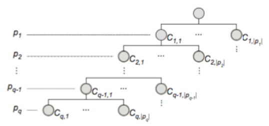
- requirements
  - R1 separate out specification of input params and inspection of output
    - from slow computations (actual image processing)
  - R2 enable param optimization. three classes of params, focus on hard ones:
    - aliases: input once, never change, minimal effort
    - nominal params: pick from list, never change, minimal effort
    - continuous params: essential to find right thresholds; difficult & time consuming
      - only 3-7 out of the 5-20 total params need to be carefully sampled
  - R3 analyze outcomes for reference image wrt input params: find good vs bad
- strategy
  - offline batch processing to compute, then interactive exploration of output
  - user selects module, subset of continuous params, range, and target # samples

[Visualization of Parameter Space for Image Analysis. Pretorius, Ruddle, Bray, Carpenter. TVCG 12(17):2402-2411 2011 (Proc. InfoVis 2011).]

Data

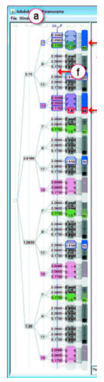
- data: samples & output
  - CellProfiler full pipeline has150-200 params
    - 10-20 modules w/ 5-20 params each
- derived data: table
  - rows are unique combos of sampled param values
  - columns are user-selected params
- derived data: hierarchical clustering
  - root contains all tuples
  - each level represents user-selected parameter
  - path from the root to each leaf represents unique combination of sampled parameter
  - reorder parameters to change leaf order
    - instead of reorder columns in table

	p_1	p_2	...	p_{q-1}	p_q
t_1 ⋮	$x_{1,1}$ ⋮	$x_{2,1}$ ⋮	...	$x_{q-1,1}$ ⋮	$x_{q,1}$ ⋮
$t_{\|p_q\|}$	$x_{1,1}$	$x_{2,1}$	...	$x_{q-1,1}$	$x_{q,\|p_q\|}$
$t_{\|p_q\|+1}$ ⋮	$x_{1,1}$ ⋮	$x_{2,1}$ ⋮	...	$x_{q-1,2}$ ⋮	$x_{q,1}$ ⋮
$t_{2\|p_q\|}$ ⋮	$x_{1,1}$ ⋮	$x_{2,1}$ ⋮	...	$x_{p-1,2}$ ⋮	$x_{q,\|p_q\|}$ ⋮



Overview

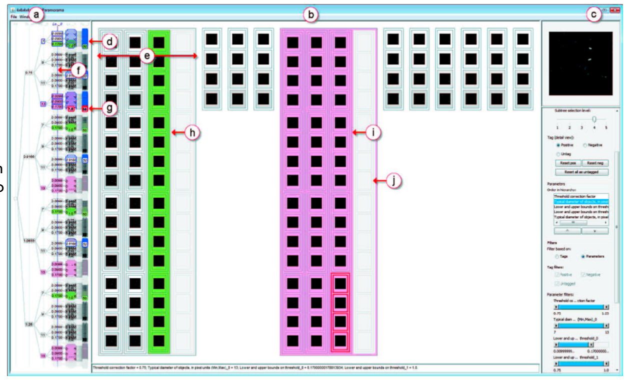
- cluster hierarchy of sampled params
- primary navigation control
  - user selects areas, linked highlighting in refinement view
- visual encoding spatial position: rectilinear node-link view
  - considerations: compactness, linear ordering, skinny aspect ratio
  - rejected: icicle plots & tree maps vs node-link
  - rejected: radial vs rectilinear
- vis enc: color
  - perceptually ordered, colourblind-safe
  - luminance high, saturation low



[Fig 4. Visualization of Parameter Space for Image Analysis. Pretorius, Ruddle, Bray, Carpenter. TVCG 12(17):2402-2411 2011 (Proc. InfoVis 2011).]

Refinement view: Custom layout

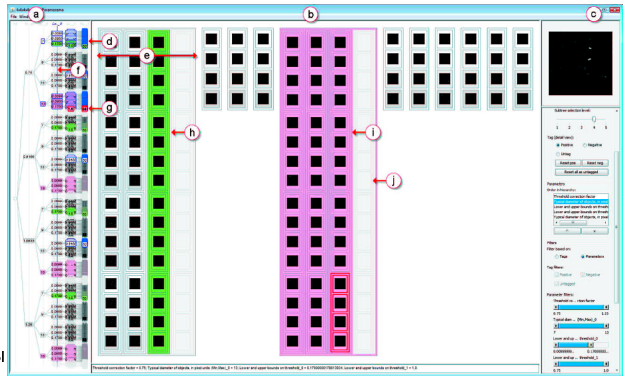
- outputs in adjacent but visually distinct areas
- preserve top-to-bottom order from overview
- dynamically control parameter level to lay out side by side
  - so contiguous regions in cluster hierarchy map to refinement view
  - vertical blue line
    - cut through tree
- ex: 11 blue subtrees highlighted in overview, 11 regions shown on right.



[Fig 4. Visualization of Parameter Space for Image Analysis. Pretorius, Ruddle, Bray, Carpenter. TVCG 12(17):2402-2411 2011 (Proc. InfoVis 2011).]

Interaction

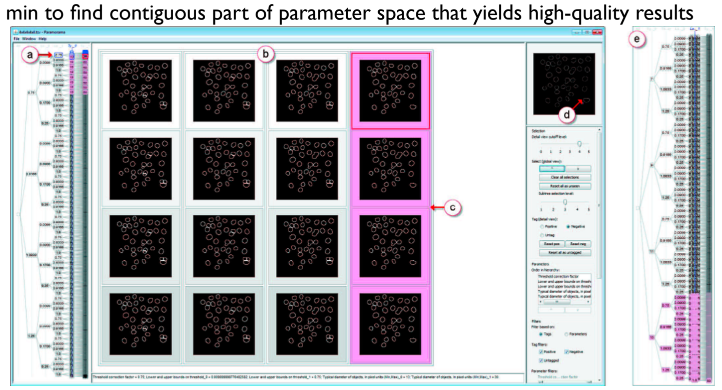
- multiple views w/ 3 scales
  - overview
  - mid-level refinement
  - detail view for selected single image (top right)
    - shortcut: next unselected subtree
- linked highlighting
  - selection blue
  - focus red
- tagging: good (green) vs bad (magenta)
- filtering: range or tags
- detail text view on control panel not popups



[Fig 4. Visualization of Parameter Space for Image Analysis. Pretorius, Ruddle, Bray, Carpenter. TVCG 12(17):2402-2411 2011 (Proc. InfoVis 2011).]

Case study: novice user

- speed: 10 min to find contiguous part of parameter space that yields high-quality results



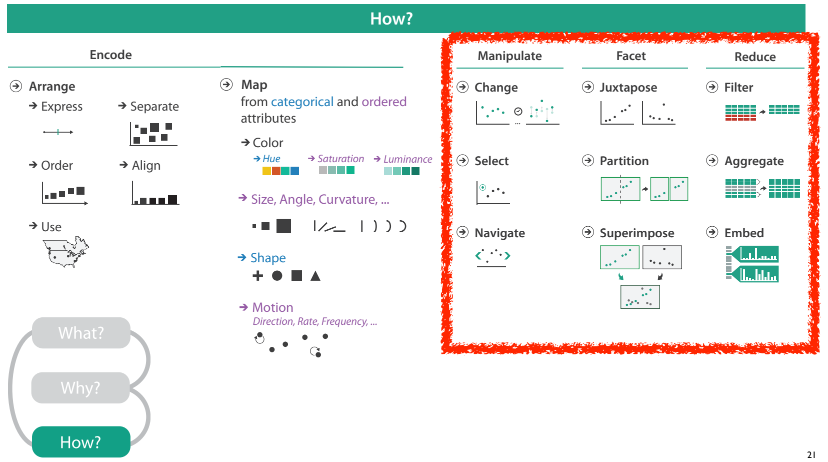
[Fig 6. Visualization of Parameter Space for Image Analysis. Pretorius, Ruddle, Bray, Carpenter. TVCG 12(17):2402-2411 2011 (Proc. InfoVis 2011).]

Case study: expert user

- quality: higher quality result from considering over 3K images

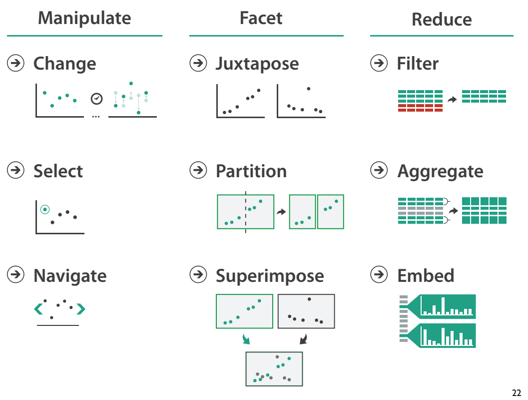
[Fig 7. Visualization of Parameter Space for Image Analysis. Pretorius, Ruddle, Bray, Carpenter. TVCG 12(17):2402-2411 2011 (Proc. InfoVis 2011).]

Ch 10: Manipulate

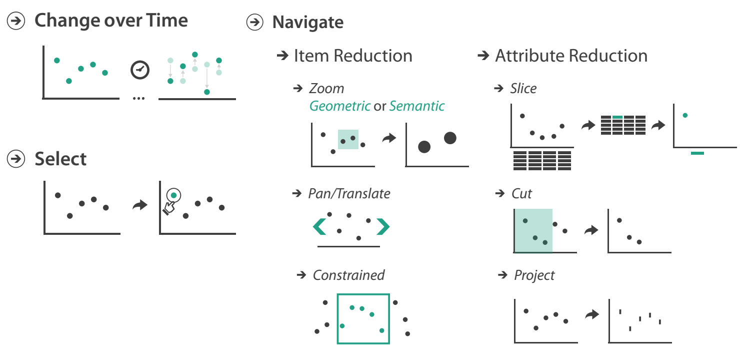


How to handle complexity: 1 previous strategy + 3 more

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



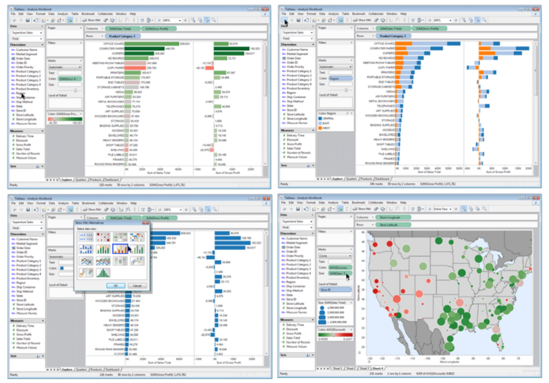
Manipulate



Change over time

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

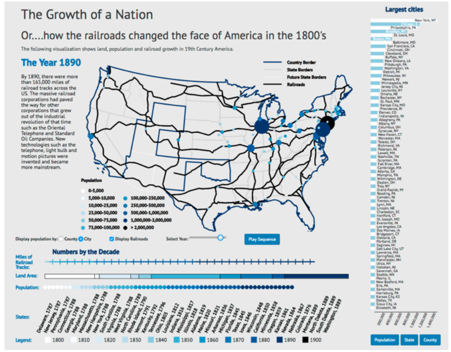
Idiom: **Re-encode** System: **Tableau**



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

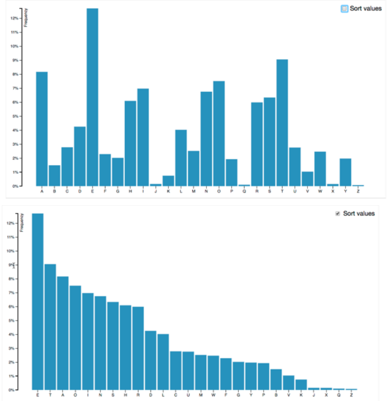


[Growth of a Nation](http://laurenwood.github.io/)

slide inspired by: Alexander Lex, Utah

Idiom: **Change order/arrangement**

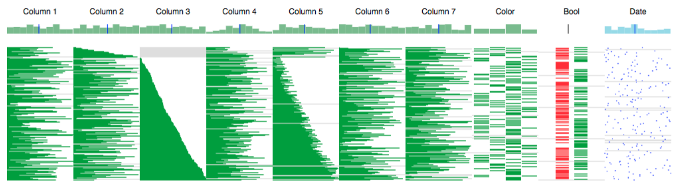
- what: simple table
- how: data-driven reordering
- why: find extreme values, trends



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

Idiom: **Reorder** System: **DataStripes**

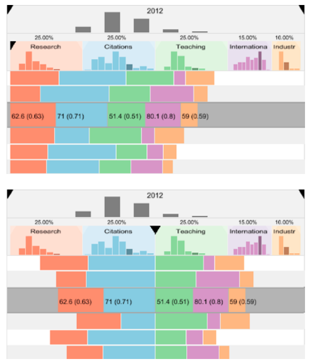
- what: table with many attributes
- how: data-driven reordering by selecting column
- why: find correlations between attributes



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

Idiom: **Change alignment** System: **LineUp**

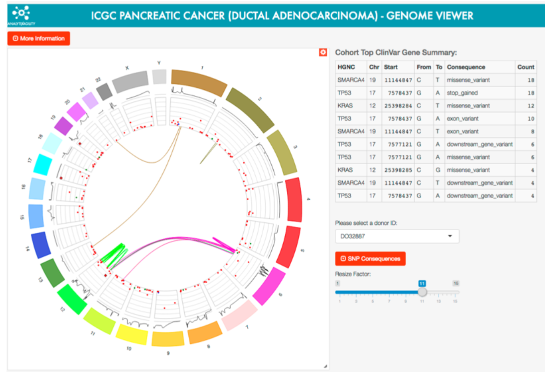
- stacked bars
  - easy to compare
    - first segment
    - total bar
- align to different segment
  - supports flexible comparison



[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.]

Shiny example

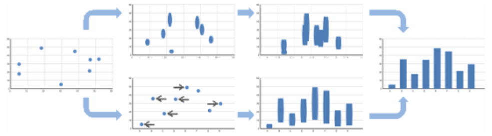
- APGI genome browser
  - tooling: R/Shiny
  - interactivity
    - tooltip detail on demand on hover
    - expand/contract chromosomes
    - expand/contract control panes



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

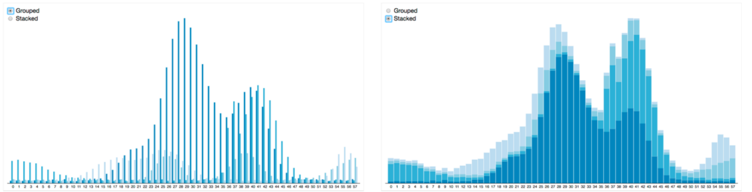


video: vimeo.com/19278444

[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**

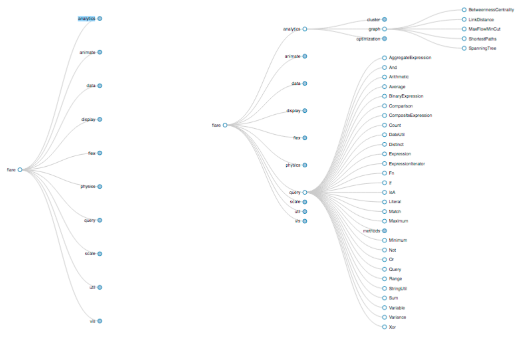
- smooth transition from one state to another
  - alternative to jump cuts, supports item tracking
    - best case for animation
  - staging to reduce cognitive load



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

Idiom: **Animated transition - tree detail**

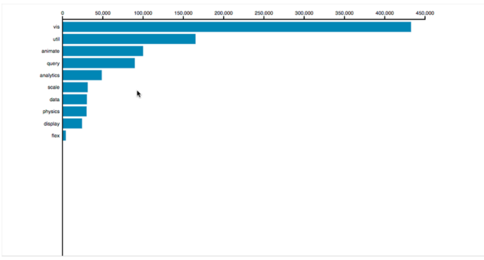
- animated transition
  - network drilldown/rollup



[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)

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?

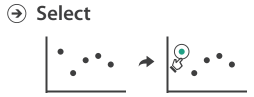
Data visualization and the news - Gregor Aisch (37 min)
vimeo.com/182590214

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

slide inspired by: Alexander Lex, Utah

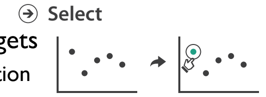
Selection

- 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

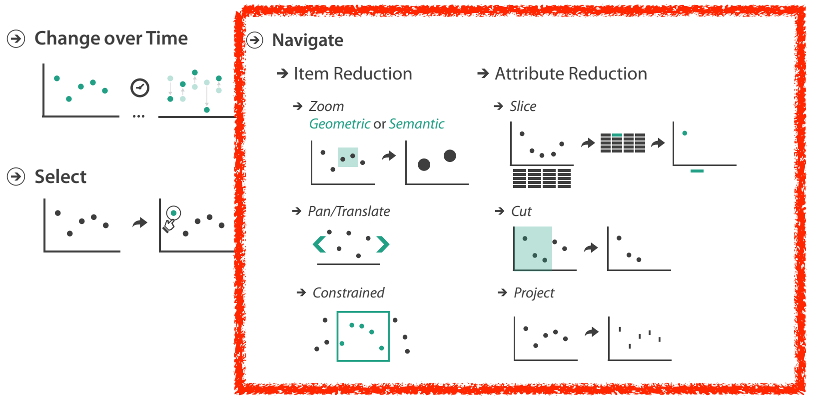
- highlight: change visual encoding for selection targets
  - visual feedback closely tied to but separable from selection (interaction)
- design choices: typical visual channels
  - change item color
    - but hides existing color coding
  - add outline mark
  - change size (ex: increase outline mark 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



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

Manipulate

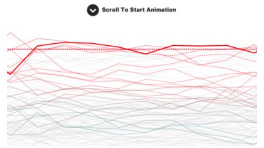


Navigate: Changing viewpoint/visibility

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

Idiom: **Scrollytelling**

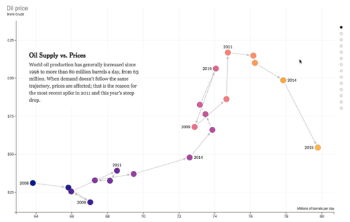
- how: navigate page by scrolling (panning down)
- pros:
  - familiar & intuitive, from standard web browsing
  - linear (only up & down) vs possible overload of click-based interface choices
- cons:
  - full-screen mode may lack affordances
  - scrolljacking, no direct access
  - unexpected behaviour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



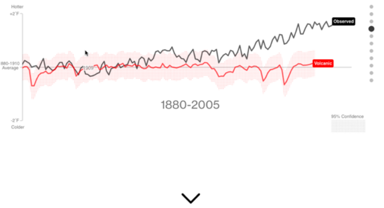
https://eagereyes.org/blog/2016/the-scrollytelling-scourge
[How to Scroll, Bostock](https://bost.ocks.org/mike/scroll/)

slide 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

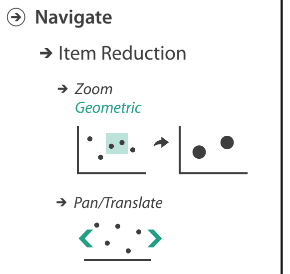


https://www.bloomberg.com/graphics/2015-whats-warming-the-world/

slide inspired by: Alexander Lex, Utah

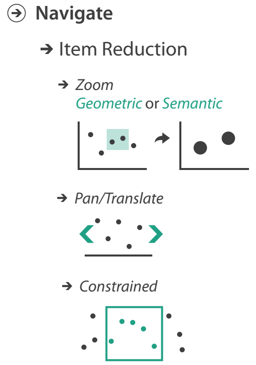
Navigate: Changing viewpoint/visibility

- 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



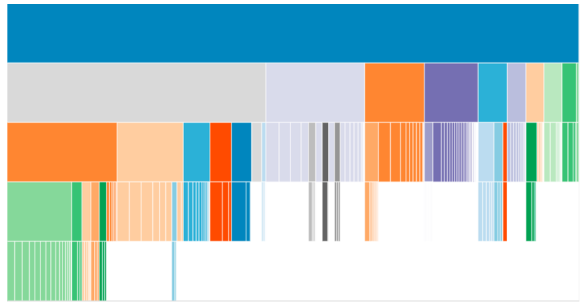
Idiom: **Animated transition + constrained navigation**

- 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**

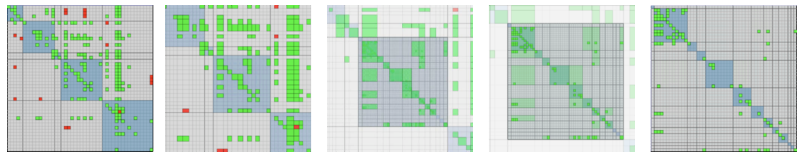
- example: icicle plot
  - transition into containing mark causes aspect ratio (shape) change



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

Idiom: **Animated transition + constrained navigation**

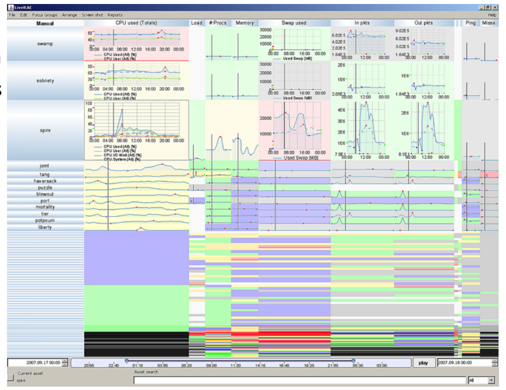
- example: multilevel matrix views
  - add detail during transition
  - movie: http://www.win.tue.nl/vis1/home/fvham/matrix/Zoomin.avi
  - movie: http://www.win.tue.nl/vis1/home/fvham/matrix/Zoomout.avi
  - movie: http://www.win.tue.nl/vis1/home/fvham/matrix/Pan.avi



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

Idiom: **Semantic zooming** System: **LiveRAC**

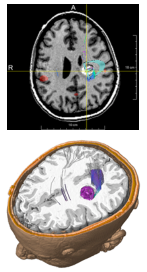
- semantic zoom
  - alternative to geometric zoom
  - resolution-aware layout adapts to available space
  - goal: legible at multiple scales
  - dramatic or subtle effects
- visual encoding change
  - colored box
  - sparkline
  - simple line chart
  - full chart: axes and tickmarks

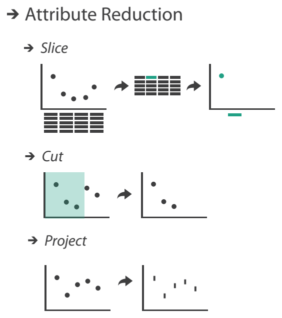


[LiveRAC - Interactive Visual Exploration of System Management Time-Series Data. McLachlan, Munzner, Koutsofios, and North. Proc. ACM Conf. Human Factors in Computing Systems (CHI), pp. 1483–1492, 2008.]

Navigate: Reducing attributes

- continuation of camera metaphor
  - 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)

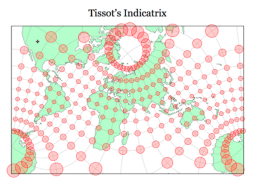




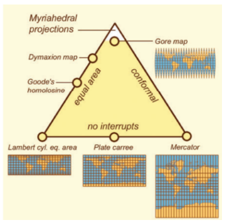
[Interactive Visualization of Multimodal Volume Data for Neurosurgical Tumor Treatment. Rieder, Ritter, Raspe, and Peitgen. Computer Graphics Forum (Proc. EuroVis 2008) 27:3 (2008), 1055–1062.]

Navigate: Cartographic projections

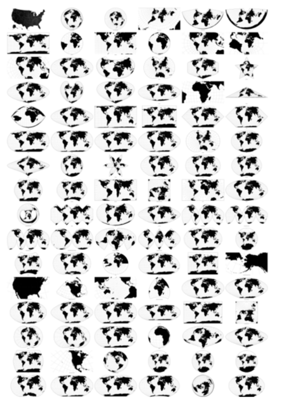
- project from 2D sphere surface to 2D plane
  - can only fully preserve 2 out of 3
    - angles: conformal
    - area: equal area
    - contiguity: no interruptions



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



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



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

Interaction benefits

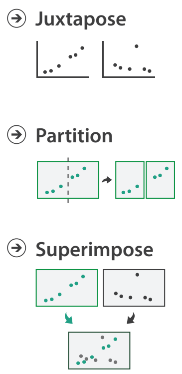
- interaction pros
  - major advantage of computer-based vs paper-based visualization
  - flexible, powerful, intuitive
    - exploratory data analysis: change as you go during analysis process
    - fluid task switching: different visual encodings support different tasks
  - animated transitions provide excellent support
    - empirical evidence that animated transitions help people stay oriented

Interaction limitations

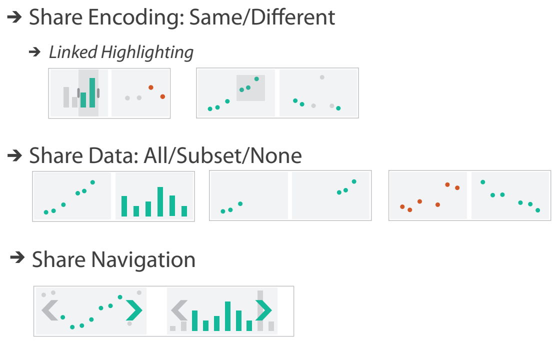
- interaction has a time cost
  - sometimes minor, sometimes significant
  - degenerates to human-powered search in worst case
- remembering previous state imposes cognitive load
  - *rule of thumb: eyes over memory*
    - *hard to compare visible item to memory of what you saw*
    - ex: maintaining context/orientation when navigating
    - ex: 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

Ch 11: Facet

Facet

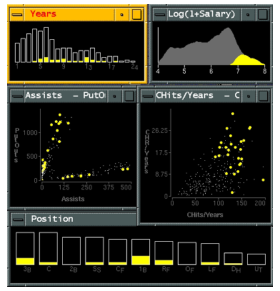


Juxtapose and coordinate views



Idiom: **Linked highlighting** System: **EDV**

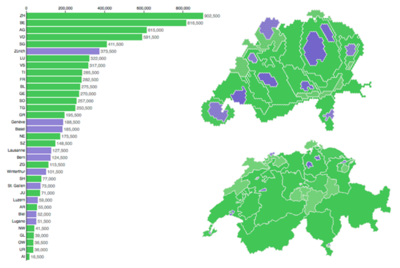
- see how regions contiguous in one view are distributed within another
  - powerful and pervasive interaction idiom
- encoding: different
  - ***multiform***
- data: all shared
- aka: brushing and linking



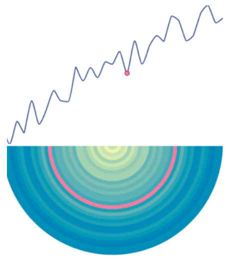
[Visual Exploration of Large Structured Datasets. Wills. Proc. New Techniques and Trends in Statistics (NTTS), pp. 237–246. IOS Press, 1995.]

Linked views

- unidirectional vs bidirectional linking

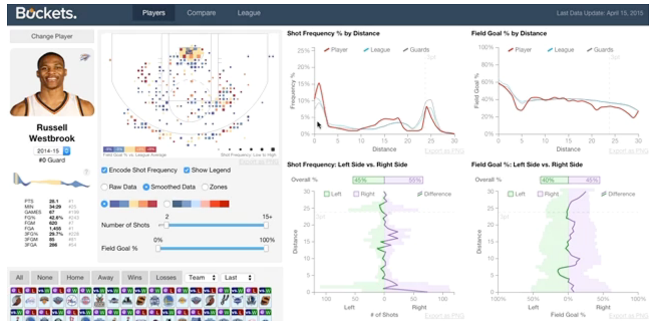


http://www.ralphstraumann.ch/projects/swiss-population-cartogram/



http://peterbeshai.com/linked-highlighting-react-d3-reflux/

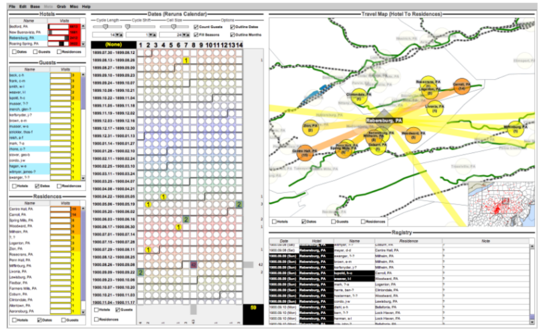
Linked views: Multidirectional linking System: **Buckets**



http://buckets.peterbeshai.com/

https://medium.com/@pbesh/linked-highlighting-with-react-d3-js-and-reflux-16e9c0b2210b

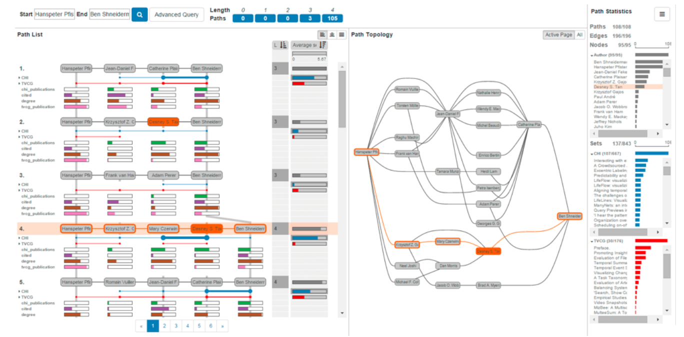
Video: Visual Analysis of Historical Hotel Visitation Patterns



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

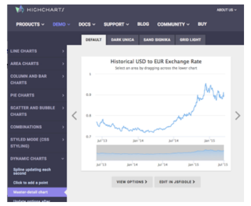
Idiom: **Overview-detail views** System: **Google Maps**

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

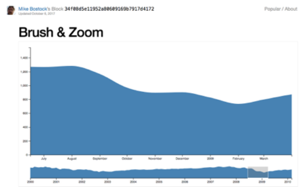
[A Review of Overview+Detail, Zooming, and Focus+Context Interfaces. Cockburn, Karlson, and Bederson. ACM Computing Surveys 41:1 (2008), 1–31.]

Idiom: **Overview-detail navigation**

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



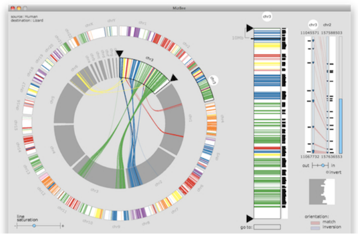
https://www.highcharts.com/demo/dynamic-master-detail



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

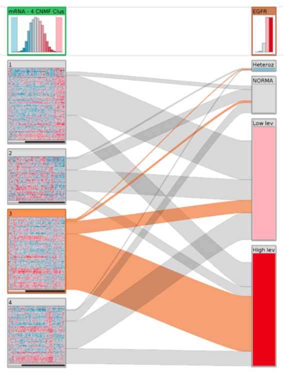
Overview-detail System: **MizBee**

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



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

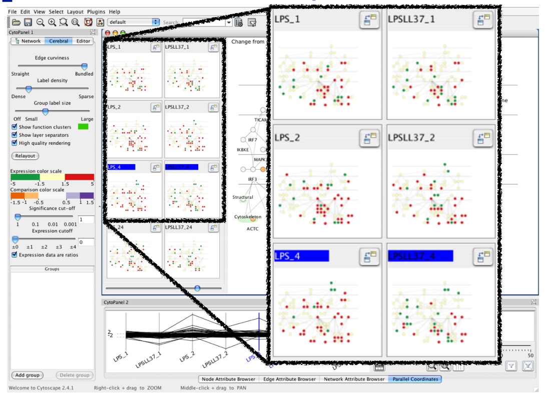
Overview-detail System: **StratomeX**



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

Idiom: **Small multiples** — System: **Cerebral**

- 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.]

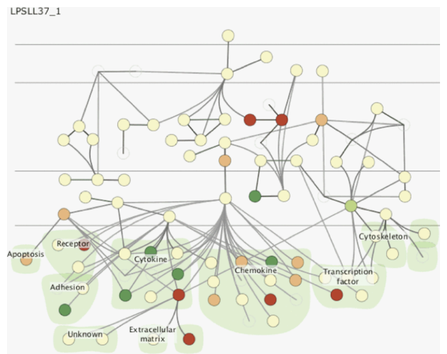
Coordinate views: Design choice interaction

		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

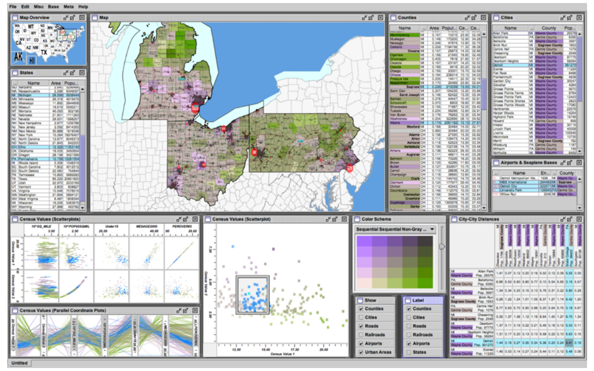
Why not animation?

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



System: **Improvise**

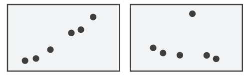
- investigate power of multiple views
  - pushing limits on view count, interaction complexity
  - how many is ok?
    - open research question
  - reorderable lists
    - easy lookup
    - useful when linked to other encodings

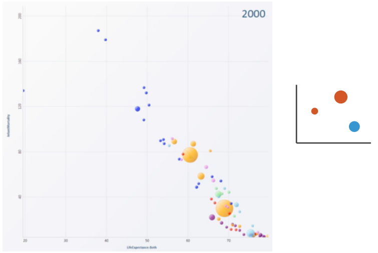


[Building Highly-Coordinated Visualizations In Improvise. Weaver. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 159–166, 2004.]

Partition into views

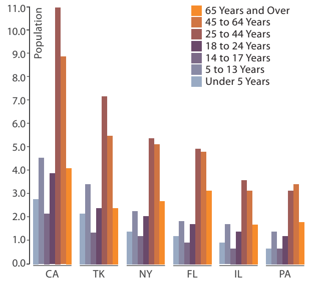
- how to divide data between views ➔ Partition into Side-by-Side Views
  - split into regions by attributes
  - encodes association between items using spatial proximity
  - order of splits has major implications for what patterns are visible
- no strict dividing line
  - *view: big/detailed*
    - contiguous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

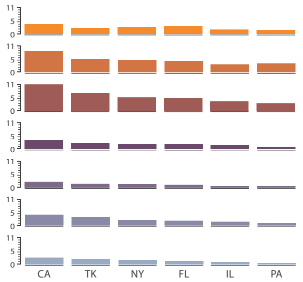




Partitioning: List alignment

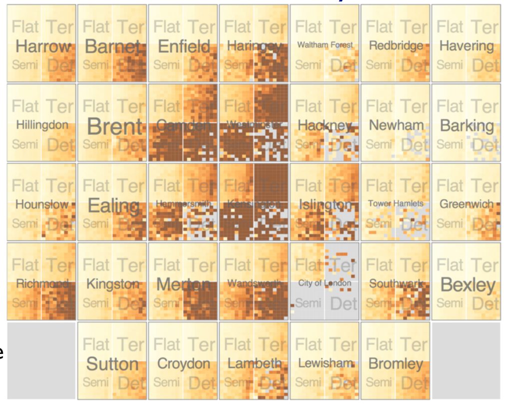
- single bar chart with grouped bars
  - split by state into regions
    - complex glyph within each region showing all ages
  - compare: easy within state, hard across ages
- small-multiple bar charts
  - split by age into regions
    - one chart per region
  - compare: easy within age, harder across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





Partitioning: Recursive subdivision — System: **HIVE**

- 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.]

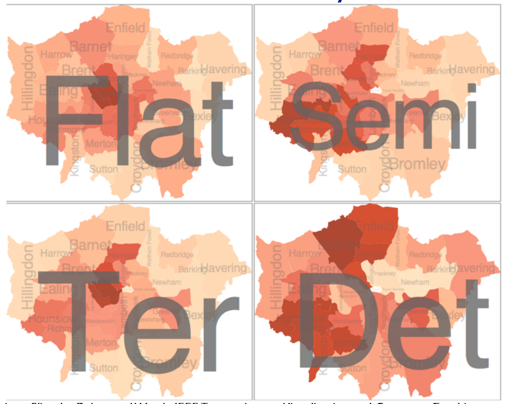
Partitioning: Recursive subdivision — System: **HIVE**

- 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.]

Partitioning: Recursive subdivision — System: **HIVE**

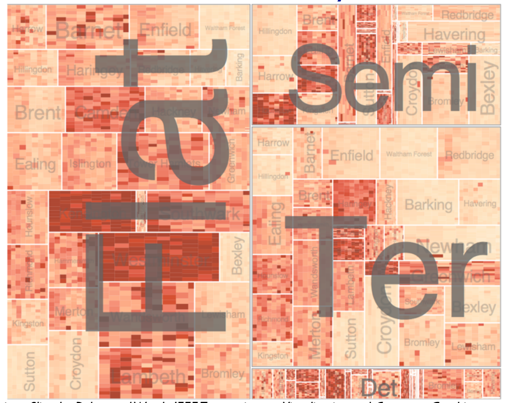
- different encoding for second-level regions
  - choropleth maps



[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.]

Partitioning: Recursive subdivision — System: **HIVE**

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

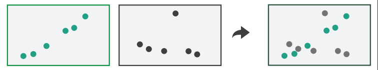


[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

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?

➔ Superimpose Layers



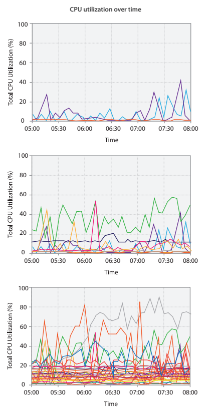
Static visual layering

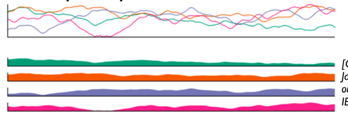
- foreground layer: roads
  - hue, size distinguishing main from minor
  - high luminance contrast from background
- background layer: regions
  - desaturated colors for water, parks, land areas
- user can selectively focus attention
- "get it right in black and white"
  - check luminance contrast with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

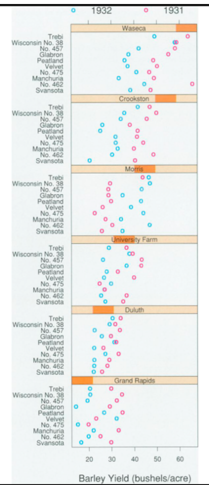




[Graphical Perception of Multiple Time Series. Javed, McDonnel, and Elmqvist. IEEE Transactions on Visualization and Computer Graphics (Proc. IEEE InfoVis 2010) 16:6 (2010), 927–934.]

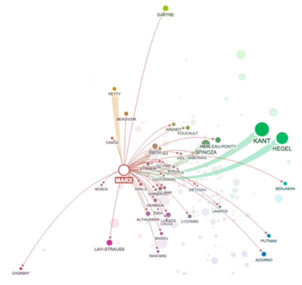
Idiom: **Trellis plots**

- 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

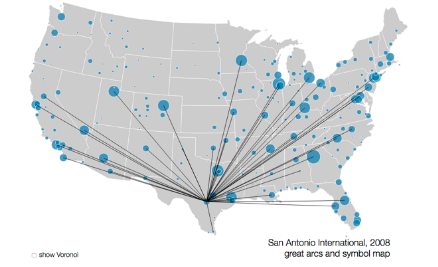


Dynamic visual layering

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



http://mariandoerk.de/edgemaps/demo/



http://mbostock.github.io/d3/talk/20111116/airports.html