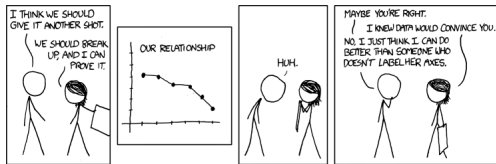## Slide 1

Lectures 1&2:
Manipulate & Interact

Tamara Munzner
Department of Computer Science
University of British Columbia

DSCI 532: Data Visualization II
Lectures 1&2: 20 & 22 March 2017

https://github.ubc.ca/ubc-mds-2016/DSCI_532_viz-2_students

Slide 2

What's when

- 8 lectures in 4 weeks
  - Mon & Wed, 11am-12:20pm (80 min), Mar 20 - Apr 12, ORCH 3058
- 4 labs
  - Mon, 2-4pm, Mar 20 - Apr 12, ESB 1042
  - start work Mon 2pm, due next Mon 9am, 12.5% each
- 2 quizzes: Week 3 (Mon Apr 3) & week 5 (Thu Apr 20)
  - 2-2:30pm, 25% each
- my (optional) office hrs are in ICICS/CS X661
  - Mondays 5:30-6:30pm, Mar 20 - Apr 10
 - or by appointment

Slide 3

Reading

- same as before

- core foundational material covered in lectures

- textbook as backup to lectures
  - Tamara Munzner. Visualization Analysis and Design. CRC Press, 2014.
    - library has multiple ebook copies for free
    - to buy yourself, see http://www.cs.ubc.ca/~tmm/vadbook/

## Slide 4

Topics

- Lectures 1&2
  - Manipulate View
    - Change over Time, Select, Navigate

- Lectures 3&4
  - Facet Into Multiple Views
    - Juxtapose, Partition, Layer

- Lectures 5&6
  - Reduce Items & Attributes
    - Filter, Aggregate, Embed

- Lectures 7&8
  - Usability/Validation & Case Studies

Slide 5

Labs

- make visualizations as self-documenting as possible
  - meaningful & useful title, labels, legends
    - axes and panes/subwindows should have labels
      - and axes should have good mix/max boundary tick marks
    - everything that's plotted should have a legend
      - and own header/labels if not redundant with main title
    - use reasonable numerical format
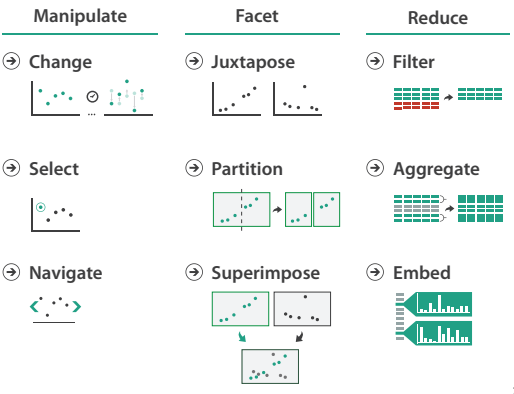   - avoid scientific notation in most cases

[https://xkcd.com/833/]

Slide 6

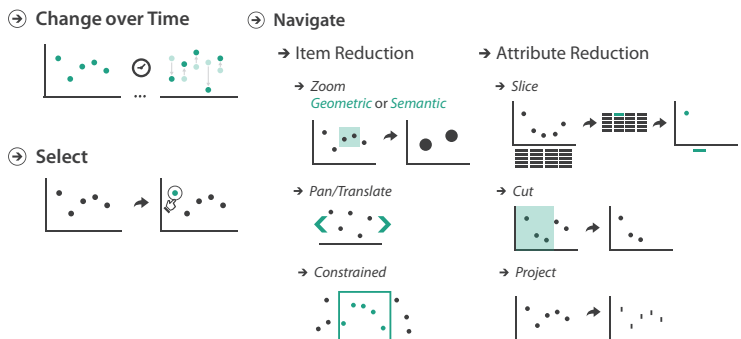## Slide 7
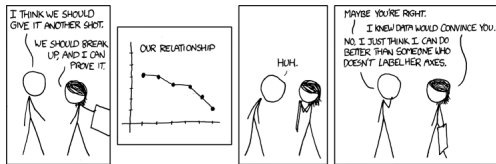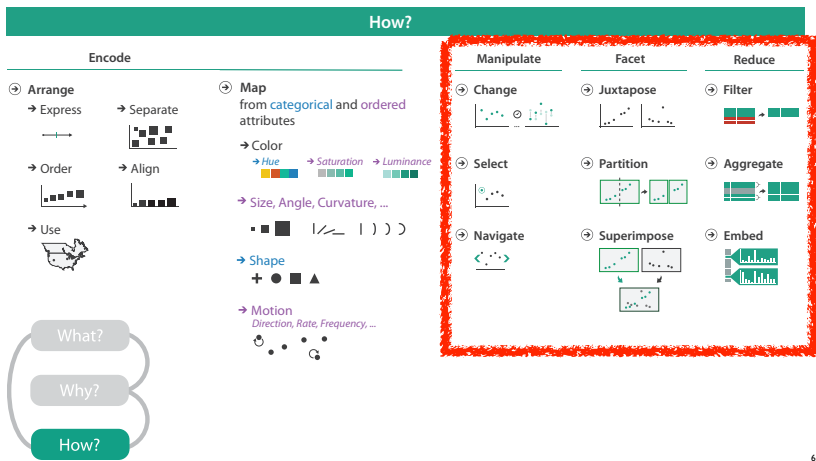
How to handle complexity: 1 previous strategy + 3 more

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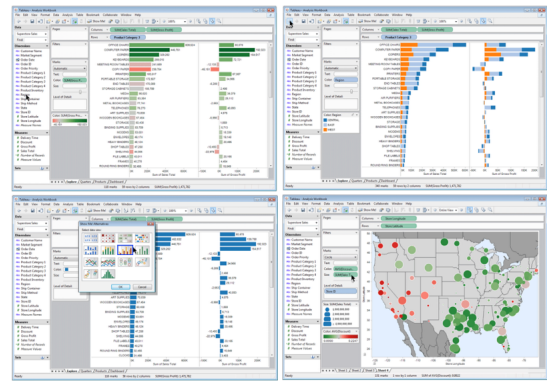- reduce items/attributes within single view

Slide 8

Manipulate

Slide 9

Change over time

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

Slide 10

Idiom: **Change encoding**   System: **Tableau**

made using Tableau, http://tableausoftware.com

Slide 11

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
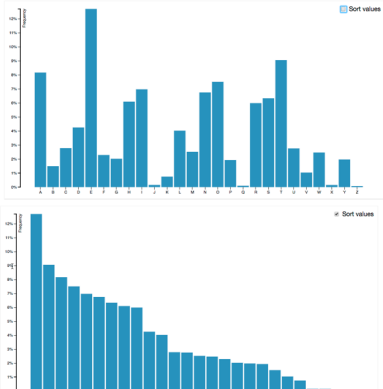   - controls & canvas
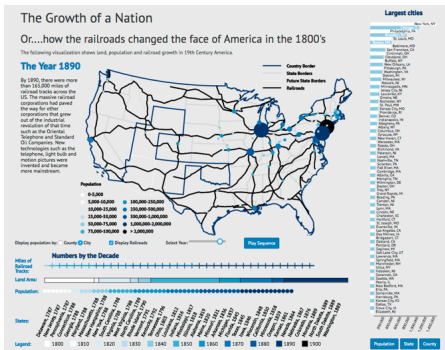
[Growth of a Nation](http://laurenwood.github.io/)
slide inspired by: Alexander Lex, Utah

Slide 12

Idiom: **Change order/arrangement**

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

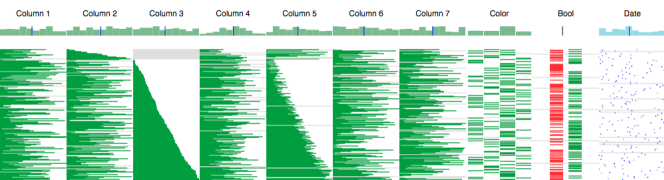[Sortable Bar Chart](https://bl.ocks.org/mbostock/3885705)

Slide 13

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

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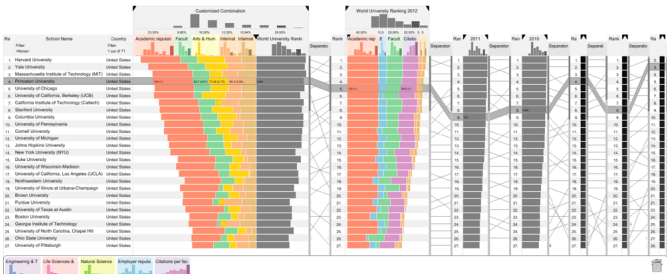- why: find correlations between attributes

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

Slide 14

### Idiom: **Reorder**   System: **LineUp**

- what: tables with many attributes; derived rankings based on weights
- task: compare rankings
- how: reorder by interactively changing weights

[LineUp: Visual Analysis of Multi-Attribute Rankings. Gratzl, Lex, Gehlenborg, Pfister, and Streit. IEEE TVGC (Proc. InfoVis 2013) 19:12 (2013), 2277–2286.]
[LineUp Demo](https://lineup.caleydoapp.org)

Slide 15

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

- stacked bars
  - easy to compare
    - first segment
    - total bar
- align to different segment
  - supports flexible comparison
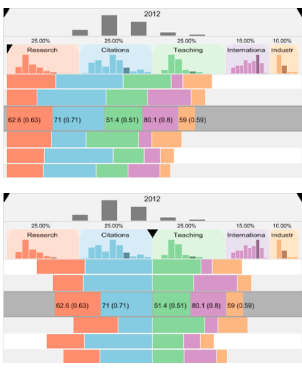
[LineUp: Visual Analysis of Multi-Attribute Rankings. Gratzl, Lex, Gehlenborg, Pfister, and Streit. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2013) 19:12 (2013), 2277–2286.]

Slide 16

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
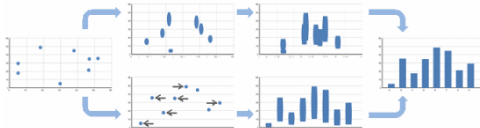
video: vimeo.com/19278444

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

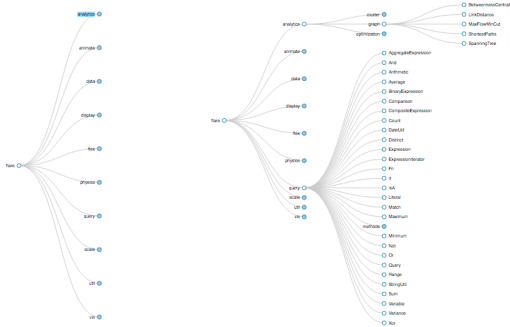## Idiom: **Animated transitions - visual encoding change**

- smooth transition from one state to another
  - alternative to jump cuts, supports item tracking
    - best case for animation
  - staging to reduce cognitive load
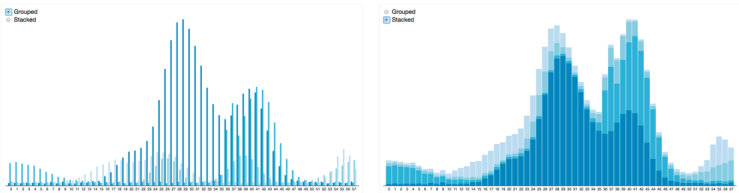
[Stacked to Grouped Bars](http://bl.ocks.org/mbostock/3943967)

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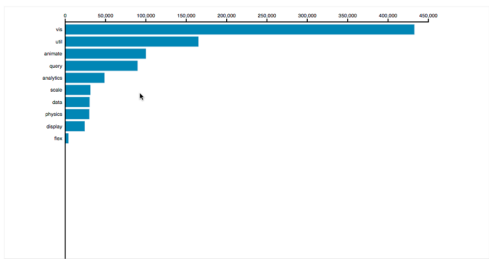## Idiom: **Animated transition - tree detail**

- animated transition
  - network drilldown/rollup

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

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## 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)

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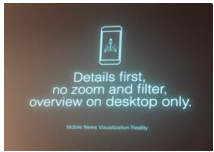
Data visualization and the news - Gregor Aisch (37 min)
vimeo.com/182590214

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

slide inspired by: Alexander Lex, Utah

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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, …)

⊕ **Select**

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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

⊕ **Select**

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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

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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)

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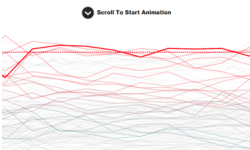## Navigate: Changing viewpoint/visibility

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

⊕ **Navigate**

→ Item Reduction

→ *Pan/Translate*
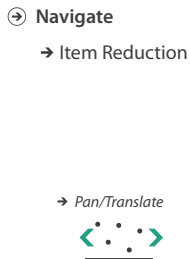
25

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
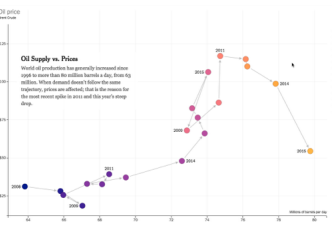 - continuous control for discrete steps

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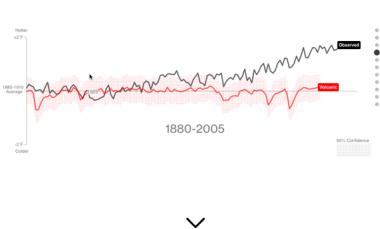[How to Scroll, Bostock](https://bost.ocks.org/mike/scroll/)

slide inspired by: Alexander Lex, Utah

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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

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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

→ *Pan/Translate*
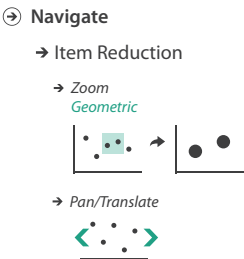
28

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*
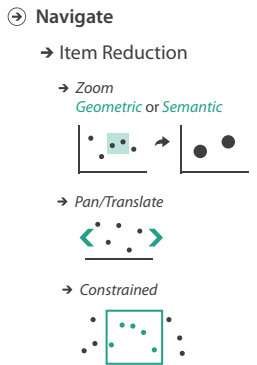
→ *Constrained*

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Idiom: **Animated transition + constrained navigation**

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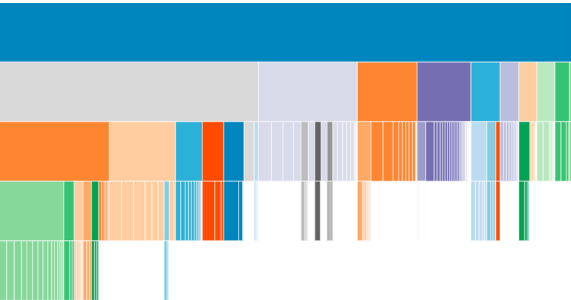 - simple zoom, only viewport changes

Zoom to Bounding Box

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

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Idiom: **Animated transition + constrained navigation**

- example: icicle plot
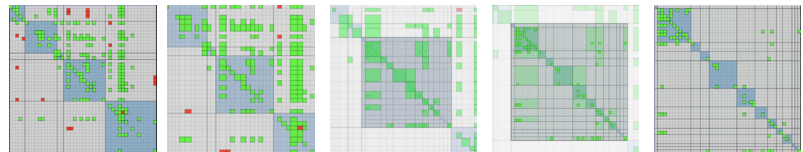 - add detail during transition into containing mark

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

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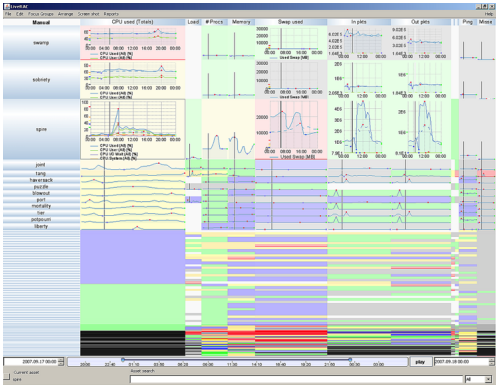
[LiveRAC - Interactive Visual Exploration of System Management Time-Series Data. McLachlan, Munzner, Koutsofios, and North. Proc. ACM Conf. Human Factors in Computing Systems (CHI), pp. 1483–1492, 2008.]

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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)

→ Attribute Reduction
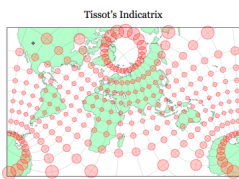
→ Slice

→ Cut

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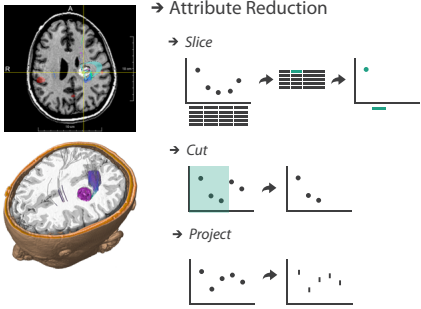
[Interactive Visualization of Multimodal Volume Data for Neurosurgical Tumor Treatment. Rieder, Ritter, Raspe, and Peitgen. Computer Graphics Forum (Proc. EuroVis 2008) 27:3 (2008), 1055–1062.]

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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

Tissot's Indicatrix

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

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

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

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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

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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
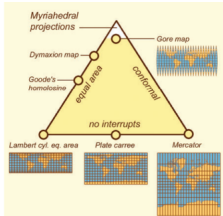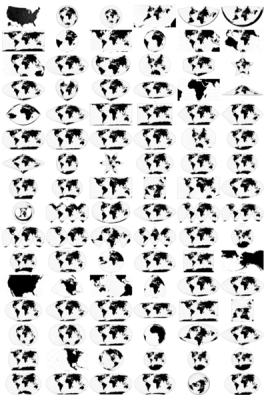
37

Further reading

- Visualization Analysis and Design. Munzner. AK Peters Visualization Series, CRC Press, 2014.
  - Chap 11: Manipulate View
- *Animated Transitions in Statistical Data Graphics*. Heer and Robertson. IEEE Trans. on Visualization and Computer Graphics (Proc. InfoVis07) 13:6 (2007), 1240– 1247.
- *Selection: 524,288 Ways to Say "This is Interesting"*. Wills. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 54–61, 1996.
- *Smooth and efficient zooming and panning*. van Wijk and Nuij. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 15–22, 2003.
- *Starting Simple - adding value to static visualisation through simple interaction*. Dix and Ellis. Proc. Advanced Visual Interfaces (AVI), pp. 124–134, 1998.

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