Information Visualization
Interactive Views

Tamara Munzner
Department of Computer Science
University of British Columbia

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https://www.students.cs.ubc.ca/~cs-436v/21Jan/
How to handle complexity: 1 previous strategy

- Derive

  - derive new data to show within view
How to handle complexity: 1 previous strategy + 2 more

- Derive
- Manipulate
  - Change
  - Select
  - Navigate
- Facet
  - Juxtapose
  - Partition
  - Superimpose

• derive new data to show within view
• change view over time
• facet across multiple views
Manipulate View
Manipulate

- Change over Time

- Select
Change over time

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

• powerful & flexible
Idiom: Re-encode

made with 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/)
made with D3
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)

made with D3
Idiom: **Reorder**

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

System: **DataStripes**


made with D3
Idiom: Change alignment

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

System: LineUp

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)
www.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
- Navigate
  - Item Reduction
    - Zoom
      - Geometric or Semantic
    - Pan/Translate
    - Constrained
- Select
Manipulate

- Change over Time
- Select

Navigate

- Zoom
- Pan/Translate
- Constrained

Geometric
Slice
Cut
Project
Navigate: Changing viewpoint/visibility

• change viewpoint
  – changes which items are visible within view

• camera metaphor
  – pan/translate/scroll
    • move up/down/sideways

→ Navigate

→ 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

[How to Scroll, Bostock](https://bost.ocks.org/mike/scroll/)

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

- **Juxtapose**

- **Partition**

- **Superimpose**
Facet

- **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

Linked views: Directionality

• unidirectional vs bidirectional linking
  – bidirectional almost always better!

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

http://peterbeshai.com/linked-highlighting-react-d3-reflux/
Linked views: Multidirectional linking

http://buckets.peterbeshai.com/

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

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

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

[https://bl.ocks.org/mbostock/1157787]
Idiom: **Small multiples + details on demand**

- combining idioms

[http://vallandingham.me/co2_small_multiple]
[https://vallandingham.me/small_multiples_with_details.html]
Interactive small multiples

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

The Rise and Decline of Ask MetaFilter

Multifactorial examination focused on decline, but loses its context blow up as well.

Here we look at some patterns Ask MetaFilter by category.

Integrated the responses to interpret time to blogging in use for a long time, most likely due to competition like Stack Overflow.

Other smaller categories have had consistent user patterns until more recently.

Disclaimer: 2014 is included, even though the year is not over yet.

[https://bl.ocks.org/ColinEberhardt/3c780088c363d1515403f50a87a87121]
[https://blog.scottlogic.com/2017/04/05/interactive-responsive-small-multiples.html]
[http://projects.flowingdata.com/tut/linked_small_multiples_demo/]

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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

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

<table>
<thead>
<tr>
<th>Encoding</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same</td>
<td>All: Redundant</td>
</tr>
<tr>
<td></td>
<td>Subset: Overview/Detail</td>
</tr>
<tr>
<td></td>
<td>None: Small Multiples</td>
</tr>
<tr>
<td>Different</td>
<td>All: Multiform</td>
</tr>
<tr>
<td></td>
<td>Subset: Multiform, Overview/Detail</td>
</tr>
<tr>
<td></td>
<td>None: No Linkage</td>
</tr>
</tbody>
</table>
Idiom: **Reorderable lists**

- list views
  - easy lookup
  - useful when linked to other views

- how many views is ok vs too complex?
  - open research question

Facet

- **Juxtapose**
  
- **Partition**
  
- **Superimpose**
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
Partitioning: Grouped vs small-multiple bars

- 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

[https://bl.ocks.org/mbostock/3887051]
[https://bl.ocks.org/mbostock/4679202]
Partitioning: Recursive subdivision

- split by neighborhood
- then by type
  - flat, terrace, semi-detached, detached
- 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

Partitioning: Recursive subdivision

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

System: HIVE

Partitioning: Recursive subdivision

- different encoding for second-level regions
  - choropleth maps

System: HIVE

Facet

- **Juxtapose**
  
- **Partition**
  
- **Superimpose**
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
Idiom: **Trellis plots**

- superimpose within same frame
  - color code by year

- partitioning
  - split by site, rows are barley varieties

- main-effects ordering
  - derive value of median for group
  - order rows within view by variety median
  - order views themselves by site median

Superimposing limits (static)

- few layers, more lines
  - up to a few dozen lines
  - but not hundreds
- superimpose vs juxtapose: empirical study
  - same size: all multiples, vs single superimposed
    - superimposed: local tasks
    - juxtaposed: global tasks, esp. for many charts

Dynamic visual layering

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

click (heavyweight)  hover (fast)

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

Encode

Arrange

→ Express
→ Separate

Order

→ Align
→ Use

Map

from **categorical** and **ordered** attributes

→ Color
   → **Hue**
   → **Saturation**
   → **Luminance**

→ Size, Angle, Curvature, ...

→ Shape

→ Motion
   *Direction, Rate, Frequency, ...

Manipulate

→ Change

Facet

→ Juxtapose
→ Partition
→ Superimpose

Reduce

→ Filter
→ Aggregate
→ Embed
→...
Credits

• Visualization Analysis and Design (Ch 11, 12)
• Alex Lex & Miriah Meyer, http://dataviscourse.net/