CIS 467/602-01: Data Visualization

Multiple Views

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Visualization Evaluation

- More details about how studies are developed
- Use of eye tracking to evaluate visualizations
- Eye tracking as a measure of user attention
- Types of studies: expert or heuristic versus user studies
Interaction Overview

- **Change over Time**

- **Select**

- **Navigate**
  - Item Reduction
    - Zoom
      - Geometric or Semantic
    - Pan/Translate
  - Constrained

- **Attribute Reduction**
  - Slice
  - Cut
  - Project

[Munzner (ill. Maguire), 2014]
Multiform

[Improvise, Weaver, 2004]
Small Multiples

[http://bl.ocks.org/mbostock/4063663]
Overview-Detail View
Assignment 4

- [Required] Mouse over states highlights corresponding bars
- [Extra credit] Mouse over bars highlights corresponding states

Extra regions: Don't need to color extra regions (DC, Puerto Rico) in Part 1

lodash URL issues: use rawgit.com
Linked Views (Juxtaposition & Coordination)

- Same visual encoding or different? (also highlighting)
- Do views show the same data, are they showing different data, or is one view showing a subset of the data in another view?
- How is navigation synchronized between views?
Multiple Views

- Juxtapose and Coordinate Multiple Side-by-Side Views

- Share Encoding: Same/Different
  - Linked Highlighting

- Share Data: All/Subset/None

- Share Navigation

[Munzner (ill. Maguire), 2014]
<table>
<thead>
<tr>
<th>Date</th>
<th>Home</th>
<th>Away</th>
<th>Score</th>
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<td>Newbury</td>
<td>96-20</td>
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<td>Maine Farmington</td>
<td>81-42</td>
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<td>71-49</td>
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## Multiple Views

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

[Munzner (ill. Maguire), 2014]
Schneiderman's Mantra

• Visual Information-Seeking Mantra [B. Schneiderman, 1996]:
  - Overview first
  - Zoom and filter (Chapter 13)
  - Details on demand
• Goal of the overview is to **summarize** all of the data
• Want specific **details** about some aspect(s) of the data, need another view/layer
  - May be permanent: side-by-side
  - May be a popup layer: often opaque or separated
• (see textbook Ch. 6.7)
Overview-Detail (Same Encoding)
EXPENDITURES BY FUNCTION
(BAR & DONUT)

Academic Support
Auxiliary Enterprises
Depreciation and Amortization
Impairment of Capital Assets
Institutional Support
Instruction
Interest
Medical Centers
Operation and Maintenance of Plant
Other
Public Service
Research
Student Financial Aid
Student Services

EXPENDITURES BY CAMPUS
FY 2012 reset

Berkeley
Davis
Irvine
Los Angeles
Merced
Riverside
San Diego
San Francisco
Santa Barbara
Santa Cruz

FIVE-YEAR TREND

[2008] [2010] [2012]

Overview-Detail (with Zoom-Filter)

- Detail involves some subset of the full dataset
- Involves user selection or filtering of some type

- How question: includes facet
- Examples:
  - Maps: partition into two views with same encoding, overview-detail
  - UC Trends: partition into multiple views, coordinated with linked highlighting, overview+detail of expenditures
Multiform & Small Multiples (Cerebral)
Navigation across multiple views

- Often navigation in one view updates navigation in another
- Example: Maps: overview shifts as you move around in detail view
- Selections in one view may trigger selections in another
Multiple Views

Partition into Side-by-Side Views

Superimpose Layers

[Munzner (ill. Maguire), 2014]
Partitioned Views

• Split dataset into groups and visualize each group
• Extremes: one item per group, one group for all items
• Can be a hierarchy
  - Order: which splits are more "related"?
  - Which attributes are used to split? Usually categorical
Glyphs, Views, and Regions

- Glyphs are composed of multiple marks
- Views are a contiguous region of space
- A region is usually associated with a group of data
- Blurry lines of distinction between them
Example: Grouped Bar Chart

![Grouped Bar Chart Example](http://bl.ocks.org/mbostock/3887051)
Example: Small Multiples Bar Chart

[M. Bostock, http://bl.ocks.org/mbostock/4679202]
Matrix Alignment & Recursive Subdivision

• Matrix Alignment:
  - regions are placed in a matrix alignment
  - splits go to rows and columns
  - main-effects ordering: use summary statistic to determine order of categorical attribute

• Recursive subdivision:
  - Designed for exploration
  - Involves hierarchy
  - User drives the ways data is broken down in recursive manner
Example: Trellis Matrix Alignment

[Becker et al., 1996]
Example: HiVE System

[Slingsby et al., 2009]
Example: HiVE System

[Slingsby et al., 2009]
Superimposed Layers

- Put different layers in the same spatial region, overlay information
- Usually each layer spans the entire view
- Must be **identifiable**: visually distinguishable
- Cartography has to deal with this a lot
- May be static or dynamic (user controls which layers are shown)
Example: Superimposed Line Charts

[M. Bostock, http://bl.ocks.org/mbostock/3884955]
Example: Hierarchical Edge Bundles

Fig. 13. A software system and its associated call graph (caller = green, callee = red). (a) and (b) show the system with bundling strength $\beta = 0.85$ using a balloon layout (node labels disabled) and a radial layout, respectively. Bundling reduces visual clutter, making it easier to perceive the actual connections than when compared to the non-bundled versions (figures 2a and 11a). Bundled visualizations also show relations between sparsely connected systems more clearly (encircled regions); these are almost completely obscured in the non-bundled versions. The encircled regions highlight identical parts of the system for (a), (b), and figure 15.

Fig. 14. Using the bundling strength $\beta$ to provide a trade-off between low-level and high-level views of the adjacency relations. The value of $\beta$ increases from left-to-right; low values mainly provide low-level, node-to-node connectivity information, whereas high values provide high-level information as well by implicit visualization of adjacency edges between parent nodes that are the result of explicit adjacency edges between their respective child nodes.

Changing the bundling strength $\beta$ and by switching between different tree layouts. The participants from academia were our fellow researchers, PhD students and MSc students from the Computer Science department of the Technische Universiteit Eindhoven. They all had experience with either software development, software visualization, or information visualization in general. Participants from industry were representatives of the Software Improvement Group (SIG) in Amsterdam, which delivers insight in the structure and technical quality of software portfolios, and representatives of FEI Company Eindhoven, which produces software to operate with FEI’s range of electron microscopes.

The majority of the participants regarded the technique as useful for quickly gaining insight in the adjacency relations present in hierarchically organized systems. In general, the visualizations were also regarded as being aesthetically pleasing. SIG and FEI Company Eindhoven are currently supporting further development by providing us with additional data sets and feedback regarding the resulting visualizations.

More specifically, most of the participants particularly valued the fact that relations between items at low levels of the hierarchy were automatically lifted to implicit relations between items at higher levels by means of bundles. This quickly gave them an impression of the high-level connectivity information while still being able to inspect the low-level relations that were responsible for the bundles by interactively manipulating the bundling strength.

This is illustrated in figure 14, which shows visualizations using different values for the bundling strength $\beta$. Low values result in visualizations that mainly provide low-level, node-to-node connectivity information. High values result in visualizations that provide high-level information as well by implicit visualization of adjacency edges between parent nodes that are the result of explicit adjacency edges between their respective child nodes.

Another aspect that was commented on was how the bundles gave an impression of the hierarchical organization of the data as well, thereby strengthening the visualization of the hierarchy. More specifically, a thick bundle shows the presence of two elements at a fairly