Data Visualization (DSC 530/CIS 602-01)

Interaction & Multiple Views

Dr. David Koop
Colormap

- A colormap specifies a mapping between colors and data values
- Colormap should follow the expressiveness principle
- Types of colormaps:

**Binary**

```
y
n
```

**Diverging**

```
-1 0 +1
```

**Categorical**

```
T F A
```

**Sequential**

```
3 2 1
```
Categorical vs. Ordered

- Hue has no implicit ordering: use for categorical data
- Saturation and luminance do: use for ordered data

[Luminance]

[Saturation]

[Hue]

[Munzner (ill. Maguire), 2014]
Continuous Colormap

[http://codepen.io/dakoop/pen/YqZJGr]
Artifacts from Rainbow Colormaps

[Borland & Taylor, 2007]
Isoluminant Rainbow Colormap

Original

Isoluminant

[Kindlmann et al., 2002]
"Get It Right in Black and White" - M. Stone

Matlab jet colormap

[S. Eddins (Matlab Blog), 2014]
"Get It Right in Black and White" - M. Stone

Matlab jet colormap (B&W)

[S. Eddins (Matlab Blog), 2014]
"Get It Right in Black and White" - M. Stone

Matlab parula colormap

[S. Eddins (Matlab Blog), 2014]
"Get It Right in Black and White" - M. Stone

Matlab parula colormap (B&W)

[S. Eddins (Matlab Blog), 2014]
Bivariate Colormaps

- Binary
  - Diverging

- Categorical

- Sequential
  - Diverging

Munzner (ill. Maguire), 2014
Project Proposal

• Turn in on myCourses)
• The name and URL of the dataset(s) you will be working with and a description of the types and semantics of your dataset
• A detailed list of the questions you plan to answer in your project
• An initial design for your visualization. Include the types of idioms and any customization of the idioms (e.g. any interactions, multiple views, different marks) that you are considering
• If doing a project with two people, both people should turn in the document
• Due Tonight
Assignment 3

- Examine trips of politicians during the primary season
- Find states that are visited often
- Find cities that are visited often
- Compare similarities between the top-visited cities
- Extra Credit: heat map showing candidates and the states they visited

- Abbreviations:
  us-states.geojson != us-states.json
- CORS issue should be fixed
  - Clear your cache if having issues
Interaction

• The view changes over time
• Changes can affect almost any aspect of the visualization
  - encoding
  - arrangement
  - ordering
  - viewpoint
  - attributes being shown
  - aggregation level
Interaction Overview

- Change over Time

- Select

[Munzner (ill. Maguire), 2014]
Encoding Changes
Sorting

• Allow user to find patterns by reordering the data
• Do this with tabular data all the time
• Note that ordered attributes don't really need sorting
  - We can compare these attributes no matter what order
  - Instead, sort categorical attribute based on an ordered attribute
Example: LineUp

[Gratzi et al., 2013]
Example: LineUp

[Gratzl et al., 2013]
Slope Graphs

- Connection marks
- Link the same item appearing in different rows
- Show changes for different attributes (parallel coordinates idea) but with one highlighted item
- Also called bump charts
Animated Transitions

[http://vadim.ogievetsky.com/IntroD3/#36]
Animated Transitions

A♥ . . . .
K♣
A♣
J♣
A♦
J♥
K♠
J♠
A♠
J♦
Q♣
K♥
K♦
Q♠
Q♦
Q♥

[http://vadim.ogievetksy.com/IntroD3/#36]
Animated Transitions

[http://bl.ocks.org/mbostock/3943967]
Animated Transitions

[http://bl.ocks.org/mbostock/3943967]
Animated Transitions

• "Jump cuts" are hard to follow
• Animations help users maintain sense of context between two states
• Empirical study showed that they work (Heer & Robertson, 2007)
Selection

- Selection is often used to initiate other changes
- User needs to select something to drive the next change
- What can be a selection target?
  - Items, links, attributes, (views)
- How?
  - mouse click, mouse hover, touch
  - keyboard modifiers, right/left mouse click, force
- Selection modes:
  - Single, multiple
  - Contiguous?
Highlighting

- Selection is the user action
- Feedback is important!
- How? Change selected item's visual encoding
  - Change color: want to achieve visual popout
  - Add outline mark: allows original color to be preserved
  - Change size (line width)
  - Add motion: marching ants
Highlighting

- Selection is the user action
- Feedback is important!
- How? Change selected item's visual encoding
  - Change color: want to achieve visual popout
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  - Change size (line width)
  - Add motion: marching ants
Highlighting

Selection Outcomes

• Selection is usually a part of an action sequence
• Can filter, aggregate, reorder selected items
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]
Navigation

• Fix the layout of all visual elements but provide methods for the viewpoint to change

• Camera analogy: only certain features visible in a frame
  - Zooming
  - Panning (aka scrolling)
  - Translating
  - Rotating (rare in 2D, important in 3D)
Navigation

 ➔ Navigate

 ➔ Item Reduction

 ➔ Zoom
  Geometric or Semantic

 ➔ Pan/Translate

 ➔ Constrained

 ➔ Attribute Reduction

 ➔ Slice

 ➔ Cut

 ➔ Project

[Munzner (ill. Maguire), 2014]
Zooming

[http://bl.ocks.org/3680999]
Geometric Zooming

[http://bl.ocks.org/3680999]
Zooming
Semantic Zooming

[http://bl.ocks.org/3680957]
Zooming

- Geometric Zooming: just like a camera
- Semantic Zooming: visual appearance of objects can change at different scales
- LiveRAC Example: (focus + context)
Navigation Constraints

• **Unconstrained** navigation: walking around in the world or an immersive 3D environment
  - Fairly standard in computer games to go where you want
  - Constrained by walls, objects (collision detection)

• Constrained navigation:
  - 3D: camera must be right-side up
  - Limit pan/zoom to certain areas
  - Comes up often with **multiple views**: want to show an area in one view that corresponds to a selection in another view
van Wijk Smooth Zooming

van Wijk Smooth Zooming

Reducing Attributes

- Often happens by reducing the number of dimensions (esp. in 3D)
- Usually in scientific visualization, will return to this when discussing that topic
Multiple Views

• Facet (noun and verb)
  - particular aspect or feature of something
  - to split

• Partition visualization into views/layers
  - Either juxtapose or superimpose
  - Depends on data and encoding
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]
Multiple Views

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

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

- Partition into Side-by-Side Views

- Superimpose Layers

[Munzner (ill. Maguire), 2014]
Multiform

[Improvise, Weaver, 2004]
Multiform Views

- The same data visualized in different ways
- Does not need to be a totally different encoding (all choices need not be disjoint), e.g. horizontal positions could be the same
- One view becomes cluttered with too many attributes
- Contributes more screen space
- Allows greater separability between channels
Small Multiples

- Same encoding, but different data in each view (e.g. SPLOM)

[http://bl.ocks.org/mbostock/4063663]
Interaction with Multiform & Small Multiples

• Key interaction with multiform and small multiples: **brushing**
  - also called linked highlighting

• Want to understand correspondences between representation in the different views
Brushing

[http://bl.ocks.org/mbostock/4063663]
D3 Brushing (Linked Highlighting) Example

<table>
<thead>
<tr>
<th>Date</th>
<th>Home</th>
<th>Away</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov. 15</td>
<td>UMass Dartmouth</td>
<td>Norwich</td>
<td>75-73</td>
</tr>
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<td>Nov. 15</td>
<td>Eastern Connecticut</td>
<td>Newbury</td>
<td>96-20</td>
</tr>
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<td>Nov. 15</td>
<td>Southern Maine</td>
<td>Maine Farmington</td>
<td>81-42</td>
</tr>
<tr>
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<td>New York U.</td>
<td>Western Connecticut</td>
<td>71-49</td>
</tr>
<tr>
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<td>UMass Boston</td>
<td>79-74</td>
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<tr>
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<td>Williams</td>
<td>Rhode Island College</td>
<td>59-47</td>
</tr>
<tr>
<td>Nov. 15</td>
<td>Wheaton (Mass.)</td>
<td>Plymouth State</td>
<td>67-48</td>
</tr>
<tr>
<td>Nov. 15</td>
<td>Tufts</td>
<td>Keene State</td>
<td>79-48</td>
</tr>
<tr>
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<td>Juniata</td>
<td>59-52</td>
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<tr>
<td>Nov. 16</td>
<td>Yeshiva</td>
<td>Plymouth State</td>
<td>43-81</td>
</tr>
<tr>
<td>Nov. 16</td>
<td>UMass Dartmouth</td>
<td>Colby-Sawyer</td>
<td>84-62</td>
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<tr>
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<tr>
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<td>UMass Dartmouth</td>
<td>71-73</td>
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<tr>
<td>Nov. 20</td>
<td>Rhode Island College</td>
<td>Emmanuel (Mass.)</td>
<td>56-72</td>
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<td>Nov. 20</td>
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<td>Lyndon St.</td>
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<td>56-62</td>
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<td>Trinity (Conn.)</td>
<td>Western Connecticut</td>
<td>57-86</td>
</tr>
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<td>WPI</td>
<td>35-56</td>
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<td>Nov. 22</td>
<td>Salem State</td>
<td>UMass Boston</td>
<td>41-63</td>
</tr>
<tr>
<td>Nov. 25</td>
<td>Keene State</td>
<td>Trinity (Conn.)</td>
<td>66-46</td>
</tr>
<tr>
<td>Nov. 25</td>
<td>Bates</td>
<td>Southern Maine</td>
<td>61-60</td>
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