Data Visualization (DSC 530/CIS 602-02)

Interaction

Dr. David Koop
(Some of) Tufte's Integrity Principles

• Show data variation, not design variation
• Clear, detailed, and thorough labeling and appropriate scales
• Size of the graphic effect should be directly proportional to the numerical quantities ("lie factor")
Bad: Data magnitude $\not\equiv$ Mark magnitude

[Image: Fox News via Flowing Data, 2012]
Tufte's Lie Factor

- Size of effect = \(\frac{2nd \ value - 1st \ value}{1st \ value}\)
- Lie factor = \(\frac{\text{size of effect in graphic}}{\text{size of effect in data}}\)
- In the graphic:

\[
\text{Lie Factor} = \frac{5.3 - 0.6}{0.6} = \frac{27.5 - 18}{18} = 14.8
\]
Avoid Chartjunk

[T. Brey via A. Lex]
Maximize Data-to-Ink Ratio

[Diagram showing bar charts comparing data for males and females across income categories.]
No Unjustified 3D (and Maximize Data-to-Ink)

Export von Bananen in Tonnen von 1994-2005

Dr. Hochhaus
Banexport 2005
Daten ZMP

[K.-H. Hochhaus, 2009]
No Unjustified 3D (and Maximize Data-to-Ink)

Which bar is higher (cyan, magenta, or yellow)?

[Export von Bananen in Tonnen von 1994-2005]

[K.-H. Hochhaus, 2009]
3D can be justified
Brushing

[http://bl.ocks.org/mbostock/4063663]
Assignment 3

- Soccer data
  - Draw two choropleth maps
  - Use the same function for both!
  - Draw a teammate graph using force-directed layout
  - Use d3.queue to load data, code provided
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
- Navigate
  - Item Reduction
    - Zoom
      Geometric or Semantic
  - Pan/Translate
  - Constrained
  - Attribute Reduction
    - Slice
    - Cut
    - Project

[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

[Gratzl 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
Animation: Jump Cut vs. Animated Transitions
### Animation: Jump Cut vs. Animated Transitions

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D. Koop, DSC 530, Spring 2017
### Animation: Jump Cut vs. Animated Transitions

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Animation: Jump Cut vs. Animated Transitions
Side-by-side views

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K♦  Q♥
A♥  Q♠
A♦  Q♣
Q♣  Q♥
Q♥  J♦
A♠  K♦
K♣  Q♣
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Side-by-side views

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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)
Studying Animated Transitions

[Heer and Robinson, 2007]
Studying Animated Transitions

[Heer and Robinson, 2007]
Design Considerations

• Based on Tversky et al.'s Congruence and Apprehension Principles

• Congruence:
  - Use consistent semantic-syntactic mappings
  - Respect semantic correspondence
  - Avoid ambiguity

• Apprehension
  - Group similar transitions
  - Minimize occlusion
  - Maximize predictability
  - Use simple transitions
  - Use staging for complex transitions
  - Transitions as long as needed, but no longer

[Heer and Robinson, 2007]
Experiment 1 (Syntactic)

- Object Tracking: Follow objects across a transition and identify the locations of the objects in the final graphic
  - Tests: bar chart to donut chart, stacked to grouped bars, sorting a bar chart, scatter plot to bar chart, timestep in a scatterplot
  - Either a jump cut or an animated transition
  - Users have to identify highlighted elements after transition
  - Measure how many pixels away from correct they are
Experiment 2 (Semantic)

- Estimating Changing Values: Follow a single target across transition and estimate the percentage change in value
  - Tests: axis rescaling + timestep animations
  - In stacked bars, each stack level updates separately, donut charts are multi-stage
  - Users asked to enter an estimate of change (increments of 20% from -90% to 90% or click "?" for no idea)

[Heer and Robinson, 2007]
Results/Conclusions

- User Preferences: Staged animation > animation > static transitions

- Animation improves graphical perception
- Staging is better (do axis rescaling before value changes)
- Avoid axis rescaling when possible

[Heer and Robinson, 2007]
Change Blindness

- [https://www.youtube.com/watch?v=uO8wpm9HSB0](https://www.youtube.com/watch?v=uO8wpm9HSB0)
Change Blindness

- [https://www.youtube.com/watch?v=uO8wpm9HSB0](https://www.youtube.com/watch?v=uO8wpm9HSB0)
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
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Highlighting

Selection Outcomes

- Selection is usually a part of an action sequence
- Can filter, aggregate, reorder selected items
Responsiveness Required

• Delays are perceived by users
• Visual feedback
  - Show the user they did something (highlighting, etc)
  - Interaction should happen quick!
• Latency: mouse click versus mouse hover
• Popup versus detail displays
Interaction Latency

• The Effects of Interactive Latency on Exploratory Visual Analysis, Z. Liu and J. Heer, 2014
• Brush & link, select, pan, zoom

• 500ms added latency causes significant cost
  - decreases user activity and dataset coverage
  - reduces rate of observations, generalizations, and hypotheses
Interaction Overview

- **Change over Time**

- **Select**

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

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Attribute Reduction

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[Munzner (ill. Maguire), 2014]
Zooming

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

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

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

[McLachlan et al., 2008]
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