Data Visualization (CSCI 627/490)

Interaction

Dr. David Koop
What is wrong with here and how can it be fixed?

3D Category Scatter

[WTF Visualizations, 2017]
Good: Data magnitude $\iff$ Mark magnitude

[Flowing Data, 2012]
Show when the baseline is not zero

See also: "Tear Up Your Baseline" [RJ Andrews]
Tufte's Lie Factor

• Size of effect = (2nd value - 1st value) / (1st value)
• Lie factor = (size of effect in graphic) / (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

Extraneous visual elements that distract from the message

[T. Brey via A. Lex]
No Unjustified 3D

- Occlusion hides information
- Perspective distortion dangers
- Tilted text isn't legible

- Can help with shape perception
Validation at each level

- **Threat**: Wrong problem
  - **Validate**: Observe and interview target users

- **Threat**: Wrong task/data abstraction
  - **Threat**: Ineffective encoding/interaction idiom
  - **Validate**: Justify encoding/interaction design

- **Threat**: Slow algorithm
  - **Validate**: Analyze computational complexity
    - **Implement system**
  - **Validate**: Measure system time/memory

- **Validate**: Qualitative/quantitative result image analysis
  - *Test on any users, informal usability study*

- **Validate**: Lab study, measure human time/errors for task

- **Validate**: Test on target users, collect anecdotal evidence of utility

- **Validate**: Field study, document human usage of deployed system

- **Validate**: Observe adoption rates

[Munzner, 2014]
Five Design Sheet Method

Sheet 1: Generate Ideas, filter, categorize.
Sheet 2, 3, 4: Explore lots of possibilities and select a set of ideas.
Sheet 5: Explore & Ideate: Improvisation.

Fig. 2: Schematic that shows where the FdS design fits in with the methodology.

Fig. 3: The FdS sheets. (a) Sheet 1: Generate Ideas, filter, categorize, (b) Sheets 2, 3, 4 with the five sections (collect, relate, donate and create), (c) Sheet 5: Explore & Ideate: Improvisation.

Fig. 4: Flowchart of the FdS method.

The five-stage methodology is as follows:
1. **Goals**
2. **Requirements**
3. **User Observation**
4. **Context**
5. **Exploration & Ideation**
6. **Concept Development**
7. **Prototyping & Solution**
8. **Relate**
9. **Validate**
10. **Understand**

**Data Collection**
Visualizing
Context
Exploration
& ideation
Concept
Development
Prototyping Solution
User...

D. Koop, CSCI 627/490, Fall 2023

Northern Illinois University
Sheets 2-4

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[Image of diagrams and data visualizations]

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[J. Roberts et al., 2016]
Assignment 4

- Corn & Soybean Production in Illinois
- Geospatial Visualizations & Treemap
  - Choose colormaps carefully
  - Add legend
- You may use D3 or Observable Plot
  - Part 1a: D3
  - Part 3 will require some D3 for treemap layout
- Due Friday
Project Design

- Feedback available on Blackboard
- Work on turning your visualization ideas into designs
- Turn in:
  - Three Designs Sketches
  - One Bad Design
  - Progress on Implementation
- Options:
  - Try vastly different options
  - Refine an initial idea
- Due Nov. 15
Guidelines for Interaction Design
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**
    - **Pan/Translate**
    - **Constrained**
  - **Attribute Reduction**
    - **Slice**
    - **Cut**
    - **Project**

[Munzner (ill. Maguire), 2014]
Sorting

- Allow user to find patterns by reordering the data
- Do this with tabular data all the time
- Note that categorical 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

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Animation: Jump Cut vs. Animated Transitions

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## Animation: Jump Cut vs. Animated Transitions

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D. Koop, CSCI 627/490, Fall 2023
## Side-by-side views

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Animated Transitions

Stacked  Grouped
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 Robertson, 2007]
Studying Animated Transitions

[Heer and Robertson, 2007]
Design Considerations

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

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

• Apprehension (Effectiveness):
  - 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 Robertson, 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 pick highlighted elements after transition (measure #pixels from correct)

![Graph showing average error in pixels for different transitions.

- Static
- Animation
- Staged Animation

[Heer and Robertson, 2007]
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)

![Graph showing average error and number of unknown responses for different chart types and animation types]

[Heer and Robertson, 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 Robertson, 2007]
Change Blindness

- https://www.youtube.com/watch?v=uO8wpm9HSB0
Change Blindness

- 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
  - 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

Obama has 431 ways to win (80% of paths)
5 ties (0.9% of paths)
Romney has 76 ways to win (10% of paths)

If Romney wins Ohio...

Florida

Ohio
North Carolina
Virginia
Wisconsin
Colorado
Iowa
Nevada
New Hampshire

and N.H., Romney wins.
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**

- **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

- **Item Reduction**
  - **Zoom**
    - Geometric or Semantic
  - **Pan/Translate**
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[Munzner (ill. Maguire), 2014]
Zooming
Geometric Zooming
Zooming
Semantic Zooming
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

[van Wijk, 2003, M. Bostock]