Data Visualization (DSC 530/CIS 602-01)

D3

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Visual Encoding

- How do we encode data visually?
  - **Marks** are the basic graphical elements in a visualization
  - **Channels** are ways to control the appearance of the marks

- Marks classified by dimensionality:
  - Points
  - Lines
  - Areas

- Also can have surfaces, volumes
- Think of marks as a mathematical definition, or if familiar with tools like Adobe Illustrator or Inkscape, the path & point definitions
Encoding Multiple Attributes

[Gapminder, Wealth & Health of Nations]
Channels by Effectiveness

Channels: Expressiveness Types and Effectiveness Ranks

**Magnitude Channels: Ordered Attributes**
- Position on common scale
- Position on unaligned scale
- Length (1D size)
- Tilt/angle
- Area (2D size)
- Depth (3D position)
- Color luminance
- Color saturation
- Curvature
- Volume (3D size)

**Identity Channels: Categorical Attributes**
- Spatial region
- Color hue
- Motion
- Shape

[Munzner (ill. Maguire), 2014]
Expressiveness and Effectiveness

- Expressiveness Principle: all data from the dataset and nothing more should be shown
  - Do encode ordered data in an ordered fashion
  - Don’t encode categorical data in a way that implies an ordering

- Effectiveness Principle: the most important attributes should be the most salient
  - Saliency: how noticeable something is
  - How do the channels we have discussed measure up?
  - How was this determined?
Discriminability

What is problematic here?

[Koop et al., 2013]
Separability

• Cannot treat all channels as independent!

• **Separable** means each individual channel can be distinguished

• **Integral** means the channels are perceived together

[Position + Hue (Color)]

[Size + Hue (Color)]

[Width + Height]

[Red + Green]

[Fully separable]

[Some interference]

[Some/significant interference]

[Major interference]

[Munzner (ill. Maguire) based on Ware, 2014]
Integral Channels

[http://magazine.good.is/infographics/americas-richest-counties-and-best-educated-counties]
Visual Popout

Visual Popout

[Munzner (ill. Maguire), 2014]
Relative vs. Absolute Judgments

- Weber’s Law:
  - We judge based on relative not absolute differences
  - The amount of perceived difference depends on the object’s magnitude!

[Munzner (ill. Maguire), 2014]
Luminance Perception

Edward H. Adelson

[E. H. Adelson, 1995]
Luminance Perception

Edward H. Adelson

[E. H. Adelson, 1995]
JavaScript Libraries

• Building Blocks: HTML, CSS, SVG, and JavaScript
• More Ideas:
  - JavaScript Libraries
    • `<script src="http://d3js.org/d3.v3.js" charset="utf-8"></script>`
  - Minification: smaller code, no functional change
    • `<script src="http://d3js.org/d3.v3.min.js" charset="utf-8"></script>`
    • Can make debugging more difficult
  - Content Delivery Networks
    • Faster delivery of Web content, also works for js
    • `https://cdnjs.cloudflare.com/ajax/libs/d3/3.5.15/d3.min.js`
JavaScript Reminders

• Functions are first-class objects in JavaScript
• Closures are functions that remember their environment
• Method Chaining: methods can also return the objects passed in or derivative objects to allow you to call another function on the result
  - You often end up following specific patterns where an object being manipulated requires multiple calls:
    • `rect.attr("width", 200).attr("height", 100);`
  - Or it is clear that the method returns a specific object that you wish to make changes to:
    • `svg.select("#myrect").style("fill", "blue");`
  - Of course, you may store the returned object as a variable and make each call separately
  - Coding style: Indent, often put each call on a new line
Data-Driven Documents (D3)

- [http://d3js.org/](http://d3js.org/)
- Original Authors: Mike Bostock, Vadim Ogievestky, and Jeff Heer
- Open Source
- Focus on Web standards, customization, and usability
- Grew from work on Protovis: more standard, more interactive
- By nature, a **low-level** library; you have control over all elements and styles if you wish
- A top project on GitHub (over 45,000 stars as of 2/17/2016)
- Lots of impressive examples
  - Bostock was a New York Times Graphics Editor
  - [http://bost.ocks.org/mike/](http://bost.ocks.org/mike/)
D3 Key Features

• Supports data as a core piece of Web elements
  - Loading data
  - Dealing with changing data (joins, enter/update/exit)
  - Correspondence between data and DOM elements

• Selections (similar to CSS) that allow greater manipulation

• Method Chaining

• Integrated layout algorithms, axes calculations, etc.

• Focus on interaction support
  - Straightforward support for transitions
  - Event handling support for user-initiated changes
D3 Introduction

- Ogievetsky has put together a nice set of interactive examples that show off the major features of D3
- Other references:
  - Murrary’s book on Interactive Data Visualization for the Web
  - The D3 website: [d3js.org](http://d3js.org)
D3 Data Joins

- Two groups: data and visual elements
- Three parts of the join between them: enter, update, and exit
- enter: `s.enter()`, update: `s`, exit: `s.exit()`
D3 Updates

- Deal with data items with no visual element (enter)
- Deal with visual elements with no data items (exit)
- Update visual elements based on changes in data (update)
- Enter+update:
  - `s.enter().append("rect");`  
    `s.attr("height", function(d) { return d; });`;
  - Appending to the enter selection adds the new pairs to the update part of the selection!
- Even if the number of data items and visual elements stays the same, a change to the update selection can cause major changes
- Generally end with the same number of data items and visual elements