Data Visualization (CSCI 627/490)

Web Programming

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Definition of Visualization

“Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.”

— T. Munzner
Why Computers?

[Cerebral, Barsky et al., 2007]
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Why Visual?

[F. J. Anscombe]
Why Visual?

- Mean of $x$: 9
- Variance of $x$: 11
- Mean of $y$: 7.50
- Variance of $y$: 4.122
- Correlation: 0.816

[F. J. Anscombe]
Visual Pop-out
Visual Perception Limitations

[C. G. Healey]
Assignment 1

- Write HTML, CSS, and SVG
- Use Plot library
- Text markup and styling (information)
- Drawing markup and styling (tower)
- Draw Bar chart
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Languages of the Web

- HTML
- CSS
- SVG
- JavaScript
  - Versions of Javascript: ES6, ES2015, ES2020...
  - Specific frameworks: react, jQuery, bootstrap, Plot, D3
Observable

- Observable is a platform that allows users to create notebooks using JavaScript, Markdown, and HTML
- Strong support of data visualization (company and community interests)
- Introduction: A Taste of Observable
- Type markup/code, "execute" the cell, and results appear above the code
- Pin the cell to keep the code visible
- Can choose the type of cell (JavaScript, Markdown, or HTML)
- Can create an output (variable) in each cell that can be used in other cells
- Content is all global scope!
Other Platforms

- CodePen
- deno.land
Hyper Text Markup Language (HTML)

- Markup languages allow users to encode the **semantics** of text
- Tags define the boundaries of the structures of the content
  - Tags are enclosed in angle brackets (e.g. `<html>`)
  - Most of the time, you have a start and end tag
  - End tags are just like start tags except that they have forward slash after the open bracket (e.g. `</html>`)
  - Tags may be nested but not mismatched
    - `<p>A <strong><em>very</em></strong> cool example</p>`
    - `<p>A <strong>very <em>cool</em></strong> example</p>`
  - What about `<img src="mypicture.png" alt="My Image">`?
HTML Elements and Attributes

• Tags denote **elements** of the content (e.g. sections, paragraphs, images)
• Each element may have **attributes** which define other information
  - An attribute has a **key** and **value** (*key*="*value"*)
  - e.g. `<img src="mypicture.png" alt="My Image">`
• Many different elements available
  - Common: headers (**h1**, ..., **h6**), paragraph (**p**), lists (**ul**, **ol**, **li**), emphasis (**em**, **strong**), link (**a**), spans & divisions (**span**, **div**)
  - Lots more (e.g. **abbr**): see [MDN Documentation](https://developer.mozilla.org)
• Many different attributes available
  - See [MDN Documentation](https://developer.mozilla.org): note that some are legacy due to CSS
HTML Element Structure & Naming

• Elements structure a document
  - Document Object Model (DOM)
  - We can visualize this information
  - More importantly, we can navigate this tree

• Identifying and Classifying elements: id and class attributes
  - id identifies a single element—use for a unique case
  - class may identify multiple elements—use for common cases
  - Each element may have multiple classes, separate by spaces
  - Use normal identifiers: don’t start the name with a number
Other HTML Trivia

• `<`, `>`, `&`, and " are special characters, escape with `&lt;`, `&gt;`, `&amp;`, and `&quot;` (note the semi-colon)

• Comments are enclosed by `<!--` and `-->`
  - `<!-- This is a comment -->`

• HTML Documents begin with a `DOCTYPE` declaration
  - For HTML5, this is easier `<!DOCTYPE html>`

• `meta` tag: `<meta charset="UTF-8"/>`

• HTML has audio and video tags, math equation support, and more
Basic HTML File

<!DOCTYPE html>
<html>
  <head>
    <title>A Basic Web Page</title>
  </head>
  <body>
    <h1>Da Bears</h1>
    <p><em>This is <strong>cool</strong>. What about <u><strong>this?</strong></u></em></p>
    <img alt="Justin Fields" src="https://upload.wikimedia.org/wikipedia/commons/f/f0/Justin_Fields_2022_Bears_Camp_%28cropped%29.jpg" width="400px">
  </body>
</html>
Basic HTML File

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  <body>
    <h1>Da Bears</h1>
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  </body>
</html>
```
What is CSS?
Cascading Style Sheets (CSS)

- Separate from content, just specifies how to style the content
- Style information can appear in three places:
  - External file
  - In a style element at the beginning of the HTML file
  - In a specific element in the body of a document (least preferable)
- Why Cascading?
  - Don’t want to have to specify everything over and over
  - Often want to use the same characteristics in a region of the DOM
  - Use inheritance: properties that apply to children cascade down
CSS Selectors

- How do we specify what part(s) of the page we want to style?
- The **element types** themselves (the HTML tag)
  - `strong { color: red; }`
- **Classes** of elements (ties to HTML `class` attribute)
  - `.cool { color: blue; }`
- A **specific** element (ties to HTML `id` attribute)
  - `#main-section { color: green; }`
- Relationships
  - Descendant: `p em { color: yellow; }`
  - Child: `p > em { color: orange; }`
- **Pseudo-classes**: `a:hover { color: purple; }`
Other CSS Bits

• Comments: /* This is a comment in CSS */
• Grouping Selectors: p, li { font-size: 12pt; }
• Multiple Classes: .cool.temp { color: blue; }
• Colors:
  - Names (Level 1, 2, & 3): red, orange, antiquewhite
  - Dash notation (3- & 6-character): #fff, #00ff00
  - Integer or % RGB and HSL Functions: rgb( 255, 0, 0),
    rgb(50%, 50%, 0%), hsl(120, 100%, 50%)
  - Also background-color
• Watch out for multiple rules (look at how a web browser parses)
• Again, much more documentation at MDN
What colors are displayed for this HTML (with the above stylesheet)?

- `<em>This is <strong>cool</strong>. What about <u><strong>this?</strong></u></em>`
CSS Specificity

• Example:
  - CSS:
    
    ```css
    p.exciting { color: red; }
    p { color: blue; }
    ```
  - What is the color of the paragraph
    ```html
    <p class="exciting">Cool</p>
    ```
• Generally, last rule listed overrides previous rules
• …but anytime a selector is **more specific**, it has precedence
• `p.exciting` is a more specific selector
• When in doubt, **test it** in a browser
How to add CSS to HTML

• External: a separate file via a link element (in the <head> section):
  - <link rel="stylesheet" href="styles.css">

• Embedded: in the header:
  - <style type="text/css"> ... </style>

• Inline: for a specific element: (Discouraged!)
  - <p style="font-weight: bold;">Some text</p>
Observable

• Style rules are **global**
• Make sure you scope the rules
  - Add a `<style>` block to the cell for the rules for that cell
  - Put everything in a `<div>` with an `id` attribute
    - `<div id="mydiv">...</div>`
  - CSS rules should start with the div id unless you want to have rules apply to the entire notebook
    - `#mydiv p { font-family: sans-serif }`
What is the difference between vector and raster graphics?
Scalable Vector Graphics (SVG)

- Vector graphics vs. Raster graphics
- Drawing commands versus a grid of pixels
- Why vector graphics?
SVG Background

- Another markup language:
  - Describe the shapes and paths by their endpoints, characteristics
- SVG can be embedded into HTML5 documents!
- Pixel Coordinates: **Top-left** origin

![Diagram showing pixel coordinates (0,0) at the top-left corner, width,0 at the right edge, and width,height at the bottom-right corner.](image)
SVG Elements

• Drawing primitives:
  - Lines, Circles, Rects, Ellipses, Text, Polylines, Paths
  - Work by specifying information about how to draw the shape
  - Lots more: see MDN Documentation

• Ordering/Stacking:
  - SVG Elements are drawn in the order they are specified

• Paths: directions for drawing
SVG Styles

- We can specify styles of SVG elements in CSS!
- Example:

```css
circle { fill: green; stroke: black; stroke-width: 4px; }
.normal { fill: red; stroke: blue; stroke-width: 2px; }
#p1 { fill: none; stroke: red; stroke-width: 3px; }
```
SVG Example

```html
<svg id="mysvg" width="300" height="600">
  <circle cx="50" cy="50" r="50"/>
  <rect class="lego" x="150" y="150"
       width="50" height="20"/>
  <path id="triangle" d="M 20 200
      L 120 200 L 120 250 Z"/>
</svg>

circle { fill: green; stroke: black;
         stroke-width: 4px; }
.lego { fill: red; stroke: blue;
        stroke-width: 2px; }
#triangle { fill: none; stroke: orange;
            stroke-width:3px; }
```