Data Visualization (CSCI 627/490)

Web Programming

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Languages of the Web

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

Hyper Text Markup Language (HTML)

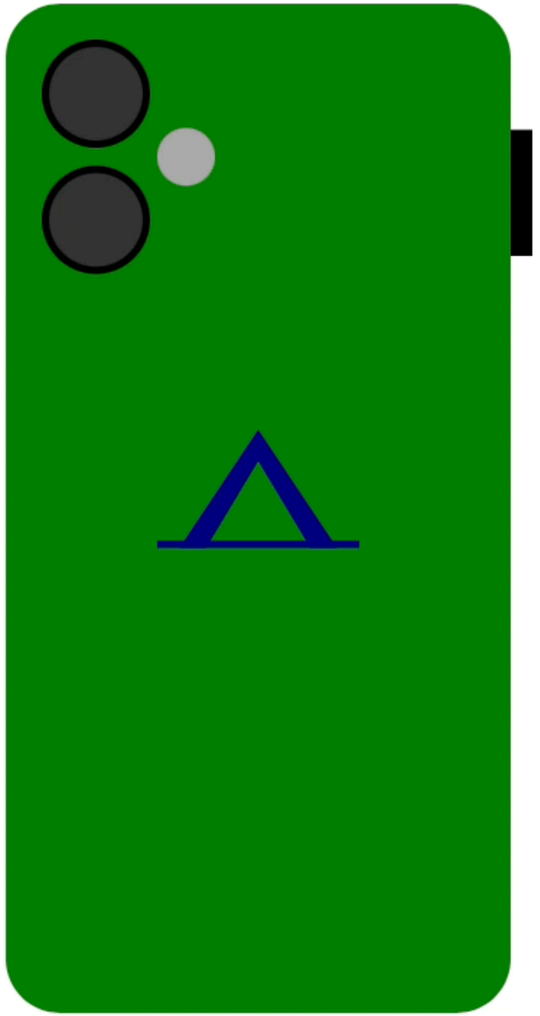
- Markup languages allow users to encode the **semantics** of text
- Elements structure a document
  - Elements delineated by tags: `<h1>An element</h1>`
  - Document Object Model (DOM)
  - We can **navigate** this tree
- Identifying and Classifying elements: `id` and `class` attributes
  - `id` identifies 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

Cascading Style Sheets (CSS)

- Separate style from content, just specifies how to style the content
- Style information appears in three places: external, head, ~~individual elements~~
- Statement: `<selectors>: { <style definitions> }`
- Cascading:
  - use inheritance idea
  - properties that apply to children cascade down
- Selectors: element types (`strong`), ids (`#main-section`), classes (`.cool`)
  - Can combine to be more specific
    - `#main-section em, .cool > strong, p.cool`
  - Can group: `#main-section, p.cool { font-size: 16pt; }`

Assignment 1

- Write HTML, CSS, and SVG
- Text markup and styling (information)
- Drawing markup and styling (camera phone)
- Draw Bar chart using Plot library
- Due Wed., Sept. 13



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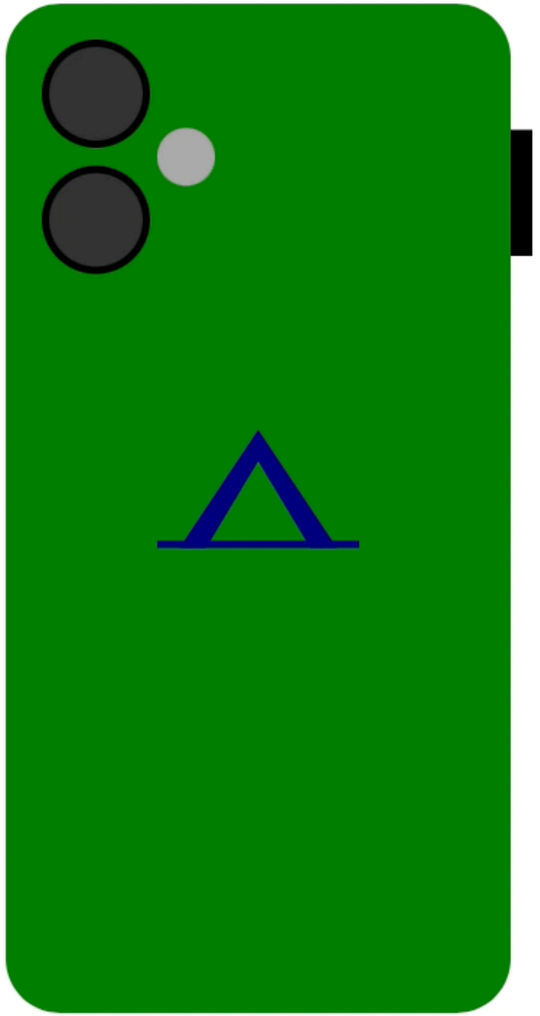
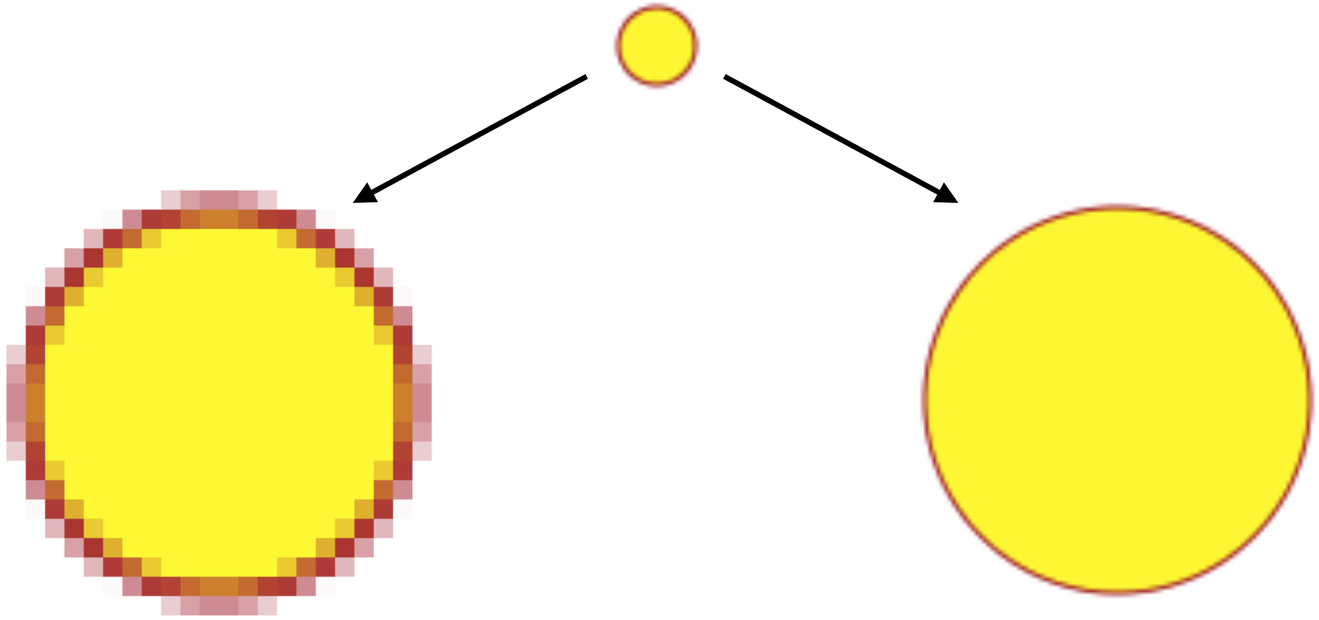


This Week

- I am traveling for a research meeting (Monday—Friday)
- No in-person office hours
- Sept. 11 (Monday) and Sept. 13 (Wednesday) lectures will be online videos on Blackboard
  - You **should watch** the lectures
  - You do not need to be in the classroom next week
  - Please ask any questions via email
- Assignment 2 should be released this week

Scalable Vector Graphics (SVG)

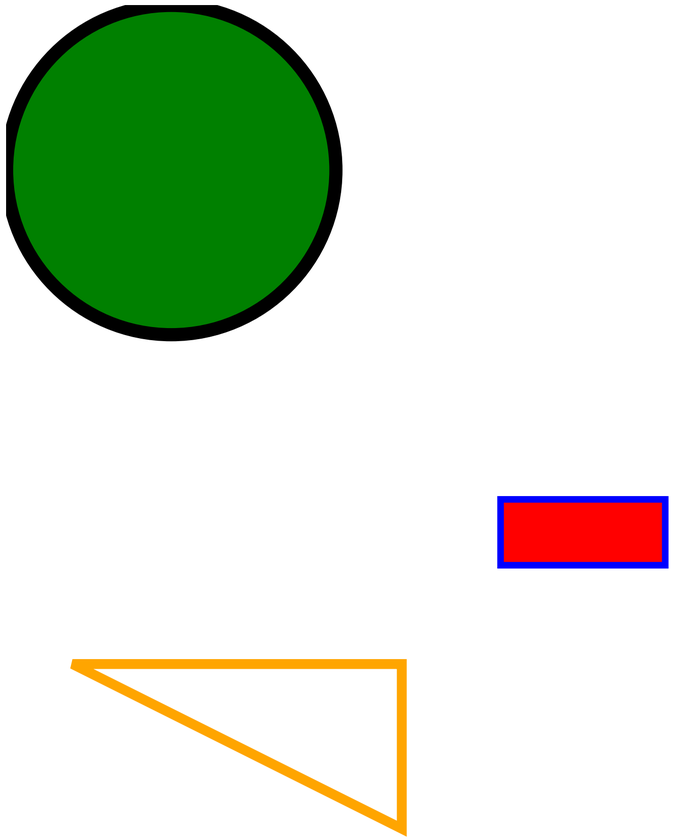
- Vector graphics vs. Raster graphics
- Drawing commands versus a grid of pixels
- Why vector graphics?



Raster

Vector

SVG Example



```
<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; }
```

SVG Grouping

- Very powerful, useful for animations and transformations
- `<g> <circle …/> <circle … /> <circle … /></g>`
- Can add transforms to the group:

```
<svg width="200" height="200">
    <g transform="translate(0, 200) scale(1, -1)">
        <circle cx="50" cy="50" r="10"/>
        <circle cx="80" cy="80" r="10"/>
        <circle cx="110" cy="50" r="10"/>
        <circle cx="140" cy="90" r="10"/>
    </g>
</svg>
```

[SVG Example, Scheidegger, 2016]

JavaScript in one slide

- Interpreted and Dynamically-typed Programming Language
- Statements end with semi-colons, normal blocking with brackets
- Variables: `var a = 0; let b = 2; const d = 4;`
- Operators: `+, -, *, /, [ ]`
- Control Statements: `if (<expr>){…} else {…}, switch`
- Loops: `for, while, do-while`
- Arrays: `var a = [1,2,3]; a[99] = 100; console.log(a.length);`
- Functions: `function myFunction(a,b) { return a + b; }`
- Objects: `var obj = {x: 2, y: 4}; obj.x = 3; obj.y = 5;`
  - Prototypes for instance functions
- Comments are `/* Comment */` or `// Single-line Comment`

JavaScript References

- Learn Just Enough JavaScript: Introduction, P. Boffa
- Eloquent JavaScript, M. Haverbeke
- MDN Tutorials
- Interactive Data Visualization for the Web, Murray

JavaScript Objects

- `var student = {name: "John Smith", id: "000012345", class: "Senior", hometown: "Peoria, IL, USA"};`
- Objects contain multiple values: key-value pairs called **properties**
- Accessing properties via dot-notation: `student.name`
- May also contain functions:
  -
```
var student = {firstName: "John",
               lastName: "Smith",
               fullName: function() {
            return this.firstName + " " + this.lastName; }};
student.fullName()
```
- JavaScript Object Notation (JSON): data interchange format
  - nested objects and arrays (data only, no functions!), **subset** of JavaScript

Objects as Associative Arrays/Dictionaries

- Objects have key-value pairs and can be addressed via those keys, either via dot-notation or via bracket notation: `[<key>]`
- Example:

```
states = {"AZ": "Arizona", "IL": "Illinois", …};
// Get a state's name given it's abbreviation
console.log("IL is " + states["IL"]);
```

- Similar to dictionaries or associative arrays in other languages (e.g. Python)
- Dot-notation only works with certain identifiers, bracket notation works with more identifiers
- Notebook

Functional Programming

Functional Programming in JavaScript

- Functions are first-class objects in JavaScript
- You can pass a function to a method just like you can pass an integer, string, or object
- Instead of writing loops to process data, we can instead use a `map/filter/reduce/forEach` function on the data that runs our logic for each data item
- `map`: transform each element of an array
- `filter`: check each element of an array and keep only ones that pass
- `forEach`: run the function for each element of the array
- `reduce`: collapse an array to a single object

Quiz

- Using `map`, `filter`, `reduce`, and `foreach`, and given this data:
  - `var a = [6, 2, 6, 10, 7, 18, 0, 17, 20, 6];`
- Questions:
  - How would I return a new array with values one less than in a?
  - How would I find only the values >= 10?
  - How would I sum the array?
  - How would I create a reversed version of the array?

Function Chaining in JavaScript

- When programming functionally, it is useful to chain functions
- No intermediate variables!
- Often more readable code
- jQuery Example:
  - `$("#myElt").css("color", "blue").height(200).width(320)`
- Used a lot in Web programming, especially D3
- Can return the same object or a new object
- Lazy chaining keeps track of functions to be applied but will apply them later (e.g. when the page loads)

Closures in JavaScript

- Functions can return functions with some values set
- Allows assignment of some of the values
- Closures are functions that "remember their environments" [MDN]

```
function makeAdder(x) {
  return function(y) {
    return x + y;
  };
}
var add5 = makeAdder(5);
var add10 = makeAdder(10);

console.log(add5(2));  // 7
console.log(add10(2)); // 12
```

- Notebook

Manipulating the DOM with JavaScript

- Key global variables:
  - `window`: Global namespace
  - `document`: Current document
  - `document.getElementById(...)`: Get **one** element via its id
  - `document.querySelector(...)`: Get **one** element via selector
  - `document.querySelectorAll(...)`: Get **all** matching elements via selector
- HTML is parsed into an in-memory document (DOM)
- Can access and **modify** information stored in the DOM
- Can add information to the DOM

Example: JavaScript and the DOM

- Start with no real content, just divs:

```
<div id="firstSection"></div>
<div id="secondSection"></div>
<div id="finalSection"></div>
```

- Get existing elements:
  - `document.querySelector/querySelectorAll`
  - `document.getElementById`
- Programmatically add elements:
  - `document.createElement`
  - `document.createTextNode`
  - `Element.appendChild`
  - `Element.setAttribute`

Bears

Chicago, IL

2018-2019 NFC North Champions

What will happen this year?

Example (continued): Using Data to Build Content

Bears

Chicago, IL

2018-2019 NFC North Champions

September 9: Loss (23-24)

September 17: Win (24-17)

September 23: Win (16-14)

September 30: Win (48-10)

October 14: Loss (28-31)

October 21: Loss (31-38)

October 28: Win (24-10)

November 4: Win (41-9)

November 11: Win (34-22)

November 18: Win (25-20)

November 22: Win (23-16)

December 2: Loss (27-30)

December 9: Win (15-6)

December 16: Win (24-17)

December 23: Win (14-9)

December 30: Win (24-10)

- We can loop through data to add content to a web page (schedule and results)
- Data: `[{"date": "September 9", "opponent": "Green Bay Packers", "home": false, "win": false, "score": "23-24"}, … ]`
- Can use `forEach` to iterate through each game and build content
- Or, for…of loop:

```
for (const game of data)
```

- Notebook

Observable's HTML Templating

- Allows JavaScript expressions to be **inlined** in HTML (or SVG content)
- Use `${...}`
- Example:
  - [JavaScript] `name = "Prof. Koop"`
  - [HTML] `<p>Hello, my name is ${name}</p>`

Using Observable's HTML Templating

```
<div id="firstSection">
  <h1>Bears</h1><p>Chicago, IL</p>
</div>
<div id="secondSection">
  <h2>2018-2019 NFC North Champions</h2>
</div>
<div id="finalSection">
  ${scores.map((game) => html`<p>${game.date}:
        ${game.win ? "Win" : "Loss"} (${game.score})</p>`)}
  <img src="…Justin_Fields….jpg" width="240"></img>
  <p>What will happen this year?</p>
</div>
```

Notebook

Creating SVG figures via JavaScript

- SVG elements can be accessed and modified just like HTML elements
- Create a new SVG programmatically and add it into a page:
  - ```
    var divElt = document.getElementById("chart");
    var svg = document.createElementNS(
                        "http://www.w3.org/2000/svg", "svg");
    divElt.appendChild(svg);
    ```
- You can assign attributes:
  - ```
    svg.setAttribute("height", 400);
    svg.setAttribute("width", 600);
    svgCircle.setAttribute("r", 50);
    ```

Manipulating SVG via JavaScript

- SVG can be navigated just like the DOM
- Example:

```
function addEltToSVG(svg, name, attrs) {
    var element = document.createElementNS(
                  "http://www.w3.org/2000/svg", name);
    if (attrs === undefined) attrs = {};
    for (var key in attrs) {
       element.setAttribute(key, attrs[key]);
    }
    svg.appendChild(element);
}
mysvg = document.getElementById("mysvg");
addEltToSVG(mysvg, "rect", {"x": 50, "y": 50,
                            "width": 40,"height": 40,
                            "fill": "blue"});
```

- Notebook