CSE/ISE 332
Introduction to Visualization

Introduction to D3

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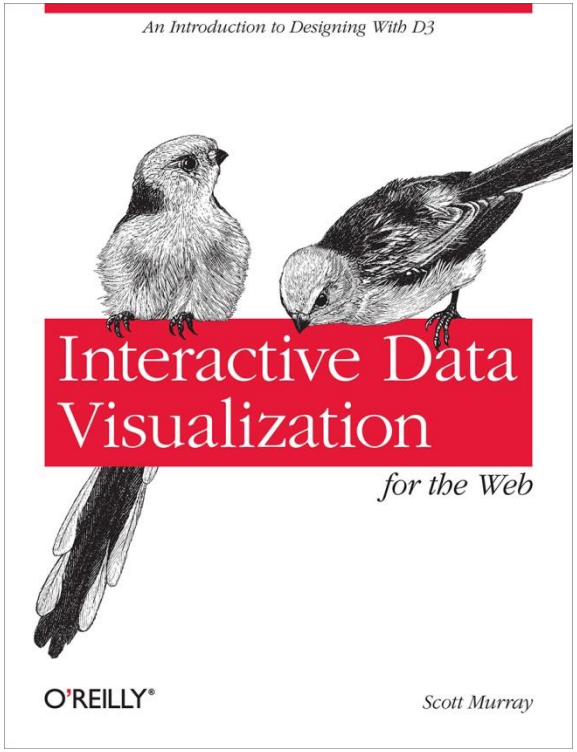
Lecture	Topic	Projects
1	Intro and logistics	
2	Basic visualizations and tasks, data types, examples, ethical considerations	
3	Data preparation (cleaning, imputation, data set integration)	Project #1 out
4	AI-assisted coding for VIS applications (design, debugging, refactoring)	
5	Big data and data reduction (distance/sim metrics, intro to clustering)	
6	High-D data: concept, subspaces, dimension reduction, PCA	
7	Cluster analysis: hierarchical, density, model, embedding, temporal	Project #2(a) out
8	Perception and cognition (human visual system, color, contrast)	
9	Visual design and aesthetics	
10	Visualization of multivariate and high-D data: linear methods, projections	
11	Vis. of multivariate and high-D data: non-linear methods, embeddings	Project #2(b) out
12	Visualization and AI: mutual support and capabilities (VIS4AI, AI4VIS)	
13	Principles of interaction: drive what is visualized, analyzed & how (HCI4VIS)	
14	Midterm recap	
15	Midterm	
16	Visual analytics, human-centered AI, mixed-initiative & collaborative VA	Capstone proposal due
17	Visualization system design & evaluation: nested model, study designs	
18	Visualization of hierarchical data	
19	Visualization of maps and data with geo-reference	
20	Vis. of time-varying, time-series, streaming data, progressive visualization	
21	Critiquing visualization: Tufte's views, integrity, uncertainty, responsibility	Capstone prelim report due
22	Design of effective infographics	
23	Foundations scientific & medical visualization, computer graphics	
24	Intro to volume rendering	
25	Scientific visualization	
26	Capstone project demos (4-5 minutes + 2 minutes Q&A)	All capstone materials due
27	Capstone project demos (4-5 minutes + 2 minutes Q&A)	
28	Capstone project demos (4-5 minutes + 2 minutes Q&A)	
Final	Final exam	

The material presented in these slides is derived from this book:



Also available online

What is D3.js?

D3 = Data Driven Documents

JavaScript library for manipulating documents based on data

- frequent tool to support *data journalism* (New York Times)

D3 helps you bring data to life using HTML, SVG, and CSS

- great library to construct animated visualizations (D3 website)

Runs in any modern web browser (Chrome, Firefox, IE)

- no need to download any software
- independent of OS (Linux, Windows Mac)

Makes Use Of

HTML Hypertext Markup Language

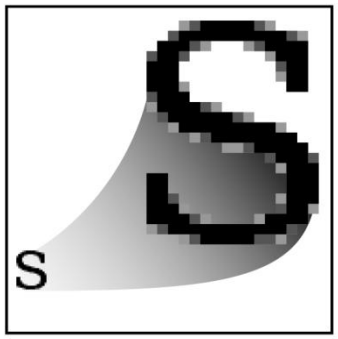
CSS Cascading Style Sheets

JS JavaScript

DOM The Document Object Model

- tree structured organization of HTML objects

SVG Scalable Vector Graphics



Raster

.jpeg .gif .png

Vector

.svg

What You Need

A text editor

- Visual Studio Code, Atom, sublime text 2, or your browser
- need an editor with syntax highlighting. else it's easy to get lost

The d3 library

- from http://d3js.org

Data files for your code

A web server

- use python -m http.server 8000

A browser

- to run the code

Setup

Your folder structure should look like this:

```
project-folder/
    d3/
        d3.v3.js // D3 library
        d3.v3.min.js (optional) // minified D3 library
    index.html
```

Setup

Your initial webpage (index.html) should look like this:

```
<!DOCTYPE html>
<html lang="en">
    <head>
        <meta charset="utf-8">
        <title>D3 Page Template</title>
        <script type="text/javascript" src="d3/d3.v3.js"></script>
    </head>
    <body>
        <script type="text/javascript">
            // Your beautiful D3 code will go here
        </script>
    </body>
</html>
```

Setting up a webserver

Option 1: use python

- Python 3: Run python3 -m http.server 8000
- Python 2: Run python -m SimpleHTTPServer 8000

Option 2: use VS Code "Live Server" (Best for editing code)

- Open VS Code and open your project folder
- Click the Extensions icon on the left sidebar (or press Ctrl+Shift+X / Cmd+Shift+X)
- Search for Live Server and click Install
- Look at the bottom-right corner of your VS Code window and click the Go Live button

Then:

- open browser and point to http://localhost:8000/ or http://localhost:8000/project-folder/
- Put your data files in this folder
- Load with d3.csv("data.csv")

Let's Use Some Simple Data

```
var dataset = [ 5, 10, 15, 20, 25 ];
```

Chaining

Consider the following js code … all methods are chained:

```
d3.select("body").selectAll("p")
    .data(dataset)
    .enter()
    .append("p")
    .text("New paragraph!");
```

which gives this output

- how did this happen?

New paragraph!

New paragraph!

New paragraph!

New paragraph!

New paragraph!

Chaining

Consider the following js code … all methods are chained:

```
d3.select("body").selectAll("p") // selects all paragraphs in the DOM (none so far …)
    .data(dataset)   // counts and parses the data values
    .enter()  //  creates new, data-bound elements (placeholders) for the data values
    .append("p")  // takes the empty placeholder and adds a p-element
    .text("New paragraph!");  // takes the p-element and inserts a text value
```

which gives this output

- how did this happen?

New paragraph!

New paragraph!

New paragraph!

New paragraph!

New paragraph!

Using the Data

Change the last line to:

```
d3.select("body").selectAll("p")
    .data(dataset)
    .enter()
    .append("p")
    .text(function(d) { return d; });
```

which gives this output

- how did this happen?

5

10

15

20

25

Using the Data

Change the last line to:

```
d3.select("body").selectAll("p")
    .data(dataset)
    .enter()
    .append("p")
    .text(function(d) { return d; });  // used the data to populate the contents of each paragraph of the data-driven document
```

which gives this output

- how did this happen?

5

10

15

20

25

Using Functions

Change the last line to:

```
d3.select("body").selectAll("p")
    .data(dataset)
    .enter()
    .append("p")
    .text(function(d) { return "I can count up to " + d; });
```

which gives this output

- how did this happen?

I can count up to 5

I can count up to 10

I can count up to 15

I can count up to 20

I can count up to 25

Adding Aesthetics

Change the last line to:

```
d3.select("body").selectAll("p")
    .data(dataset)
    .enter()
    .append("p")
    .text(function(d) { return "I can count up to " + d; })
    .style("color", "red");
```

which gives this output

- how did this happen?

I can count up to 5

I can count up to 10

I can count up to 15

I can count up to 20

I can count up to 25

More Complex Functions

Replace the last line with:

```
d3.select("body").selectAll("p")
    .data(dataset)
    .enter()
    .append("p")
    .text(function(d) { return "I can count up to " + d; })
    .style("color", function(d) { if (d > 15) {return "red"; } else { return "black"; } });
```

which gives this output

- how did this happen?

I can count up to 5

I can count up to 10

I can count up to 15

I can count up to 20

I can count up to 25

Drawing With Data

Let's draw some bar charts

For this, put this embedded style in the document head

```
div.bar {
    display: inline-block;
    width: 20px;
    height: 75px;   /* We'll override height later */
    background-color: teal;
}
```

Simple Bar Chart

Run this code:

```
var dataset = [ 5, 10, 15, 20, 25 ];

d3.select("body").selectAll("div")
    .data(dataset)
    .enter()
    .append("div")
    .attr("class", "bar");
```

which gives this output

- five bars with no space between them
- how did this happen?

More Complex Bar Chart

Run this code:

```
var dataset = [ 5, 10, 15, 20, 25 ];

d3.select("body").selectAll("div")
    .data(dataset)
    .enter()
    .append("div")
    .attr("class", "bar")
    .style("height", function(d) { return d + "px"; });
```

which gives this output

- how did this happen?

More Complex Bar Chart

Run this code:

```
var dataset = [ 5, 10, 15, 20, 25 ];

d3.select("body").selectAll("div")
    .data(dataset)
    .enter()
    .append("div")
    .attr("class", "bar")
    .style("height", function(d) { return d + "px"; });   // adds text “px” to specify that the units are pixels → heights are 5px, 10px, 15px, 20px, and 25px
```

which gives this output

- how did this happen?

Make Bars Taller and Add Spaces

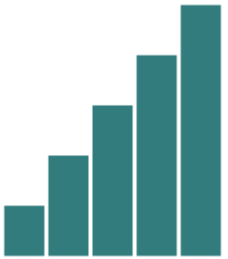
Run this code: (also add margin-right: 2px; to the css style)

```
var dataset = [ 5, 10, 15, 20, 25 ];

d3.select("body").selectAll("div")
    .data(dataset)
    .enter()
    .append("div")
    .attr("class", "bar")
    .style("height", function(d) { var barHeight = d * 5; return barHeight + "px"; });
```

which gives this output

- how did this happen?



Get Ready to Draw Some SVGs

Optionally define some variable beforehand, e.g.:

```
// width and height
var w = 500;
var h = 50;
```

Define the svg object:

```
var svg = d3.select("body")
            .append("svg")
            .attr("width", w)
            .attr("height", h);
```

get Ready to Draw Some SVG Circles

Define the circles as variables for ease of reference:

```
var circles = svg.selectAll("circle")
              .data(dataset)
              .enter()
              .append("circle");
```

But could so this just as well:

```
svg.selectAll("circle")
   .data(dataset)
   .enter()
   .append("circle"); // now circles are appended to the end of the SVG element
```

Now Draw The Circles

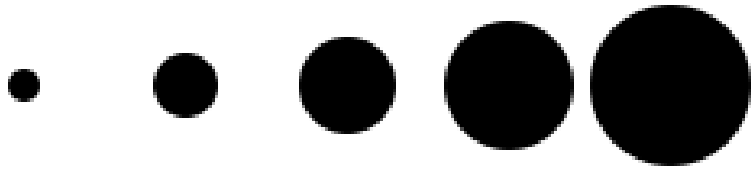
Run this code (still using var dataset = [5, 10, 15, 20, 25];)

```
circles.attr("cx", function(d, i) {return (i * 50) + 25;})
      .attr("cy", h/2)
      .attr("r", function(d) {return d;});
```

or append it to the .append("circle") method

This gives this output

- how did this happen?



Now Draw The Circles

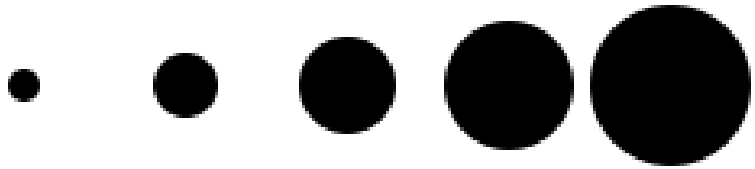
Run this code (still using var dataset = [5, 10, 15, 20, 25];)

```
circles.attr("cx", function(d, i) {return (i * 50) + 25;})  // i increments by 1 each time,
                                                            //   starting at 0
    .attr("cy", h/2)
    .attr("r", function(d) {return d;});
```

or append it to the .append("circle") method

This gives this output

- how did this happen?



Adding Colors

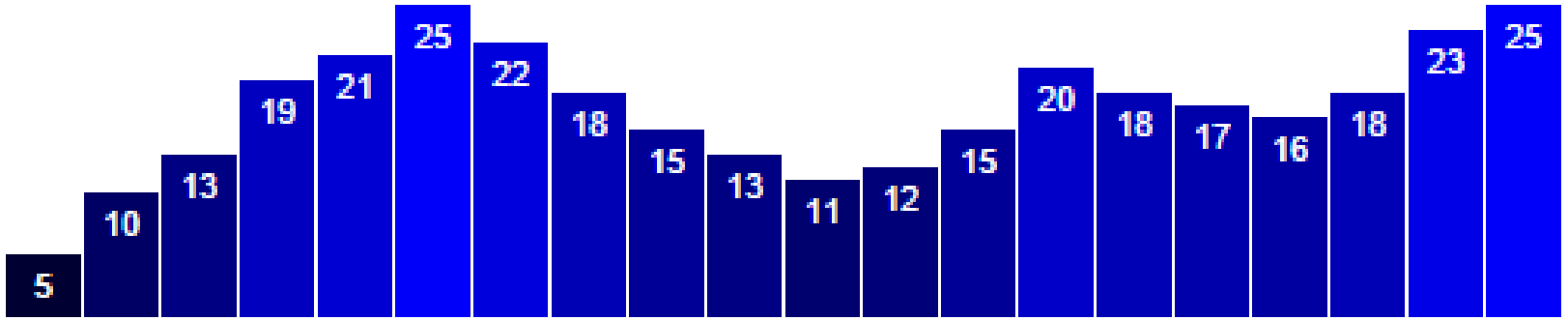
Run this code (still using var dataset = [5, 10, 15, 20, 25];)

```
circles.attr("cx", function(d, i) {return (i * 50) + 25;})
      .attr("cy", h/2)
      .attr("r", function(d) {return d;}
      .attr("fill", "yellow")
      .attr("stroke", "orange")
      .attr("stroke-width", function(d) {return d/2;});
```

This gives this output

- how did this happen?

Bar Charts



Code

Updates

This will update the bar chart on a mouse click:

```
d3.select("p")
    .on("click", function() {

        //New values for dataset
        dataset = [ 11, 12, 15, 20, 18, 17, 16, 18, 23, 25, 5, 10, 13, 19, 21, 25, 22, 18, 15, 13 ];

        //Update all rects
        svg.selectAll("rect")
           .data(dataset)
           .attr("y", function(d) {
                return h - yScale(d);
           })
           .attr("height", function(d) {
                return yScale(d);
           });

    });
```

Adding Animated Transitions

Smooth animations are desirable:

```
svg.selectAll("rect")
   .data(dataset)
   .transition()
   .attr("y", function(d) {
        return h - yScale(d);
   })
   .attr("height", function(d) {
        return yScale(d);
   })
   .attr("fill", function(d) {
        return "rgb(0, 0, " + (d * 10) + ")";
   });
```

Control Duration

Now run this code:

```
svg.selectAll("rect")
   .data(dataset)
   .transition()
   .duration(1000)  // <-- Now this is new!
   .attr("y", function(d) {
        return h - yScale(d);
   })
   .attr("height", function(d) {
        return yScale(d);
   })
   .attr("fill", function(d) {
        return "rgb(0, 0, " + (d * 10) + ")";
   });
```

Interaction

Facilitated by event handlers (listeners), e.g.:

```
d3.select("p")
    .on("click", function() {
        //Do something on click
    });
```

others react on

- mouse hovering
- mouse over
- mouse out
- and others

Example

Directing Action to a Specific Item

Assume you selected a certain item by mouseover

```
.on("mouseover", function() {
        //Do something on mouseover of any bar
});
```

Keyword “this” maps the action to the selected item

```
.on("mouseover", function() {
        d3.select(this)
          .attr("fill", "orange");
});
```

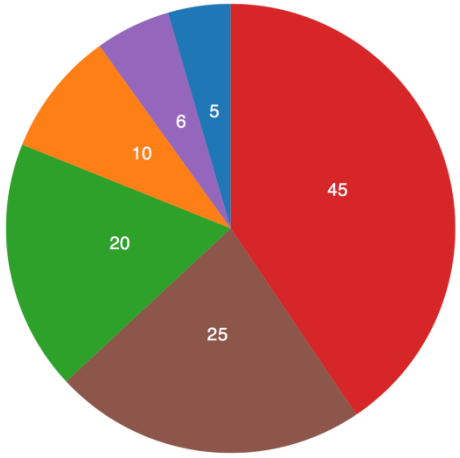
Layouts

D3 layouts take data that you provide

- remap or otherwise transform it
- and so generating new data that is more convenient for a specific visual task

The supported layouts are:

- Bundle and Chord
- Cluster
- Force
- Histogram
- Pack, Partition, and Pie
- Stack
- Tree and Treemap



Force-Directed Layout

```
var dataset = {
        nodes: [
                { name: "Adam" },
                { name: "Bob" },
                { name: "Carrie" },
                { name: "Donovan" },
                { name: "Edward" },
                { name: "Felicity" },
                { name: "George" },
                { name: "Hannah" },
                { name: "Iris" },
                { name: "Jerry" }
        ],
        edges: [
                { source: 0, target: 1 },
                { source: 0, target: 2 },
                { source: 0, target: 3 },
                { source: 0, target: 4 },
                { source: 1, target: 5 },
                { source: 2, target: 5 },
                { source: 2, target: 5 },
                { source: 3, target: 4 },
                { source: 5, target: 8 },
                { source: 5, target: 9 },
                { source: 6, target: 7 },
                { source: 7, target: 8 },
                { source: 8, target: 9 }
        ]
};
```

```
var force = d3.layout.force()
                     .nodes(dataset.nodes)
                     .links(dataset.edges)
                     .size([w, h])
                     .linkDistance([50])        // <-- New!
                     .charge([-100])            // <-- New!
                     .start();
```

Next, we create an SVG line for each edge:

```
var edges = svg.selectAll("line")
        .data(dataset.edges)
        .enter()
        .append("line")
        .style("stroke", "#ccc")
        .style("stroke-width", 1);
```

Note that I set all the lines to have the same stroke color and weight, but of course you could set this dynamically based on data (say, thicker or darker lines for "stronger" connections, or some other value).

Demo

Then, we create an SVG circle for each node:

```
var nodes = svg.selectAll("circle")
        .data(dataset.nodes)
        .enter()
        .append("circle")
        .attr("r", 10)
        .style("fill", function(d, i) {
                return colors(i);
        })
        .call(force.drag);
```