Columbia University

# E6893 Big Data Analytics Lecture 7:

## *Big Data Visualization II*

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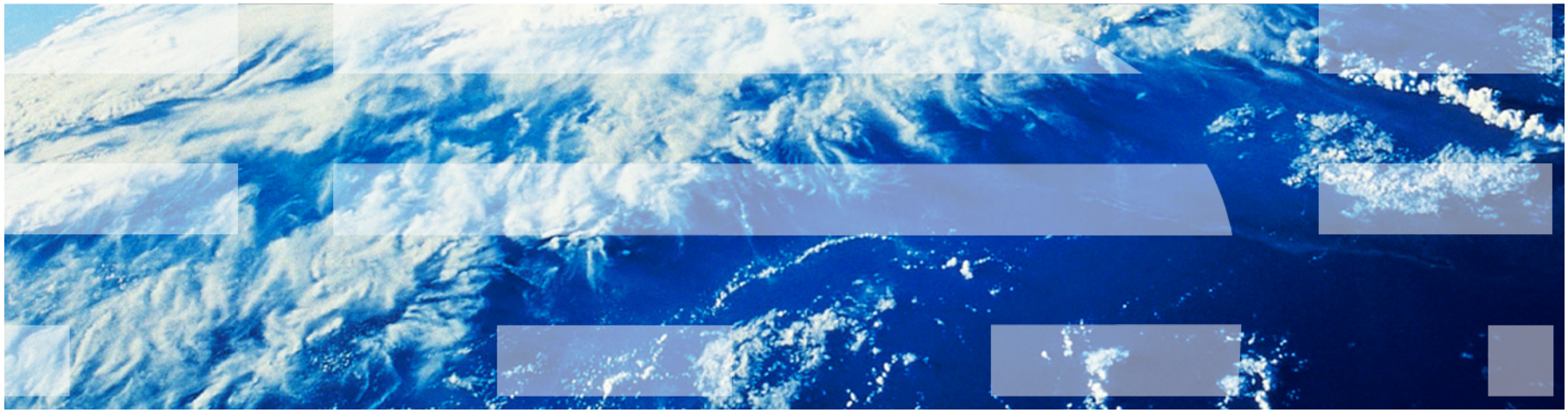


October 18th, 2024

# Final Project Proposal (11/8/2024)

Presentation Format:

- Each group shall have 5 mins to present -> Do not overtime.
- CVN and Remote Student groups —> Please submit your presentation video
- Please sign up, including team members, project title, and links to slides (open to let people in Columbia can view) at the webpage to be provided by TA.

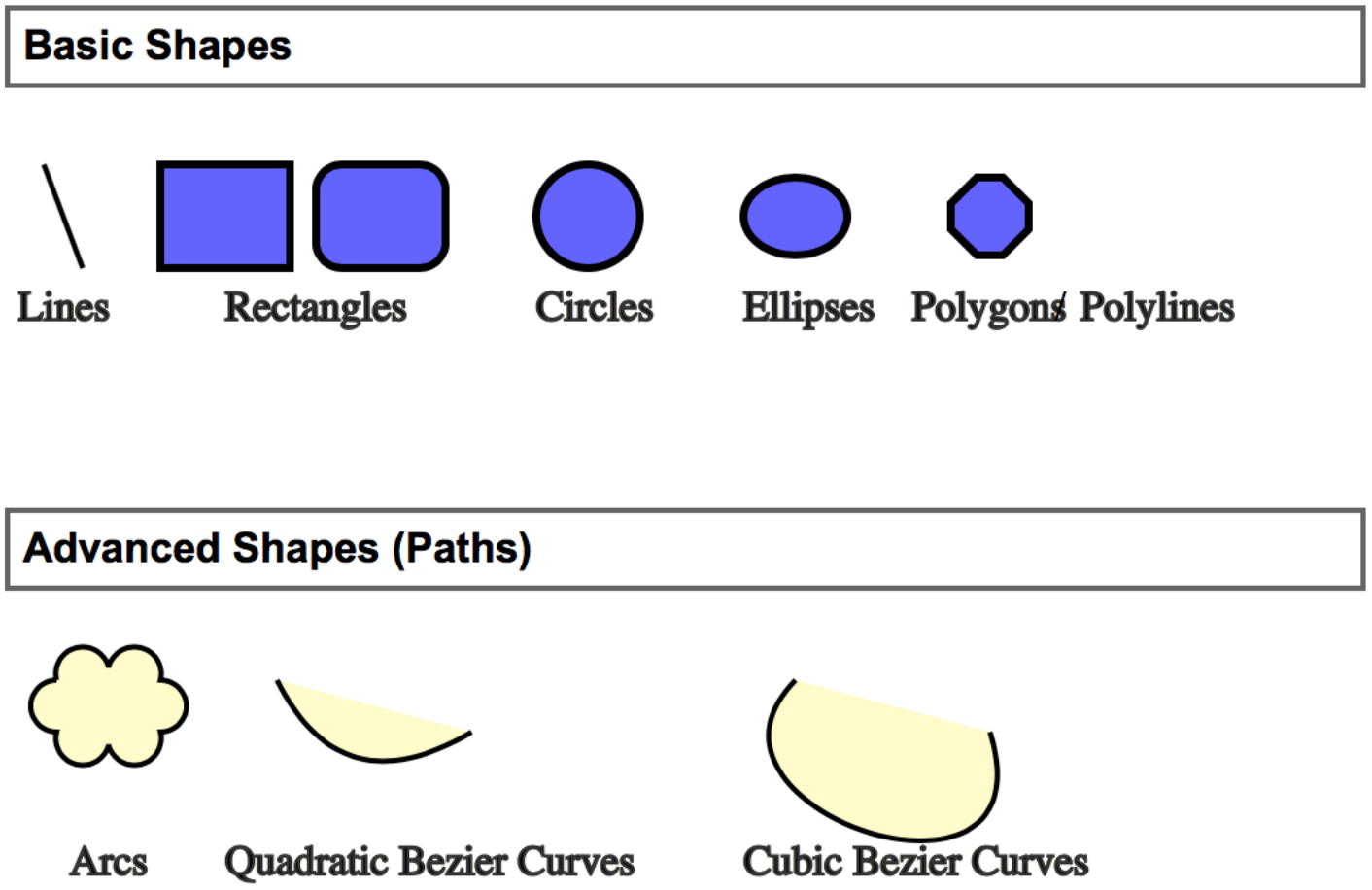
Proposal Scoring — preparing no more than 5 page slides (each item 1/5 of the proposal score):

- Goal — novel? challenging?
- Data — Big Data 3Vs? New or Existing dataset (from where)?
- Methods — potential methodologies and algorithms? Feasible?
- System — an overview of system. Multiple steps? Scalable?
- Schedule — what to achieve by what time, and by whom?

# Data Visualization — SVG short Introduction

Reference: http://tutorials.jenkov.com/svg/svg-examples.html

# SVG Examples



# SVG Examples

Text

Text

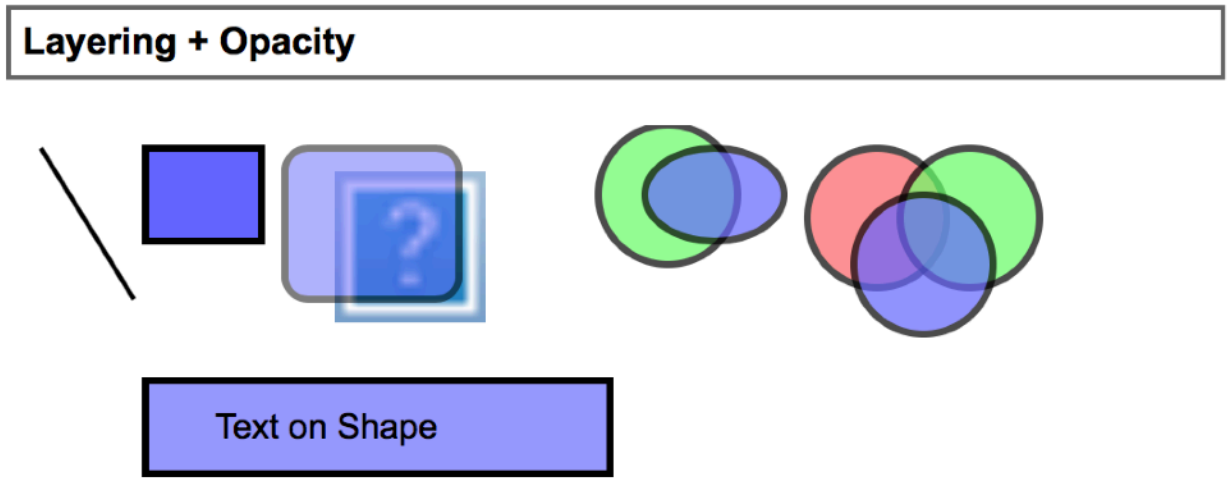
Text

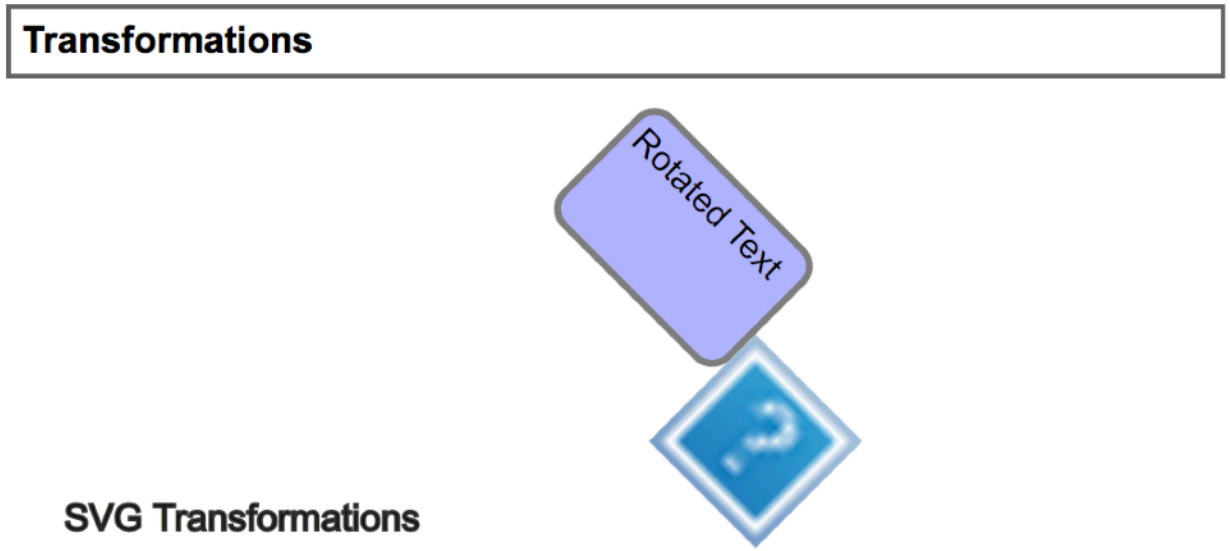
Text

Text along a curved pa

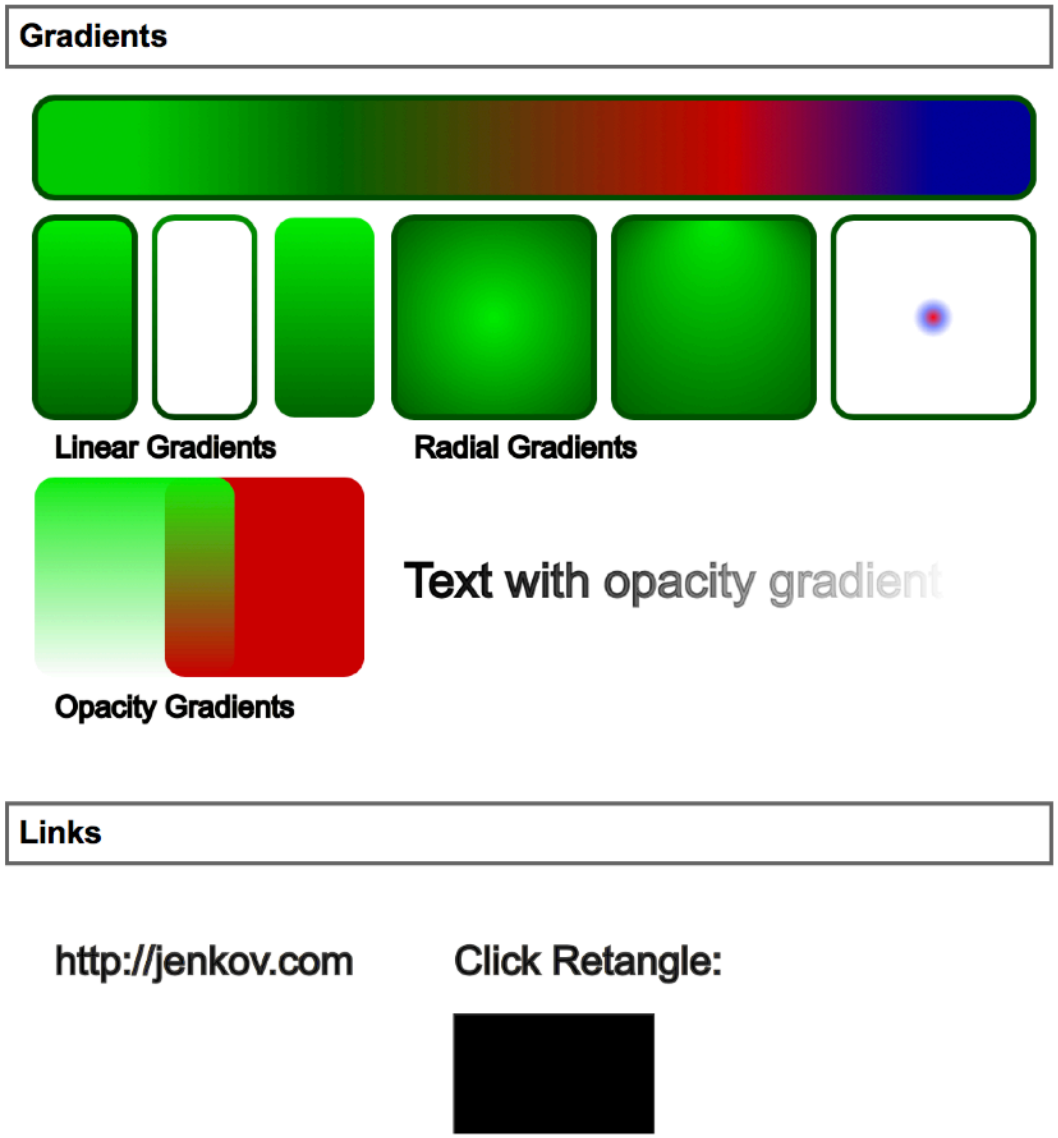
Images

# SVG Examples

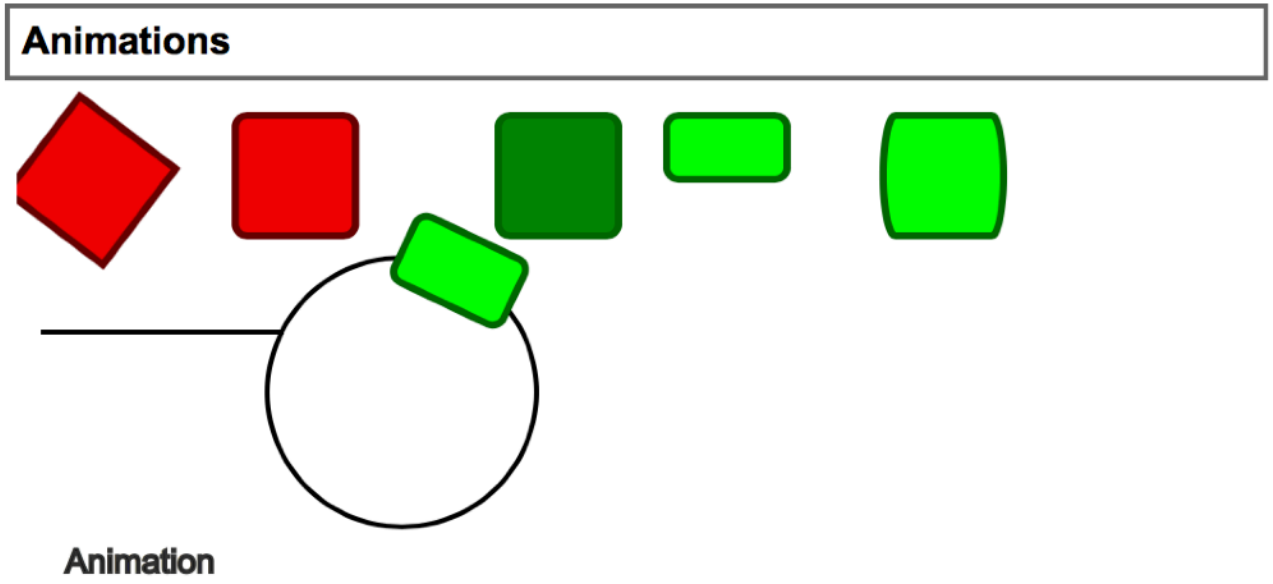


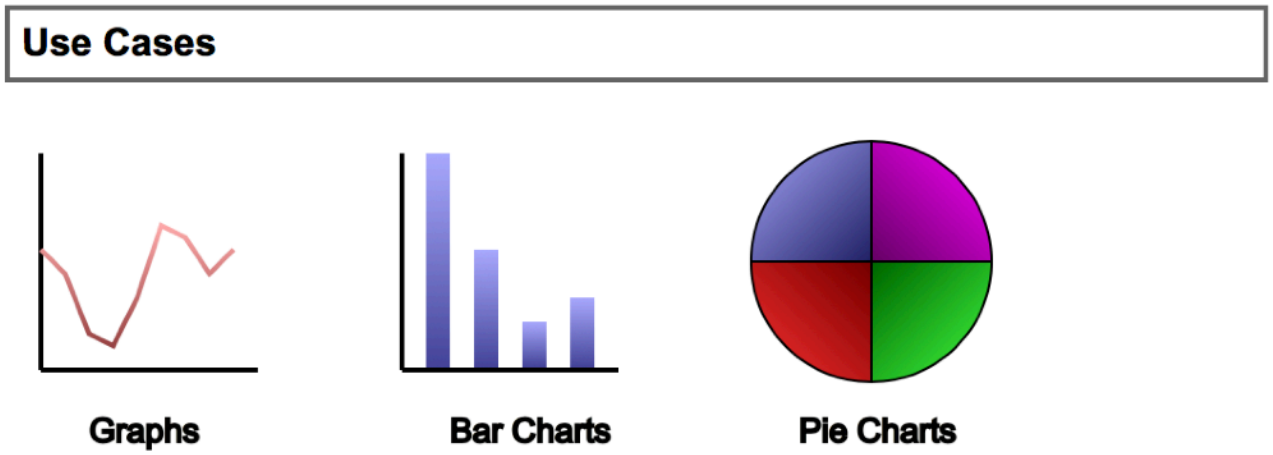



# SVG Examples



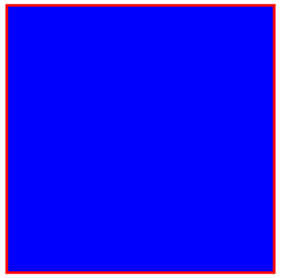
# SVG Examples



# A Simple SVG Example

```
<svg  xmlns="http://www.w3.org/2000/svg"
      xmlns:xlink="http://www.w3.org/1999/xlink">
    <rect x="10" y="10" height="100" width="100"
          style="stroke:#ff0000; fill: #0000ff"/>
</svg>
```



## SVG as Background Images

Since the browsers treat SVG images just like bitmap images, you can use SVG images as background images via CSS. Here is an example:

```
div {
    background-image: url('my-svg-image.svg');
    background-size : 100px 100px;
}
```

## svg Element Inside HTML

Embedding an SVG image using the `svg` element can be done by embedding an `svg` element directly in an HTML page, like this:

```
<div>
<svg>
    <circle cx="40" cy="40" r="24" style="stroke:#006600; fill:#00cc00"/>
    </svg>
</div>
```

# SVG g, line, rect, and text Elements

```
<svg xmlns="http://www.w3.org/2000/svg"
    xmlns:xlink="http://www.w3.org/1999/xlink">

    <g>
      <line x1="10" y1="10" x2="85" y2="10"
          style="stroke: #006600;"/>

      <rect x="10" y="20" height="50" width="75"
          style="stroke: #006600; fill: #006600"/>

      <text x="10" y="90" style="stroke: #660000; fill: #660000">
        Text grouped with shapes</text>
    </g>

</svg>
```

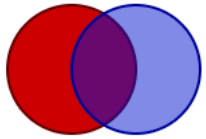
Text grouped with shapes

# SVG strokes and fill

```
<circle cx="40" cy="40" r="24"
    style="stroke:#006600;
           stroke-width: 3;
           fill:#00cc00"/>
```

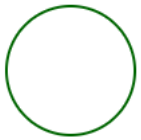
```
<circle cx="40" cy="40" r="24"
    style="stroke: #660000;
           fill: #cc0000" />
<circle cx="64" cy="40" r="24"
    style="stroke: #000066;
           fill: #0000cc"
           fill-opacity: 0.5/>
```

```
<circle cx="40" cy="40" r="24"
    style="stroke:#006600;
           stroke-width: 3;
           stroke-dasharray: 10 5;
           fill:#00cc00"/>
```



```
<circle cx="40" cy="40" r="24"
    style="stroke: none;
           fill:#00cc00"/>
```

```
<circle cx="40" cy="40" r="24"
    style="stroke: #00600;
           fill:none"/>
```



# SVG path Element

```
<svg xmlns="http://www.w3.org/2000/svg"
    xmlns:xlink="http://www.w3.org/1999/xlink">

    <path d="M50,50
             A30,30 0 0,1 35,20
             L100,100
             M110,110
             L100,0"
          style="stroke:#660000; fill:none;"/>
</svg>
```

A: Arc
M: Move
L: Line

# SVG arc

```
<svg xmlns="http://www.w3.org/2000/svg"
    xmlns:xlink="http://www.w3.org/1999/xlink">

    <path d="M50,50
             A30,50 0 0,1 100,100"
          style="stroke:#660000; fill:none;"/>
</svg>
```

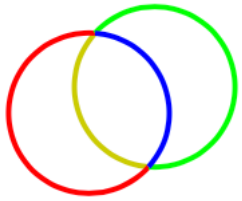
The radius of the arc is set by the two first parameters set on the `A` command. The first parameter is `rx` (radius in x-direction) and the second is `ry` (radius in y-direction). Setting `rx` and `ry` to the same value will result in a circular arc. Setting `rx` and `ry` to different values will result in an elliptical arc. In the example above `rx` was set to `30` and `ry` to `50`.

The third parameter set on the `A` command is the `x-axis-rotation`. This sets the rotation of the arc's x-axis compared to the normal x-axis. In the above example the `x-axis-rotation` is set to `0`. Most of the time you will not need to change this parameter.

The fourth and fifth parameters are the `large-arc-flag` and `sweep-flag` parameters. The `large-arc-flag` determines whether to draw the smaller or bigger arc satisfying the start point, end point and `rx` and `ry`.

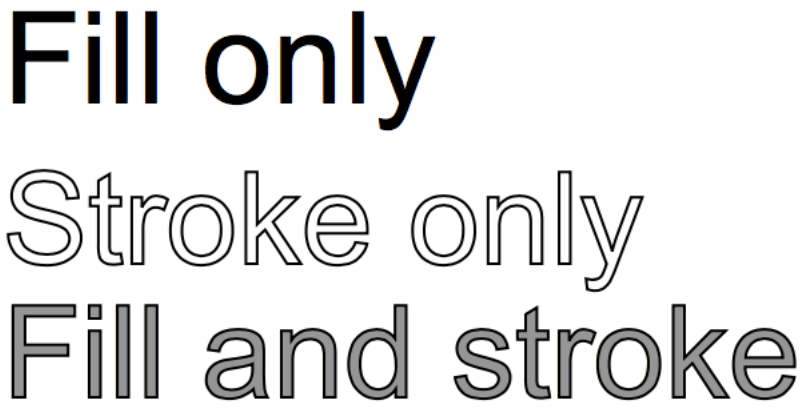
# SVG path Element

```
<path d="M40,20  A30,30 0 0,0 70,70"
    style="stroke: #cccc00; stroke-width:2; fill:none;"/>

<path d="M40,20  A30,30 0 1,0 70,70"
    style="stroke: #ff0000; stroke-width:2; fill:none;"/>

<path d="M40,20  A30,30 0 1,1 70,70"
    style="stroke: #00ff00; stroke-width:2; fill:none;"/>

<path d="M40,20  A30,30 0 0,1 70,70"
    style="stroke: #0000ff; stroke-width:2; fill:none;"/>
```



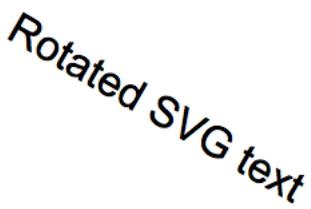
# SVG text Element

```
<text x="20" y="40"
      style="fill: #000000; stroke: none; font-size: 48px;">
    Fill only
</text>
<text x="20" y="100"
      style="fill: none; stroke: #000000;  font-size: 48px;">
    Stroke only
</text>
<text x="20" y="150"
      style="fill: #999999; stroke: #000000;  font-size: 48px;">
    Fill and stroke
</text>
```

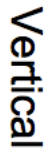


# SVG text Element

```
<svg xmlns="http://www.w3.org/2000/svg"
     xmlns:xlink="http://www.w3.org/1999/xlink">

    <text x="20"  y="40"
          transform="rotate(30 20,40)"
          style="stroke:none; fill:#000000;"
          >Rotated SVG text</text>
</svg>
```




```
<text x="10" y="20" style="writing-mode: tb;">
    Vertical
</text>
```

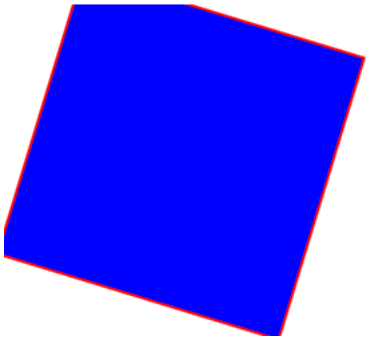


# SVG Transformation

```
<svg xmlns="http://www.w3.org/2000/svg"
    xmlns:xlink="http://www.w3.org/1999/xlink">

    <rect x="50" y="50" height="110" width="110"
          style="stroke:#ff0000; fill: #ccccff"
          transform="translate(30) rotate(45 50 50)"
            >
    </rect>
    <text x="70" y="100"
          transform="translate(30) rotate(45 50 50)"
    >Hello World</text>
</svg>
```

# SVG Animation

```
<svg xmlns="http://www.w3.org/2000/svg"
    xmlns:xlink="http://www.w3.org/1999/xlink">

    <rect x="10" y="10" height="110" width="110"
         style="stroke:#ff0000; fill: #0000ff">

        <animateTransform
            attributeName="transform"
            begin="0s"
            dur="20s"
            type="rotate"
            from="0 60 60"
            to="360 60 60"
            repeatCount="indefinite"
        />
    </rect>

</svg>
```



# Overview of Animation Options

1. <set>
2. <animate>
3. <animateColor>
4. <animateTransform>
5. <animateMotion>

## set

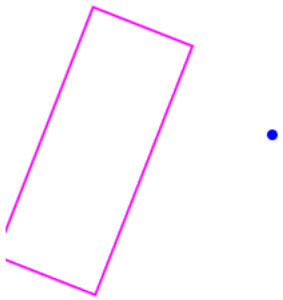
```
<circle cx="30" cy="30" r="25" style="stroke: none; fill: #0000ff;">
    <set attributeName="r" attributeType="XML"
         to="100"
         begin="0s"  />

</circle>
```

## animate

```
<circle cx="30" cy="30" r="25" style="stroke: none; fill: #0000ff;">
    <animate attributeName="cx" attributeType="XML"
             from="30"  to="470"
             begin="0s" dur="5s"
             fill="remove" repeatCount="indefinite"/>

</circle>
```

## animateTransform

```
<rect x="20" y="20" width="100" height="40"
    style="stroke: #ff00ff; fill:none;" >
  <animateTransform attributeName="transform"
                    type="rotate"
                    from="0 100 100" to="360 100 100"
                    begin="0s" dur="10s"
                    repeatCount="indefinite"
          />
</rect>
```

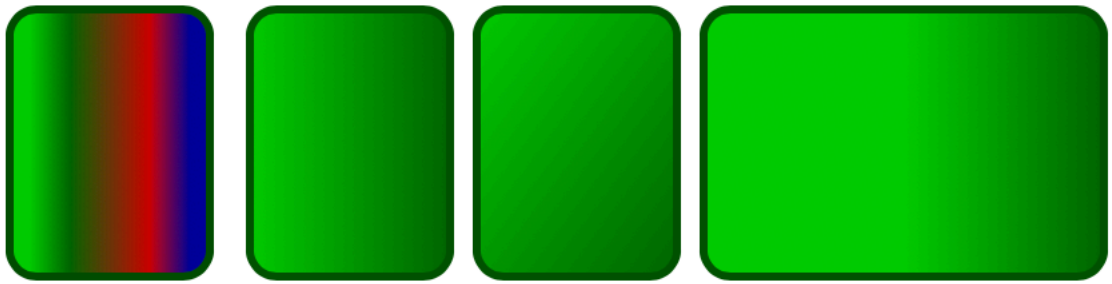


## animateMotion

```
<rect x="0" y="0" width="30" height="15"
      style="stroke: #ff0000; fill: none;">
    <animateMotion
            path="M10,50 q60,50 100,0 q60,-50 100,0"
            begin="0s" dur="10s" repeatCount="indefinite"
            />
</rect>
```

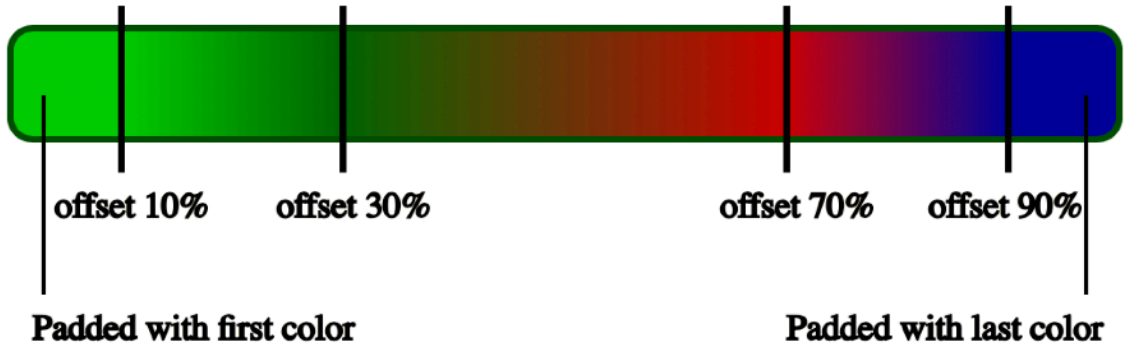
# Linear Gradients

```
<svg xmlns="http://www.w3.org/2000/svg"
     xmlns:xlink="http://www.w3.org/1999/xlink">

  <defs>
    <linearGradient id="myLinearGradient1"
                    x1="0%" y1="0%"
                    x2="0%" y2="100%"
                    spreadMethod="pad">
      <stop offset="0%"   stop-color="#00cc00" stop-opacity="1"/>
      <stop offset="100%" stop-color="#006600" stop-opacity="1"/>
    </linearGradient>
  </defs>

  <rect x="10" y="10" width="75" height="100" rx="10" ry="10"
     style="fill:url(#myLinearGradient1);
            stroke: #005000;
            stroke-width: 3;" />

</svg>
```

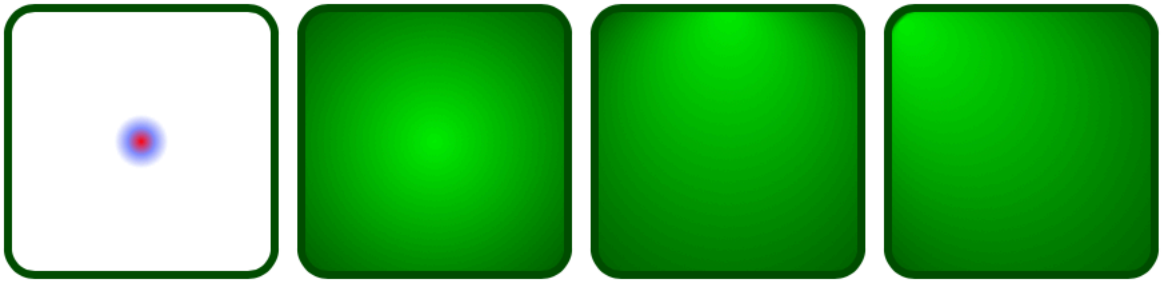


# SVG Gradients

```
<svg xmlns="http://www.w3.org/2000/svg"
     xmlns:xlink="http://www.w3.org/1999/xlink">


<defs>
  <linearGradient id="myLinearGradient1"
                  x1="0%" y1="0%"
                  x2="100%" y2="0%"
                  spreadMethod="pad">
    <stop offset="10%" stop-color="#00cc00" stop-opacity="1"/>
    <stop offset="30%" stop-color="#006600" stop-opacity="1"/>

    <stop offset="70%" stop-color="#cc0000" stop-opacity="1"/>
    <stop offset="90%" stop-color="#000099" stop-opacity="1"/>

  </linearGradient>

</defs>

<rect x="10" y="10" width="500" height="50" rx="10" ry="10"
   style="fill:url(#myLinearGradient1); stroke: #005000;
          stroke-width: 3;" />

</svg>
```



## Radial Gradients

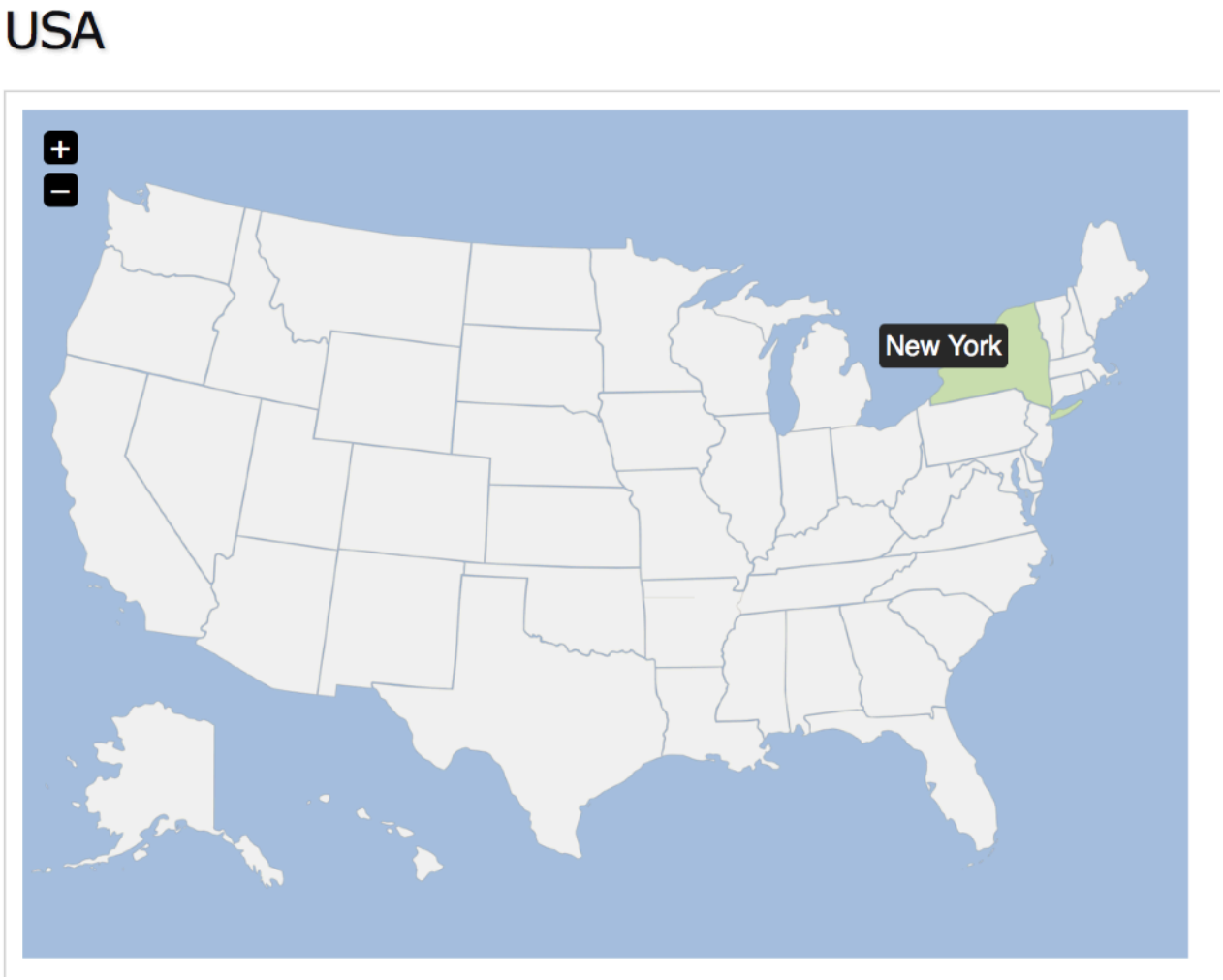


```
<svg xmlns="http://www.w3.org/2000/svg"
         xmlns:xlink="http://www.w3.org/1999/xlink">

    <defs>
        <radialGradient id="myRadialGradient4"
           fx="5%" fy="5%" r="65%"
           spreadMethod="pad">
          <stop offset="0%"   stop-color="#00ee00" stop-opacity="1"/>
          <stop offset="100%" stop-color="#006600" stop-opacity="1" />
        </radialGradient>
    </defs>

    <rect x="340" y="10" width="100" height="100" rx="10" ry="10"
           style="fill:url(#myRadialGradient4);
                  stroke: #005000; stroke-width: 3;" />
</svg>
```

# SVG Image

```
<svg xmlns="http://www.w3.org/2000/svg"
    xmlns:xlink="http://www.w3.org/1999/xlink">

  <rect x="10" y="10" height="130" width="500" style="fill: #000000"/>

  <image x="20" y="20" width="300" height="80"
     xlink:href="http://jenkov.com/images/layout/top-bar-logo.png" />

  <line x1="25" y1="80" x2="350" y2="80"
           style="stroke: #ffffff; stroke-width: 3;"/>
</svg>
```

https://www.tutorialspoint.com/svg/maps.htm

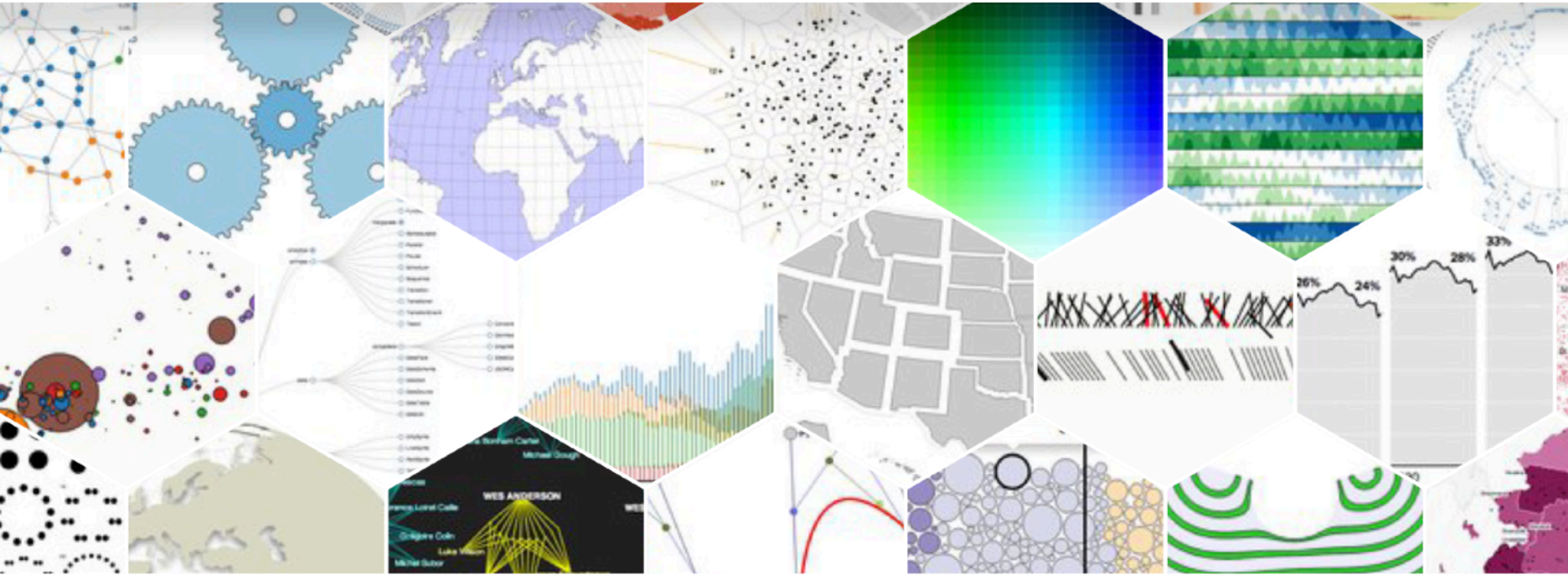


# Visualization — D3 Introduction and Examples

# D3 Website

http://d3js.org

Data-Driven Documents



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## Installing

For NPM, `npm install d3`. For Yarn, `yarn add d3`. Otherwise, download the latest release. The released bundle supports AMD, CommonJS, and vanilla environments. Create a custom bundle using Rollup or your preferred bundler. You can also load directly from d3js.org:

```
<script src="https://d3js.org/d3.v5.js"></script>
```

For the minified version:

```
<script src="https://d3js.org/d3.v5.min.js"></script>
```

You can also use the standalone D3 microlibraries. For example, d3-selection:

```
<script src="https://d3js.org/d3-selection.v1.min.js"></script>
```

# D3 Selections

In Javascript:

```
var paragraphs = document.getElementsByTagName("p");
for (var i = 0; i < paragraphs.length; i++) {
  var paragraph = paragraphs.item(i);
  paragraph.style.setProperty("color", "white", null);
}
```

D3 employs a declarative approach, operating on arbitrary sets of nodes called *selections*. For example, you can rewrite the above loop as:

```
d3.selectAll("p").style("color", "white");
```

# D3 Dynamic Properties

Randomly color paragraphs:

```
d3.selectAll("p").style("color", function() {
  return "hsl(" + Math.random() * 360 + ",100%,50%)";
});
```

Alternate shades of gray for even and odd nodes:

```
d3.selectAll("p").style("color", function(d, i) {
  return i % 2 ? "#fff" : "#eee";
});
```

# D3 Dynamic Properties

Randomly color paragraphs:

```
d3.selectAll("p")
  .data([4, 8, 15, 16, 23, 42])
    .style("font-size", function(d) { return d + "px"; });
```

Computed properties often refer to bound data. Data is specified as an array of values, and each value is passed as the first argument (d) to selection functions. With the default join-by-index, the first element in the data array is passed to the first node in the selection, the second element to the second node, and so on. For example, if you bind an array of numbers to paragraph elements, you can use these numbers to compute dynamic font sizes:

# D3 Enter

Using D3's *enter* and *exit* selections, you can create new nodes for incoming data and remove outgoing nodes that are no longer needed.

When data is bound to a selection, each element in the data array is paired with the corresponding node in the selection. If there are fewer nodes than data, the extra data elements form the enter selection, which you can instantiate by appending to the `enter` selection. For example:

```
d3.select("body")
  .selectAll("p")
  .data([4, 8, 15, 16, 23, 42])
  .enter().append("p")
    .text(function(d) { return "I'm number " + d + "!"; });
```

# D3 Exit

```
// Update…
var p = d3.select("body")
  .selectAll("p")
  .data([4, 8, 15, 16, 23, 42])
    .text(function(d) { return d; });

// Enter…
p.enter().append("p")
    .text(function(d) { return d; });

// Exit…
p.exit().remove();
```

# D3 Transformation

For example, to fade the background of the page to black:

```
d3.select("body").transition()
    .style("background-color", "black");
```

Or, to resize circles in a symbol map with a staggered delay:

```
d3.selectAll("circle").transition()
    .duration(750)
    .delay(function(d, i) { return i * 10; })
    .attr("r", function(d) { return Math.sqrt(d * scale); });
```

https://bost.ocks.org/mike/bar/

```
var data = [4, 8, 15, 16, 23, 42];
```

## Selecting an Element

Javascript:

```
var div = document.createElement("div");
div.innerHTML = "Hello, world!";
document.body.appendChild(div);
```

D3:

```
var body = d3.select("body");
var div = body.append("div");
div.html("Hello, world!");
```

## Chaining Methods

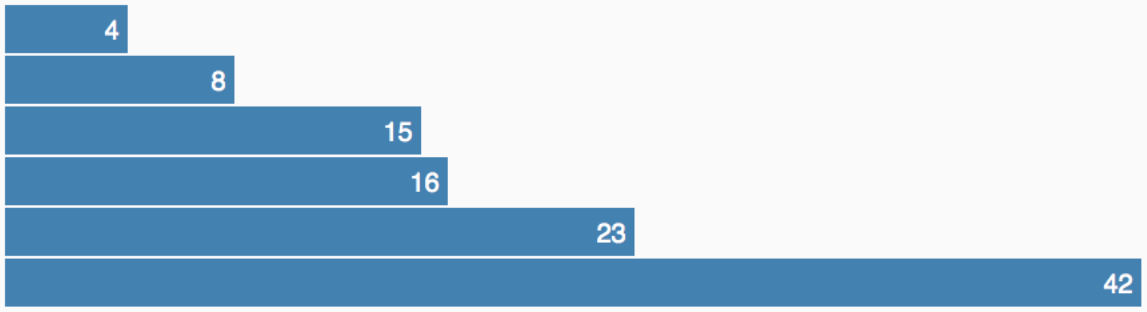
```
var body = d3.select("body");
body.style("color", "black");
body.style("background-color", "white");
```

```
d3.select("body")
    .style("color", "black")
    .style("background-color", "white");
```

```
var section = d3.selectAll("section");

section.append("div")
    .html("First!");

section.append("div")
    .html("Second.");
```

# Coding a Chart, Manually

```
<!DOCTYPE html>
<style>

.chart div {
  font: 10px sans-serif;
  background-color: steelblue;
  text-align: right;
  padding: 3px;
  margin: 1px;
  color: white;
}

</style>
<div class="chart">
  <div style="width: 40px;">4</div>
  <div style="width: 80px;">8</div>
  <div style="width: 150px;">15</div>
  <div style="width: 160px;">16</div>
  <div style="width: 230px;">23</div>
  <div style="width: 420px;">42</div>
</div>
```



## Coding a Chart, Automatically

```
d3.select(".chart")
  .selectAll("div")
    .data(data)
  .enter().append("div")
    .style("width", function(d) { return d * 10 + "px"; })
    .text(function(d) { return d; });
```

First, we select the chart container using a class selector.

```
var chart = d3.select(".chart");
```

Next we initiate the data join by defining the selection to which we will join data.

```
var bar = chart.selectAll("div");
```

## Coding a Chart, Automatically

```
var barUpdate = bar.data(data);
```

```
var barEnter = barUpdate.enter().append("div");
```

```
barEnter.style("width", function(d) { return d * 10 + "px"; });
```

```
barEnter.text(function(d) { return d; });
```

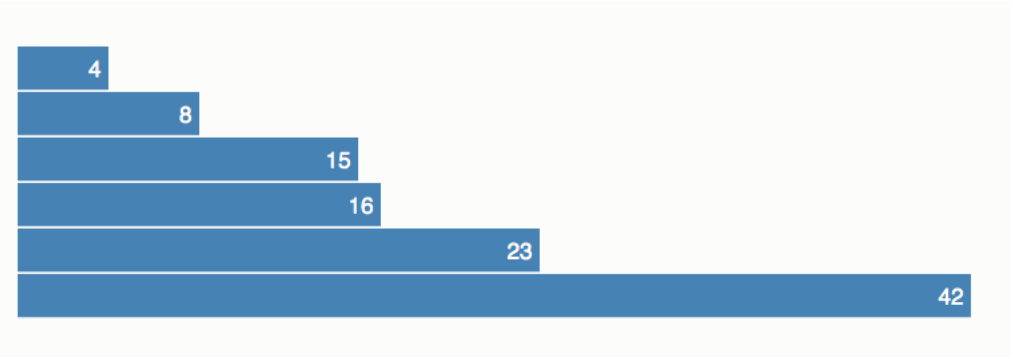
## Scaling to Fit

```
var x = d3.scale.linear()
    .domain([0, d3.max(data)])
    .range([0, 420]);
```

# D3 Bar Chart Tutorial

```
<!DOCTYPE html>
<style>

.chart rect {
  fill: steelblue;
}

.chart text {
  fill: white;
  font: 10px sans-serif;
  text-anchor: end;
}

</style>
<svg class="chart" width="420" height="120">
  <g transform="translate(0,0)">
    <rect width="40" height="19"></rect>
    <text x="37" y="9.5" dy=".35em">4</text>
  </g>
  <g transform="translate(0,20)">
    <rect width="80" height="19"></rect>
    <text x="77" y="9.5" dy=".35em">8</text>
  </g>
  <g transform="translate(0,40)">
    <rect width="150" height="19"></rect>
    <text x="147" y="9.5" dy=".35em">15</text>
  </g>
  <g transform="translate(0,60)">
    <rect width="160" height="19"></rect>
    <text x="157" y="9.5" dy=".35em">16</text>
  </g>
  <g transform="translate(0,80)">
    <rect width="230" height="19"></rect>
    <text x="227" y="9.5" dy=".35em">23</text>
  </g>
  <g transform="translate(0,100)">
    <rect width="420" height="19"></rect>
    <text x="417" y="9.5" dy=".35em">42</text>
  </g>
</svg>
```

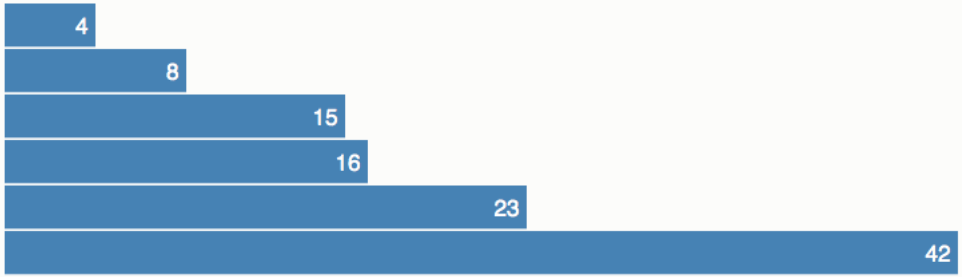
Full code to do it manually



# D3 Bar Chart Tutorial

Full code to do it automatically

```
<!DOCTYPE html>
<meta charset="utf-8">
<style>

.chart rect {
  fill: steelblue;
}

.chart text {
  fill: white;
  font: 10px sans-serif;
  text-anchor: end;
}

</style>
<svg class="chart"></svg>
<script src="//d3js.org/d3.v3.min.js" charset="utf-8"></script>
```



# D3 Bar Chart Tutorial

Full code to do it automatically

```
<script>

var data = [4, 8, 15, 16, 23, 42];

var width = 420,
    barHeight = 20;

var x = d3.scale.linear()
    .domain([0, d3.max(data)])
    .range([0, width]);

var chart = d3.select(".chart")
    .attr("width", width)
    .attr("height", barHeight * data.length);

var bar = chart.selectAll("g")
    .data(data)
  .enter().append("g")
    .attr("transform", function(d, i) { return "translate(0," + i * barHeight + ")"; });

bar.append("rect")
    .attr("width", x)
    .attr("height", barHeight - 1);

bar.append("text")
    .attr("x", function(d) { return x(d) - 3; })
    .attr("y", barHeight / 2)
    .attr("dy", ".35em")
    .text(function(d) { return d; });

</script>
```

## Load data

```
// 1. Code here runs first, before the download starts.

d3.tsv("data.tsv", function(error, data) {
  // 3. Code here runs last, after the download finishes.
});

// 2. Code here runs second, while the file is downloading.
```

| name | value |
|---|---|
| Locke | 4 |
| Reyes | 8 |
| Ford | 15 |
| Jarrah | 16 |
| Shephard | 23 |
| Kwon | 42 |

The equivalent of Javascript code:

```
var data = [
  {name: "Locke",    value:  4},
  {name: "Reyes",    value:  8},
  {name: "Ford",     value: 15},
  {name: "Jarrah",   value: 16},
  {name: "Shephard", value: 23},
  {name: "Kwon",     value: 42}
];
```

# D3 Bar Chart Tutorial

```
<!DOCTYPE html>
<meta charset="utf-8">
<style>

.chart rect {
  fill: steelblue;
}

.chart text {
  fill: white;
  font: 10px sans-serif;
  text-anchor: end;
}

</style>
<svg class="chart"></svg>
<script src="//d3js.org/d3.v3.min.js" charset="utf-8"></script>
```

# D3 Bar Chart Tutorial

```
<script>

var width = 420,
    barHeight = 20;

var x = d3.scale.linear()
    .range([0, width]);

var chart = d3.select(".chart")
    .attr("width", width);

d3.tsv("data.tsv", type, function(error, data) {
  x.domain([0, d3.max(data, function(d) { return d.value; })]);

  chart.attr("height", barHeight * data.length);

  var bar = chart.selectAll("g")
      .data(data)
    .enter().append("g")
      .attr("transform", function(d, i) { return "translate(0," + i * barHeight + ")"; });

  bar.append("rect")
      .attr("width", function(d) { return x(d.value); })
      .attr("height", barHeight - 1);

  bar.append("text")
      .attr("x", function(d) { return x(d.value) - 3; })
      .attr("y", barHeight / 2)
      .attr("dy", ".35em")
      .text(function(d) { return d.value; });
});

function type(d) {
  d.value = +d.value; // coerce to number
  return d;
}

</script>
```

# D3 Example Circles

https://bost.ocks.org/mike/circles/

```
<svg width="720" height="120">
  <circle cx="40" cy="60" r="10"></circle>
  <circle cx="80" cy="60" r="10"></circle>
  <circle cx="120" cy="60" r="10"></circle>
</svg>
```

```
var circle = d3.selectAll("circle");
```

```
circle.style("fill", "steelblue");
circle.attr("r", 30);
```

# D3 Example Circles

https://bost.ocks.org/mike/circles/

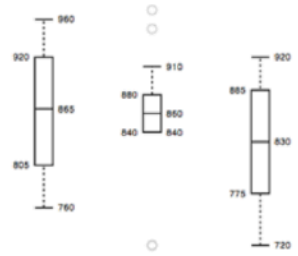
```
<svg width="720" height="120">
  <circle cx="40" cy="60" r="10"></circle>
  <circle cx="80" cy="60" r="10"></circle>
  <circle cx="120" cy="60" r="10"></circle>
</svg>
```

```
var circle = d3.selectAll("circle");
circle.style("fill", "steelblue");
circle.attr("r", 30);
```

```
circle.attr("cx", function() { return Math.random() * 720; });
```

# D3 Gallery

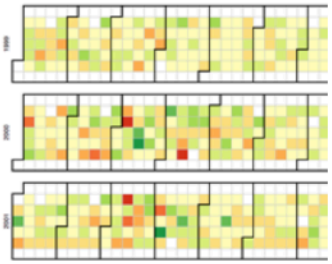
Box Plots



Bubble Chart

Bullet Charts

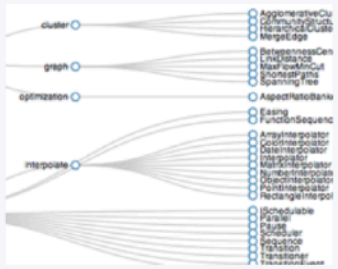

Calendar View



Non-contiguous Cartogram

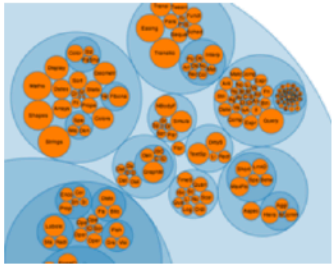
Chord Diagram

Dendrogram

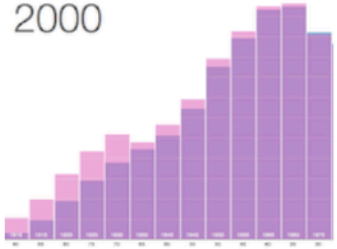



Force-Directed Graph

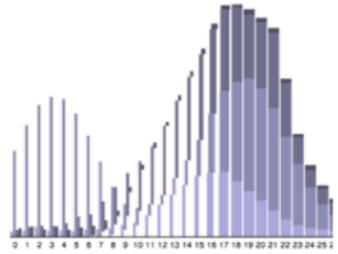
Circle Packing



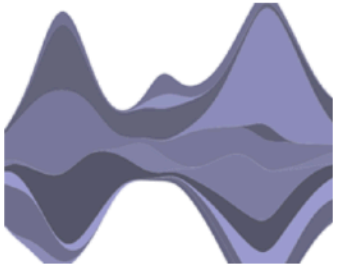
Population Pyramid




Stacked Bars



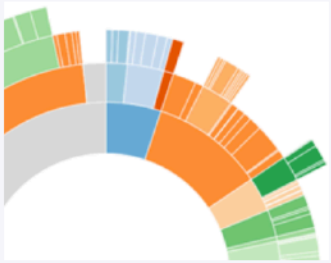
Streamgraph



# D3 Gallery

Columbia University

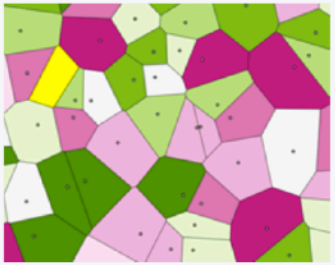
Sunburst



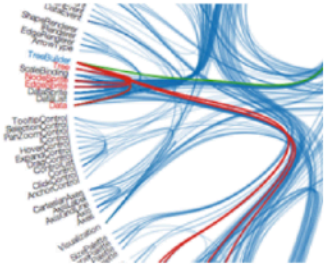
Node-Link Tree

Treemap

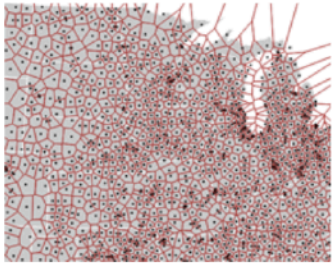
Voronoi Diagram



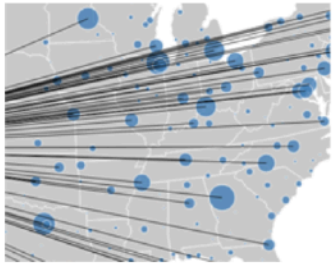
Hierarchical Edge Bundling



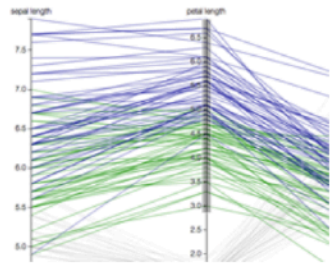
Voronoi Diagram



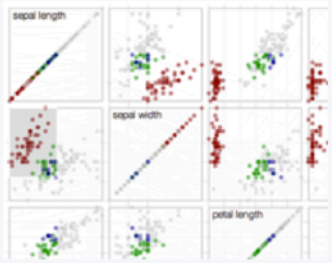
Symbol Map



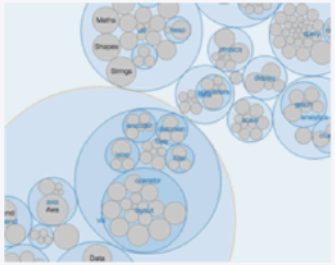
Parallel Coordinates



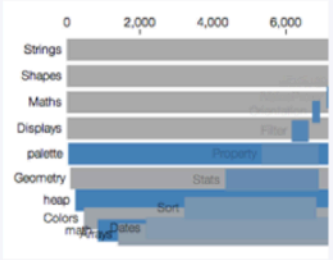
Scatterplot Matrix



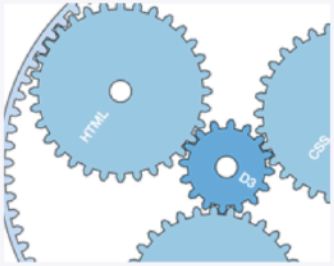

Zoomable Pack Layout



Hierarchical Bars



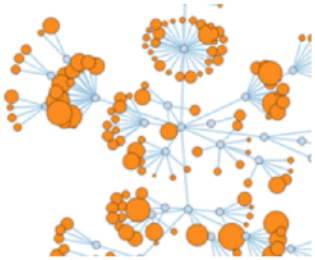

Epicyclical Gears



# D3 Gallery

Collision Detection

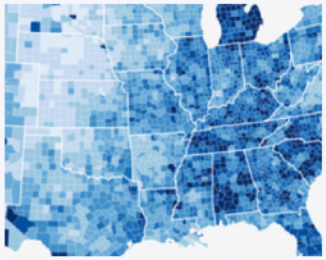
Collapsible Force Layout



Force-Directed States

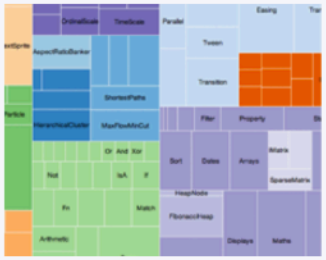
Azimuthal Projections

Choropleth



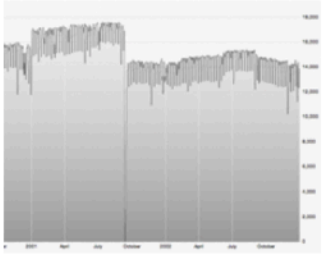
Collapsible Tree Layout


Zoomable Treemap

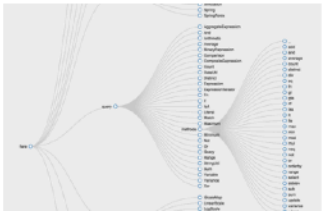


Zoomable Partition Layout

Zoomable Area Chart

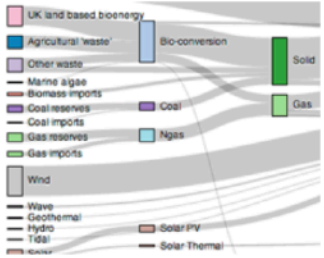


Drag and Drop Collapsible Tree Layout



Radial Cluster Layout

Sankey Diagram

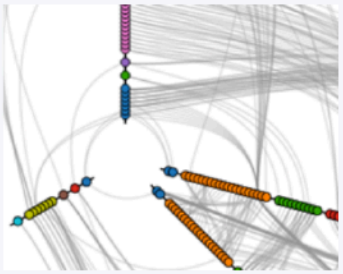


# D3 Gallery

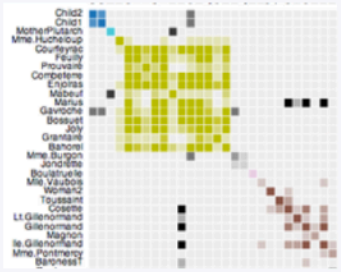
Columbia University

## Fisheye Distortion

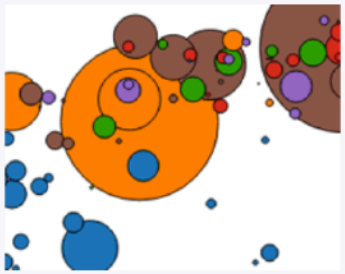
## Hive Plot



## Co-occurrence Matrix

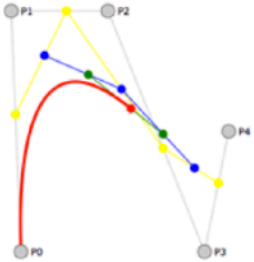


## Motion Chart



## Chord Diagram

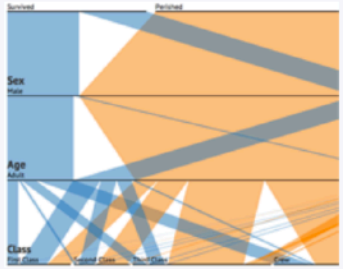

## Animated Béziers




## Zoomable Sunburst

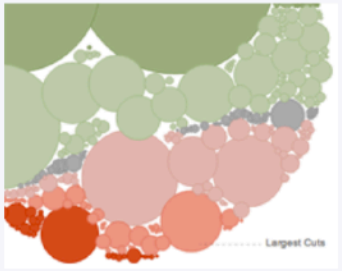
## Collatz Graph

## Parallel Sets




## Word Cloud


## Obama's Budget Proposal

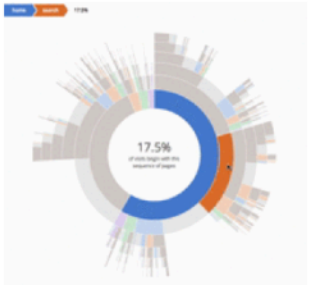


## Facebook IPO

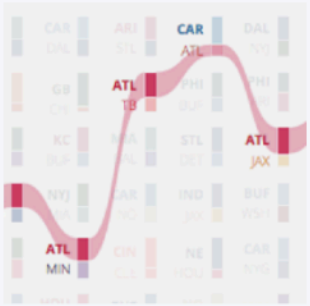
# D3 Gallery

US Trade Deficit

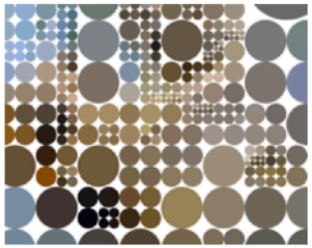
Sequences sunburst




NFL Predictions

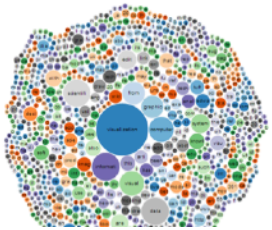



Koalas to the Max



Sankey Creator

Convert any page into bubbles



D3 Builder