Data Visualization (CIS 468)

Tasks & D3

Dr. David Koop
Data

• What is this data?

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• **Semantics**: real-world meaning of the data
• **Type**: structural or mathematical interpretation
• Both often require **metadata**
  - Sometimes we can infer some of this information
  - Line between data and metadata isn’t always clear
• Example: 94023, 90210, 52790, 02747
Table Visualization

[D. Koop, CIS 468, Fall 2018]

[M. Bostock, 2011]
Network Visualization

Figure 7: US airlines graph (235 nodes, 2101 edges) (a) not bundled and bundled using (b) FDEB with inverse-linear model, (c) GBEB, and (d) FDEB with inverse-quadratic model.

Figure 8: US migration graph (1715 nodes, 9780 edges) (a) not bundled and bundled using (b) FDEB with inverse-linear model, (c) GBEB, and (d) FDEB with inverse-quadratic model. The same migration flow is highlighted in each graph.

Figure 9: A low amount of straightening provides an indication of the number of edges comprising a bundle by widening the bundle. (a) $s = 0$, (b) $s = 10$, and (c) $s = 40$. If $s$ is 0, color more clearly indicates the number of edges comprising a bundle.

We generated our results using the rendering technique described in Section 4.1. To facilitate the comparison of migration flow in Figure 8, we use a similar rendering technique as the one Cui et al. [CZQ+08] used to generate Figure 8c.

The airlines graph is comprised of 235 nodes and 2101 edges. It took 19 seconds to calculate the bundled airlines graphs (Figures 7b and 7d) using the calculation scheme presented in Section 3.3. The migration graph is comprised of 1715 nodes and 9780 edges. It took 80 seconds to calculate the bundled migration graphs (Figures 8b and 8d) using the same calculation scheme. All measurements were performed on an Intel Core 2 Duo 2.66GHz PC running Windows XP with 2GB of RAM and a GeForce 8800GT graphics card.

Our prototype was implemented in Borland Delphi 7.

[Holten & van Wijk, 2009]
Attribute Types

- Categorical
- Ordered
  - Ordinal
  - Quantitative

[Munzner (ill. Maguire), 2014]
### Categorial, Ordinal, and Quantitative

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**Legend:**
- **Quantitative**
- **Ordinal**
- **Categorical**
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Data Model vs. Conceptual Model

- Data Model: raw data that has a specific data type (e.g. floats):
  - Temperature Example: [32.5, 54.0, -17.3] (floats)

- Conceptual Model: how we think about the data
  - Includes semantics, reasoning
  - Temperature Example:
    - Quantitative: [32.50, 54.00, -17.30]
Data Model vs. Conceptual Model

• Data Model: raw data that has a specific data type (e.g. floats):
  - Temperature Example: \([32.5, 54.0, -17.3]\) (floats)

• Conceptual Model: how we think about the data
  - Includes semantics, reasoning
  - Temperature Example:
    • Quantitative: \([32.50, 54.00, -17.30]\)
    • Ordered: \([\text{warm}, \text{hot}, \text{cold}]\)

[via A. Lex, 2015]
Data Model vs. Conceptual Model

• Data Model: raw data that has a specific data type (e.g. floats):
  - Temperature Example: [32.5, 54.0, -17.3] (floats)

• Conceptual Model: how we think about the data
  - Includes semantics, reasoning
  - Temperature Example:
    • Quantitative: [32.50, 54.00, -17.30]
    • Ordered: [warm, hot, cold]
    • Categorical: [not burned, burned, not burned]
Ordering Direction

- **Sequential**
- **Diverging**
- **Cyclic**

[Munzner (ill. Maguire), 2014]
Sequential and Diverging Data

- **Sequential**: homogenous range from a minimum to a maximum
  - Examples: Land elevations, ocean depths
- **Diverging**: can be deconstructed into two sequences pointing in opposite directions
  - Has a zero point (not necessary 0)
  - Example: Map of both land elevation and ocean depth

[Rogowitz & Treinish, 1998]
Derived Data

• Often, data in its original form isn't as useful as we would like

• Examples: Data about a basketball team's games

• Example 1: 1stHalfPoints, 2ndHalfPoints
  - More useful to know total number of points
  - Points = 1stHalfPoints + 2ndHalfPoints

• Example 2: Points, OpponentPoints
  - Want to have a column indicating win/loss
  - Win = True if (Points > OpponentPoints) else False

• Example 3: Points
  - Want to have a column indicating how that point total ranks
  - Rank = index in sorted list of all Point values
Assignment 1

- Due today (Sept. 25) at 11:59pm
- HTML, CSS, SVG, JavaScript
- Questions?
“Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.”

— T. Munzner
Tasks

• Why? Understand data, but what do I want to do with it?
• Levels: High (Produce/Consume), Mid (Search), Low (Queries)
• Another key concern: Who?
  - Designer <-> User (A spectrum)
  - Complex <-> Easy to Use
  - General <-> Context-Specific
  - Flexible <-> Constrained
  - Varied Data <-> Specific Data
Actions: Analyze

→ Consume

→ Discover

→ Present

→ Enjoy

→ Produce

→ Annotate

→ Record

→ Derive

[Munzner (ill. Maguire), 2014]
Visualization for Consumption

- Discover new knowledge
  - Generate new hypothesis or verify existing one
  - Designer doesn’t know what users need to see
  - "why doesn't dictate how"
- Present known information
  - Presenter already knows what the data says
  - Wants to communicate this to an audience
  - May be static but not limited to that
- Enjoy
  - Similar to discover, but without concrete goals
  - May be enjoyed differently than the original purpose
Explore MTA Fare Data
Each solid circle represents a bee species active in Carlinville, Ill., in both the late 1800s and 2010.

Hatching represents a bee species active in the 1800s but now locally extinct.

The spot where each block rests on the circle indicates one of 26 plant species frequented by these bees.

In the 1880s, scientists observed the following about the bee-plant encounters:

- Present
- Frequent
- Abundant

Studies in 2009 and 2010 showed many bee-plant interactions had changed:

- Lost
- Persisted
- New

[M. Stefaner, 2013]
Name Voyager

NameVoyager: Explore baby names and name trends letter by letter
Looking for the perfect baby name? Sign up for free to receive access to our expert tools!

Baby Name > An[ ]  ○ Both □ Boys ○ Girls

Names starting with 'AN' per million babies

Visualization for Production

- Generate new material
- Annotate
- Record
- Derive (Transform)
Annotation: Circle Annotations
Record: Provenance of MTA Data Exploration

- Initial data
  - Corrected data
    - November ff
    - November 2 data
    - August 16 Tab
  - Station locations
    - Station map
    - Added fares
      - Full fares map
      - Difference
        - Broadway line
        - August 16
          - Broadway diff map
  - Sum of ffs
  - 30-D weekly
  - 161st-River
    - With labels
    - Concourse line
      - Filtered
      - Heatmap

D. Koop, CIS 468, Fall 2018
Derived Data

Original Data

Derived Data

trade balance = exports – imports

[Munzner (ill. Maguire), 2014]
Visualization for Production

- Generate new material
- Annotate:
  - Add more to a visualization
  - Usually associated with text, but can be graphical
- Record:
  - Persist visualizations for historical record
  - Provenance (graphical histories): how did I get here?
- Derive (Transform):
  - Create new data
  - Create derived attributes (e.g. mathematical operations, aggregation)
Actions: Search

<table>
<thead>
<tr>
<th></th>
<th>Target known</th>
<th>Target unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location known</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lookup</td>
<td></td>
<td>Browse</td>
</tr>
<tr>
<td>Location unknown</td>
<td>Locate</td>
<td>Explore</td>
</tr>
</tbody>
</table>

- What does a user know?
  - Lookup: check bearings
  - Locate: find on a map
  - Browse: what’s nearby
  - Explore: where to go (patterns)

[Munzner (ill. Maguire), 2014]
Query

- Identify: characteristics or references
- Compare: similarities and differences
- Summarize: overview of everything

- Number of targets: One, Some (Often 2), or All
- Identify: characteristics or references
- Compare: similarities and differences
- Summarize: overview of everything

[Munzner (ill. Maguire), 2014]
Targets

- **ALL DATA**
  - Trends
  - Outliers
  - Features

- **ATTRIBUTES**
  - One
    - Distribution
    - Extremes
  - Many
    - Dependency
    - Correlation
    - Similarity

- **NETWORK DATA**
  - Topology
  - Paths

- **SPATIAL DATA**
  - Shape

---

[Munzner (ill. Maguire), 2014]
Analysis Example: Different “Idioms”

[SpaceTree, Grosjean et al.]  [TreeJuxtaposer, Munzner et al.]
“Idiom” Comparison

SpaceTree

TreeJuxtaposer

[Munzner (ill. Maguire), 2014]
**“Idiom” Comparison**

**SpaceTree**
- **Actions**
  - Present
  - Locate
  - Identify
- **Targets**
  - Path between two nodes

**TreeJuxtaposer**
- **Actions**
  - Encode
  - Navigate
  - Select
  - Filter
  - Aggregate
- **Targets**
  - SpaceTree
  - TreeJuxtaposer

---

**What?**

Why?

How?

**What?**

**Why?**

**How?**

**Actions**

**Targets**

**References**


[Munzner (ill. Maguire), 2014]
Analysis Example: Derivation

• Strahler number
  – centrality metric for trees/networks
  – derived quantitative attribute
  – draw top 5K of 500K for good skeleton


Task 1

<table>
<thead>
<tr>
<th>In Tree</th>
<th>Out Quantitative attribute on nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>What?</td>
<td>Derive</td>
</tr>
</tbody>
</table>

Task 2

<table>
<thead>
<tr>
<th>In Tree + Out Quantitative attribute on nodes</th>
<th>Out Filtered Tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>What? In Tree</td>
<td></td>
</tr>
<tr>
<td>Why? Summarize</td>
<td></td>
</tr>
<tr>
<td>How? Reduce Topology</td>
<td></td>
</tr>
</tbody>
</table>

[Munzner (ill. Maguire), 2014]
Tools
**D3.js** is a JavaScript library for manipulating documents based on data. **D3** helps you bring data to life using HTML, SVG, and CSS. D3’s emphasis on web standards gives you the full capabilities of modern browsers without tying yourself to a proprietary framework, combining powerful visualization tools with a direct and efficient interface for manipulating documents.
JavaScript Libraries

• Building Blocks: HTML, CSS, SVG, and JavaScript

• More Ideas:

  - JavaScript Libraries
    • `<script src="http://d3js.org/d3.js" charset="utf-8"></script>`

  - Minification: smaller code, no functional change
    • `<script src="http://d3js.org/d3.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/d3/5.7.0/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/
- Original Authors: Mike Bostock, Vadim Ogievetsky, 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 60,000 stars as of 2/8/2017)
- Lots of impressive examples
  - Bostock was a New York Times Graphics Editor
  - 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
  - (Updated from original for D3 v5)
- Other references:
  - Murrary’s book on Interactive Data Visualization for the Web
  - The D3 website: [d3js.org](http://d3js.org)
  - Ros's Slides on v4: [https://iros.github.io/d3-v4-whats-new/](https://iros.github.io/d3-v4-whats-new/)
  - D3 v5 Change:
    - Uses Promises to load data instead of callbacks
    - `d3.csv("file.csv").then(function(data) { ... })`