CSE 412 - Intro to Data Visualization

Networks

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Topics

Mon - Tree Visualization

TODAY - Graph Layout: Node-Link Diagrams

TODAY - Alternative Visualizations and Techniques

Select an image to jump to those slides.
Trees and Graphs

Trees
Graphs with hierarchical structure
Connected graph with N-1 edges
Nodes as parents and children

Graphs
Model relations among data
Nodes and edges
Network Analysis Tasks  [Pretorius '13]

Structure-based: relationships and connectivity

Attribute-based: specific node/link attributes

Browsing: understand paths in the data

Estimation: summarization and temporal changes
Network Analysis Tasks  [Pretorius '13]

**Structure-based:** relationships and connectivity

*Find all of the friends of friends for Taylor.*

*Find all of the people who are friends with Jordan and Alex.*

*Six degrees of separation: shortest path between two individuals.*

**Attribute-based:** specific node/link attributes

**Browsing:** understand paths in the data

**Estimation:** summarization and temporal changes
Network Analysis Tasks  [Pretorius '13]

**Structure-based:** relationships and connectivity

- Find all of the friends of friends for Taylor.
- Find all of the people who are friends with Jordan and Alex.
- Six degrees of separation: shortest path between two individuals.

**Attribute-based:** specific node/link attributes

- Find all "students" attending CSE412.
- Find all the "friends" and "family" of Alex.

**Browsing:** understand paths in the data

**Estimation:** summarization and temporal changes
Network Analysis Tasks  [Pretorius '13]

**Structure-based:** relationships and connectivity
Find all of the friends of friends for Taylor.
Find all of the people who are friends with Jordan and Alex.
Six degrees of separation: shortest path between two individuals.

**Attribute-based:** specific node/link attributes
Find all "students" attending CSE412.
Find all the "friends" and "family" of Alex.

**Browsing:** understand paths in the data
Find Alex's friend Taylor, and then Taylor's friend Jordan.

**Estimation:** summarization and temporal changes
Network Analysis Tasks [Pretorius '13]

**Structure-based:** relationships and connectivity
Find all of the friends of friends for Taylor.
Find all of the people who are friends with Jordan and Alex.
Six degrees of separation: shortest path between two individuals.

**Attribute-based:** specific node/link attributes
Find all "students" attending CSE442.
Find all the "friends" and "family" of Alex.

**Browsing:** understand paths in the data
Find Alex's friend Taylor, and then Taylor's friend Jordan.

**Estimation:** summarization and temporal changes
How does Jordan's friend group change over the course of the year?
Node-Link Graph Layout
Node-Link Graph Visualization

Nodes connected by lines/curves

**Sugiyama-Style Layout** - arranged by depth

**Force-Directed Layout** - physical simulation

**Attribute-Driven Layout** - arranged by value

**Constraint-Based Layout** - optimization

**Arc Diagrams** - aligned layout
Sugiyama-Style Layout
Sugiyama-Style Layout

Evolution of the UNIX operating system
Hierarchical layering based on descent
GraphViz package!
Sugiyama-style layout emphasizes hierarchy. However, cycles in the graph may mislead. Long edges can impede perception of proximity.
Force-Directed Layout
Interactive Example: Configurable Force Layout
Zephoria

User ID: 21721
Friends: 268
Age: ??
Gender: Female
Status: Single
Location: San Francisco, CA
Hometown: Lancaster, PA
Occupation: researcher, social networks, identity, context
Interests: apohemia, observing people, culture, questioning power, reading, Buddhism, gossip, computer-mediated communication, social networks, technology, anthropology, stamping
Music: psytrance/ghostrance [Infected Mushroom, San Kie...]
Books: Authors: Irving Goffman, Stanley Milgram, Jeanette Winterson, Eric Schlosser, Leslie Feinberg, Dorothy Allison, Italo Calvino, Hermann Hesse
TV Shows: ??
Movies: Koyaanisqatsi, Amelie, Walking Life, Tank Girl, The Matrix, Clockwork Orange, American Beauty, Fight Club, Boys Don't Cry
??
Member Since: ??
Last Login: 2003-10-21
Last Updated: 2003-10-21
About: Some know me as danah...!

I'm a geek, an activist and an academic, fascinated by people and society. I see life as a very large playground and enjoy exploring its intricacies. I revel in life's chaos, while simultaneously providing my own insane element.

My musings: http://www.zephoria.org/thoughts/

Want to Meet: Someone who makes life's complexities seem simply
Use the Force!

http://mbostock.github.io/d3/talk/20110921/
d3.force
7,922 nodes
11,881 edges

[Kai Chang]
Customized Force Layouts

Different forces can be composed to create an expressive space of custom layouts.

A **beeswarm plot** can be made by combining:
- Attractive **X** and **Y** forces to draw nodes of a certain category to a desired point
- **Collide** force to detect collision & remove overlap
Attribute-Driven Layout
How many herbivores have no predators?
How many herbivores have no predators?
Attribute-Driven Layout

Large node-link diagrams get messy!
Is there additional structure we can exploit?

Idea: Use data attributes to perform layout
For example, scatter plot based on node values

Attributes may be associated with nodes or edges
or may be statistical properties of the graph.

Use dynamic queries / brushing to explore...
Attribute-Driven Layout

The “Skitter” Layout
Internet Connectivity
Radial Scatterplot

Angle = Longitude
Geography

Radius = Degree
# of connections
(a statistic of the nodes)
Drawing all edges is not particularly useful here...
Node layout determined by geographic location.
Adjacent edges shown on node selection.
PivotGraph [Wattenberg ‘06]

Layout aggregate graphs using node attributes. Analogous to pivot tables and trellis display.
Limitations of PivotGraph

Only 2 variables (no nesting as in Tableau)
Doesn’t support continuous variables
Multivariate edges?
Nodes (dots) may be replicated.

Nodes sorted on radial axes by network statistics (e.g., by degree).

Different axes may contain different subsets of nodes.

egweb.bcgsc.ca
Constraint-Based Layout
Constraint-Based Layout

Treat layout as an *optimization problem*

Define layout using an *energy model* along with *constraints*: equations the layout should obey.

Use optimization algorithms to solve

**Position Constraints:**
- a must be to the left of b
- d, c, and b must have the same x position
- a, b, and e must have the same y position
Optimizing Aesthetic Constraints

Minimize edge crossings
Minimize area
Minimize line bends
Minimize line slopes
Maximize smallest angle between edges
Maximize symmetry

but, can’t do it all.

Optimizing these criteria is often NP-Hard, requiring approximations.
SetCoLa: High-Level Layout

(1) Define **sets** of nodes based on attributes.
(2) Apply **constraints** to set elements.

Layout using SetCoLa:

(1) **ON ALL NODES**
   (i) **POSITION** LEFT OF "RBOUND"
   (ii) **POSITION** RIGHT OF "LBOUND"

(2) **PARTITION TYPE**
   (iii) **PADDING** 18

(3) **COMPOSE SET FROM TYPES**
   (iv) **ORDER** BY TYPE

[Hoffswell '18]
Arc Diagrams
Linear node layout, circular arcs show connections. Layout quality sensitive to node ordering!
The Shape of Song

[Wattenberg ’01]

For example, the picture above was built from the first line of a very simple piece: *Mary Had a Little Lamb*. Each arch connects two identical passages. To clarify the connection between the visualization and the song, in this diagram the score is displayed beneath the arches.

This diagram visualizes the refrain from the folk song *Clementine*. As you would expect, the refrain consists of multiple repetitions of the same passage—and that is exactly what the diagram shows. The score isn’t shown in this diagram since the notes would be too small to read.
Task Analysis
Node-Link Graph Visualization

Nodes connected by lines/curves

**Sugiyama-Style Layout** - arranged by depth

**Force-Directed Layout** - physical simulation

**Attribute-Driven Layout** - arranged by value

**Constraint-Based Layout** - optimization

**Arc Diagrams** - aligned layout
Node-Link Graph Visualization

Nodes connected by lines/curves

Sugiyama-Style Layout

The Good: Structured-based analysis of hierarchical relationships
The Bad: Browsing and path following due to long edges

Force-Directed Layout

Attribute-Driven Layout

Constraint-Based Layout

Arc Diagrams
Node-Link Graph Visualization

Nodes connected by lines/curves

Sugiyama-Style Layout
Force-Directed Layout
Attribute-Driven Layout
Constraint-Based Layout
Arc Diagrams
Node-Link Graph Visualization

Nodes connected by lines/curves

Sugiyama-Style Layout

The Good: Structured-based analysis of closely related elements

The Bad: Browsing and summarization of dense networks

Force-Directed Layout

Attribute-Driven Layout

Constraint-Based Layout

Arc Diagrams
Node-Link Graph Visualization

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Nodes connected by lines/curves

**Sugiyama-Style Layout**

**Force-Directed Layout**

**Attribute-Driven Layout**

The Good: Attribute-based analysis tasks

The Bad (Difficult): Designing layouts appropriately

**Constraint-Based Layout**

**Arc Diagrams**
Node-Link Graph Visualization

Nodes connected by lines/curves

Sugiyama-Style Layout
Force-Directed Layout
Attribute-Driven Layout
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Arc Diagrams
Node-Link Graph Visualization

Nodes connected by lines/curves

Sugiyama-Style Layout
Force-Directed Layout
Attribute-Driven Layout
Constraint-Based Layout

**The Good:** Graph layout based on structural/aesthetic properties

**The Bad (Difficult):** Selecting constraints appropriately

Arc Diagrams
Node-Link Graph Visualization

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Arc Diagrams

The Good: Summarization and comparison of overall structure
The Bad: Order matters for node layout; Structure-based and path following
Limitations of Node-Link Layouts

Edge-crossings and occlusion! Poor scalability....
Administrivia
Final Project

Initial Project Prototype due this Friday Feb. 26th
Prototype Deliverables: must submit link on Canvas

Prototype Expectations:
Outline of the overall project structure
Rough prototypes of visualizations and interactions
Basic descriptive (narrative) text
Discussion of any concerns or plans for next steps

The more content you have on your page, the more specific feedback we can give to refine your project.
Final Project

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Thursday Quiz Section: Final Project Check-in

Upcoming Office Hours:
Jane: today after class - Mon 12:20pm-1:20pm PST
Kalyani: tomorrow - Thur 5pm-6pm PST
Sonya: Friday 2pm-3pm PST
Aayush / Naveena: by appointment
Hierarchical Edge Bundling
Hierarchical Edge Bundling

Bundle edges with varying amounts of tension
Low-level vs. high-level information
Flare Class Hierarchy
& Dependency Graph
Matrix Diagrams
Adjacency Matrices
Summary: Hierarchies & Networks

Tree Layout
Indented / Node-Link / Enclosure / Layers
Focus+Context techniques for scale

Graph Layout
“Sugiyama” Layout
Force-Directed Layout
Attribute-Driven Layout
Constraint Layout
Arc Diagrams
Matrix Diagrams