Graph Clarity, Simplification, & Interaction
Today

- Today’s Reading: Lombardi Graphs
  - Bezier Curves
- Today’s Reading: Clustering/Hierarchical edge Bundling
  - Definition of Betweenness Centrality
- Emergency Management Graph Visualization
  - Sean Kim’s masters project
- Reading for Tuesday & Homework 3
- Graph Interaction Brainstorming Exercise

"Lombardi drawings of graphs", Duncan, Eppstein, Goodrich, Kobourov, Nollenberg, Graph Drawing 2010

- Circular arcs
- Perfect angular resolution (edges for equal angles at vertices)
- Arcs only intersect 2 vertices (at endpoints)
- *(not required to be crossing free)*
- Vertices may be constrained to lie on circle or concentric circles

![Diagram](image)
• People are more patient with aesthetically pleasing graphs (will spend longer studying to learn/draw conclusions)
• What about relaxing the circular arc requirement and allowing Bezier arcs?
• How does it scale to larger data?
• Long curved arcs can be much harder to follow
• Circular layout of nodes is often very good!
• Would like more pseudocode

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**Cubic Bézier Curve**

• 4 control points
• Curve passes through first & last control point
• Curve is tangent at $P_0$ to $(P_1 - P_0)$ and at $P_3$ to $(P_3 - P_2)$


http://www.webreference.com/dlab/9902/bezier.html
“Force-directed Lombardi-style graph drawing”, Chernobelskiy et al., Graph Drawing 2011.

- Relaxation of the Lombardi Graph requirements
- “straight-line segments rarely occur in nature ... it is not clear that humans prefer straight-line segments for the sake of graph readability”
- Forces on tangent angles as well as on vertex positions
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Reading for Today

• Color is very helpful (be careful about colorblindness)
• Relation to ‘6 degrees of separation’
• Concern that small (but important) features or communities may be lost
• Concern about high cost of computing betweenness centrality (BC) metric
• Final graphs can still be confusing to interpret
• Diagrams very helpful in explaining steps algorithm
• Well written :)


• Dense graphs, e.g., social networks
• Straight line drawings are cluttered by crossings
  – Curved edges
  – Bundled edges (similar pathways) reduce visual clutter, similar to clusters of electric wires
• Try to preserve tree balance
  – Merge equal height trees at the root
  – Differently heighted trees at levels to be balanced
• Clarifies communication, collaboration, and competition network structure

- Modularization Quality: average edge density within clusters vs. average edge density between clusters
  - Large MQ = better clustering
  - Unclear if this is actually a good metric? (degeneracies?)
- Their Contribution! Betweenness Centrality Differential
  - Inter-community vs intra-community edges
  - Was the decision to merge these trees obvious or arbitrary?
  - Used this value as the strength of an edge bundle
- Tradeoff: accuracy vs. running time
- Interactive: select or deselect nodes, text queries, change colors, edit numerical bundle strengths
- Uniform depth optimal for Radial Layout [Eades 92]


- What are some anecdotal real-world examples of a “low BC edge” and a “high BC edge”?
  - Why does it make sense to preserve or simplify away these edges?
  - Why is a tree the best simplified representation of a big complex graph?
- Ground Truth Comparisons: Why is this the “best” simplification/rendering?
- Should this be a future Data Structures Homework?

- Writing:
  - Not all steps of prior work presented in full/intuitively
  - Difficult to read when referenced figure is on the next page
  - Each example graph/figure shows something specific, a contribution
  - Lengthy discussion comparing to previous methods
  - Limitations presented and explained
  - Would be nice to also have pseudocode. (or are the many diagrams a visual pseudocode?)

![Original graph](a) ![Edge Bundles](b) ![Generated Hierarchy](c)

**Figure 10:** Graph 'S&P500', including user supplied labels of stock sectors discovered by our community clustering method.

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**Betweenness Centrality**

http://mathforum.org/mathimages/index.php/Social_Networks#Betweenness_Centrality

*Click on “A More Mathematical Explanation”*

- For each pair of nodes “A” and “C” in the graph
- Compute the shortest path between A & C
- Is B on that path? A->B->C? How many of the paths?
- “Betweenness Centrality of node B” = # of times B appears in these shortest paths
- (Assuming?) Similar definition for “Betweenness Centrality of edge B₁->B₂”

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- Scale free network \(\Rightarrow\) Power law graph
  - Degree distribution follows a power law
  - Few nodes with high degree (called “hubs”), many with low degree
  - Naturally occurring in many sciences
- Goal: Eliminate “less important” edges in the graph that are seldom used for communication
- Goal: Simplification will improve the convergence and quality of node layout algorithms
- Filtering vs. clustering?
- Automatically vs. interactively?


- **Clustering** works well for planar graphs, but can actually increase the edge density of non planar graphs. Also loses original semantics.
- **Filtering** retains edge & node semantics, simplified graph is a subset of the original.
  - Stochastic filtering (random edge deletion) can destroy connectivity & important features
  - Deterministic filtering choice:
    - preserve high betweenness centrality edges focus on communication pathways
    - preserve low betweenness centrality edges focus on clusters

- Preprocess: mark feature edges (e.g., cliques or highly connected components)
- Priority queue
- Post-processing: catch errors in connectivity preservation approximation
- Estimate of betweenness centrality is much faster than exact computation
  - Focus on paths through 50+ hub nodes

Summed squared error in shortest paths of simplified vs original graph

• Rendering
  – Alpha (transparency)
  – Occlusion of less important lines
  – Interpolate warm to cold colors, highlight high-degree hubs (warm color foreground, cool color recedes)
• Interactive slider to control simplification


• How do we know these simplifications are correct/appropriate/not misleading?
  – Metrics may be application domain specific?
  – Study graph statistics
  – Perform tests of random node/edge selection & random walks
• Overclustering (problem with prior work) can imply that items directly interact when they did not in the original dataset
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Emergency Response Decision Making
Full network detail is overwhelming

Subset of data
Zoom and “expand” information for critical nodes and network links

Trace back problem to source of outage
Multi-User Non-Linear Adaptive Magnification for Satellite Imagery and Graph Networks
Sean Kim, Masters Thesis, RPI, July 2014
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Reading for Tuesday

• “Useful Junk? The Effects of Visual Embellishment on Comprehension and Memorability of Charts” Bateman et al., CHI 2010.

  Article discussed here:
  http://eagereyes.org/criticism/chart-junk-considered-useful-after-all
Homework Assignment 3: due Thursday @ 11:59pm

Intro to (Web-Based) Interaction

• Explore the examples on the D3: Data-Driven Documents
• http://d3js.org/ website (download the examples, modify them, start to read the documentation)
• Make an interactive (visualization) artifact:
  – Depends on your level of prior experience with Web Development tools (if you’re already a D3 expert, you can choose another new-to-you tool)
  – Purpose: Can be silly & possibly exemplify our “bad visualization” traits (pie charts, chart junk, etc.)
  – Types of “interaction” may include:
    • pop up text messages
    • data hide/reveal/emphasize/restructure
    • font/size/color/transparency change

“Story-boarding”

http://pixar-animation.weebly.com/storyboard.html
“Wizard-of-Oz” for Interface Design

http://courses.cs.washington.edu/courses/cse440/12wi/projects/pocketdoctor/medfi.html

http://kate-vogt.com/bond.html

Today’s Worksheet

- **Teams of 2. Someone you did not work with last time. Hopefully someone you just met in this course :)**
- Enhance the course, prerequisite, and degree requirements graph from last lecture to include interaction.
- Story board/“Wizard of Oz” interaction use case for a sophomore planning courses and/or about adding a dual or switching majors
- Initial Visualization (showing completed courses vs. requirements)
- Sketch/label a simple UI (checkboxes, radio buttons, drop down menus, visual object interaction via click/drag, etc.)
- Clearly label a specific action the user might make…
- Post-Action Visualization (show course selection or impact of add dual or change-of-major)