

Ch 9: Networks

Papers: Sets, Stenomaps, TopoFisheye

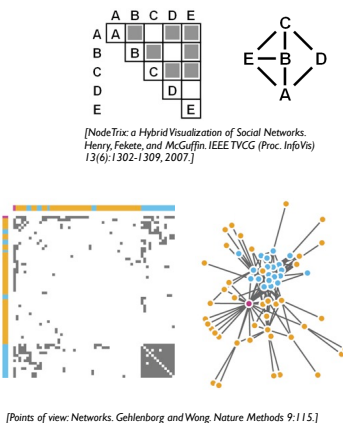
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CPSC 547, Information Visualization
 Day 9: 8 October 2015

<http://www.cs.ubc.ca/~tmm/courses/547-15>

Idiom: adjacency matrix view

- data: network
 - transform into same data/encoding as heatmap
- derived data: table from network
 - 1 quant attrib
 - weighted edge between nodes
 - 2 categ attribs: node list x 2
- visual encoding
 - cell shows presence/absence of edge
- scalability
 - 1K nodes, 1M edges



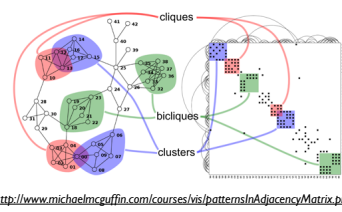
Arrange networks and trees

Arrange Networks and Trees

- Node-Link Diagrams
 - Connection Marks
 - NETWORKS ✓ TREES ✓
- Adjacency Matrix
 - Derived Table
 - NETWORKS ✓ TREES ✓
- Enclosure
 - Containment Marks
 - NETWORKS ✗ TREES ✓

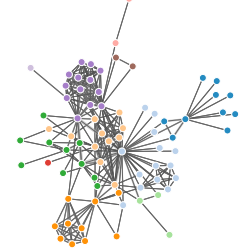
Connection vs. adjacency comparison

- adjacency matrix strengths
 - predictability, scalability, supports reordering
 - some topology tasks trainable
 - node-link diagram strengths
 - topology understanding, path tracing
 - intuitive, no training needed
 - empirical study
 - node-link best for small networks
 - matrix best for large networks
 - if tasks don't involve topological structure!
- [On the readability of graphs using node-link and matrix-based representations: a controlled experiment and statistical analysis. Ghoniem, Fekete, and Castagliola. Information Visualization 4:2 (2005), 114-135.]



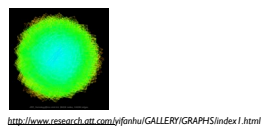
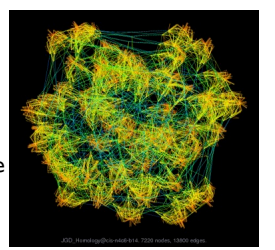
Idiom: force-directed placement

- visual encoding
 - link connection marks, node point marks
- considerations
 - spatial position: no meaning directly encoded
 - left free to minimize crossings
 - proximity semantics?
 - sometimes meaningful
 - sometimes arbitrary, artifact of layout algorithm
 - tension with length
 - long edges more visually salient than short
- tasks
 - explore topology; locate paths, clusters
- scalability
 - node/edge density $E < 4N$



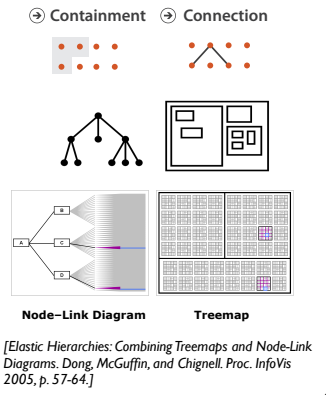
Idiom: sfdp (multi-level force-directed placement)

- data
 - original: network
 - derived: cluster hierarchy atop it
- considerations
 - better algorithm for same encoding technique
 - same: fundamental use of space
 - hierarchy used for algorithm speed/quality but not shown explicitly
 - (more on algorithm vs encoding in afternoon)
- scalability
 - nodes, edges: 1K-10K
 - hairball problem eventually hits



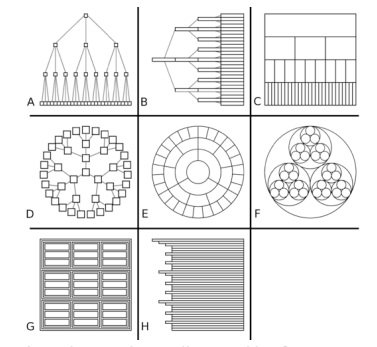
Link marks: Connection and Containment

- marks as links (vs. nodes)
 - common case in network drawing
 - 1D case: connection
 - ex: all node-link diagrams
 - emphasizes topology, path tracing
 - networks and trees
 - 2D case: containment
 - ex: all treemap variants
 - emphasizes attribute values at leaves (size coding)
 - only trees



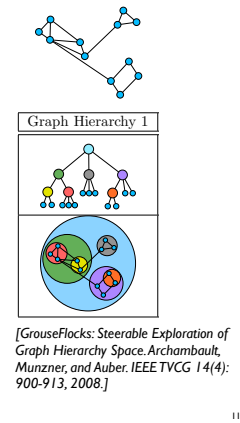
Tree drawing idioms comparison

- data shown
 - link relationships
 - tree depth
 - sibling order
 - design choices
 - connection vs containment link marks
 - rectilinear vs radial layout
 - spatial position channels
 - considerations
 - redundant? arbitrary?
 - information density?
 - avoid wasting space
- [Quantifying the Space-Efficiency of 2D Graphical Representations of Trees. McGuffin and Robert. Information Visualization 9:2 (2010), 115-140.]



Idiom: GrouseFlocks

- data: compound graphs
 - network
 - cluster hierarchy atop it
 - derived or interactively chosen
- visual encoding
 - connection marks for network links
 - containment marks for hierarchy
 - point marks for nodes
- dynamic interaction
 - select individual metanodes in hierarchy to expand/contract

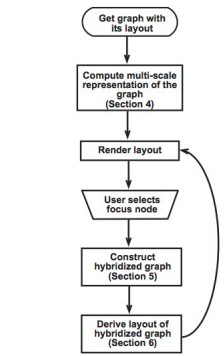
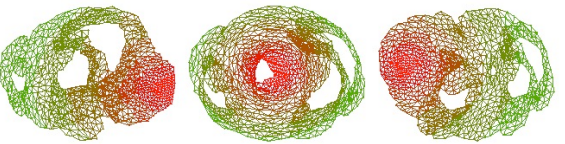


Further reading

- Visualization Analysis and Design. Munzner. AK Peters / CRC Press, Oct 2014.
 - Chap 9: Arrange Networks and Trees
- Visual Analysis of Large Graphs: State-of-the-Art and Future Research Challenges. von Landesberger et al. Computer Graphics Forum 30:6 (2011), 1719-1749.
- Simple Algorithms for Network Visualization: A Tutorial. McGuffin. Tsinghua Science and Technology (Special Issue on Visualization and Computer Graphics) 17:4 (2012), 383-398.
- Drawing on Physical Analogies. Brandes. In Drawing Graphs: Methods and Models, LNCS Tutorial, 2025, edited by M. Kaufmann and D. Wagner, LNCS Tutorial, 2025, pp. 71-86. Springer-Verlag, 2001.
- Treevis.net: A Tree Visualization Reference. Schulz. IEEE Computer Graphics and Applications 31:6 (2011), 11-15. <http://www.treevis.net>
- Perceptual Guidelines for Creating Rectangular Treemaps. Kong, Heer, and Agrawala. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis) 16:6 (2010), 990-998.

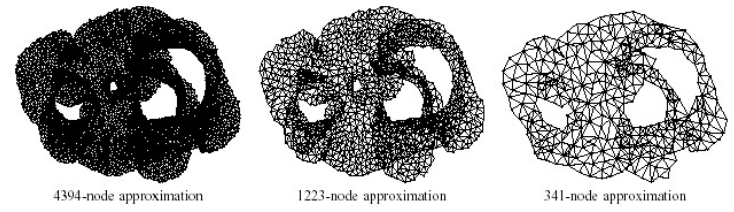
Topological Fisheye Views

- derived data
 - input: laid-out network (spatial positions for nodes)
 - output: multilevel hierarchy from graph coarsening
- interaction
 - user changed selected focus point
- visual encoding
 - hybrid view made from cut through several hierarchy levels



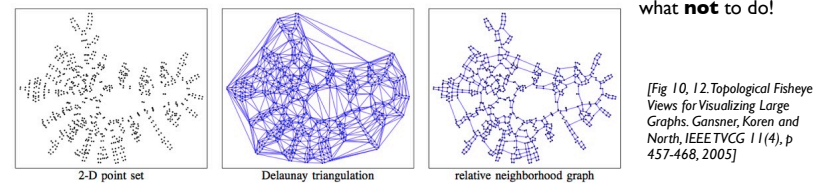
Coarsening requirements

- uniform cluster/metanode size
- match coarse and fine layout geometries
- scalable



Coarsening strategy

- must preserve graph-theoretic properties
- use both topology and geometry
 - topological distance (hops away)
 - geometric distance - but not just proximity alone!
 - just contracting nodes/edges could create new cycles
- derived data: proximity graph

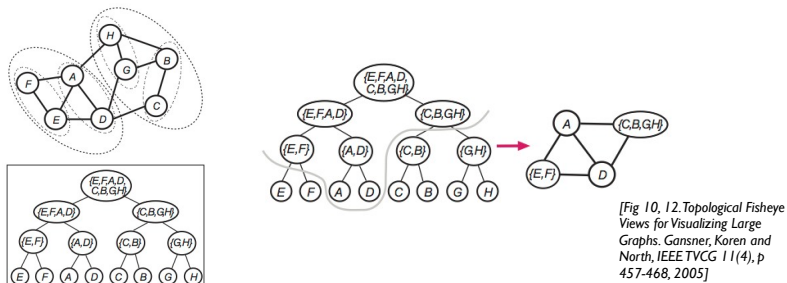


Candidate pairs: neighbors in original and proximity graph

- proximity graph: compromise between larger DT and smaller RNG
 - better than original graph neighbors alone
 - slow for cases like star graph
- maximize weighted sum of
 - geometric proximity
 - goal: preserve geometry
 - cluster size
 - goal: keep uniform cluster size
 - normalized connection strength
 - goal: preserve topology
 - neighborhood similarity
 - goal: preserve topology
 - degree
 - goal: penalize high-degree nodes to avoid salient artifacts and computational problems

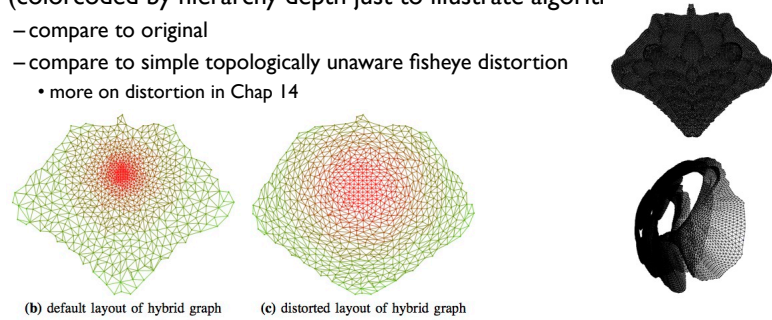
Hybrid graph creation

- cut through coarsening hierarchy to get active nodes
 - animated transitions between states



Final distortion

- geometric distortion for uniform density
- (colorcoded by hierarchy depth just to illustrate algorithm)
 - compare to original
 - compare to simple topologically unaware fisheye distortion
 - more on distortion in Chap 14



Stenomaps

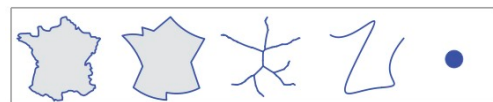


Fig. 1. Increasing the abstraction of France. From left to right: (a) untransformed polygon, (b) curved schematization, (c) pruned medial axis, (d) stenomap glyph, (e) dot.

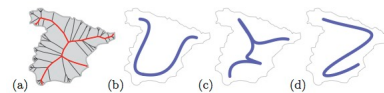
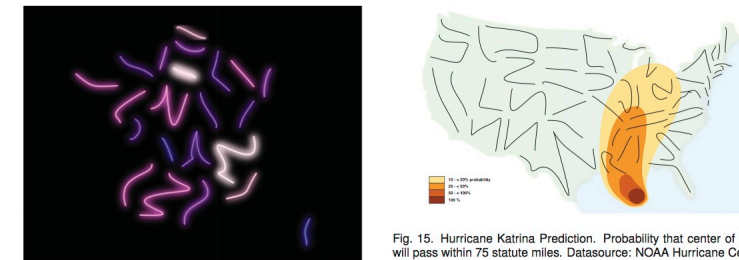


Fig. 2. Representing Spain as a glyph. (a) Polygon and (pruned) medial axis. (b) Border representation. (c) Collapse to medial axis. (d) Trade-off between border and area.

[Stenomaps: Shorthand for shapes Arthur van Goethem, Andreas Reimer, Bettina Speckmann, Jo Wood. TVCG 20(12):2053-2062 (Proc. InfoVis 2014) 2014.]

Example applications

- energy use in France, hurricane prediction



[Stenomaps: Shorthand for shapes Arthur van Goethem, Andreas Reimer, Bettina Speckmann, Jo Wood. TVCG 20(12):2053-2062 (Proc. InfoVis 2014) 2014.]

Stenomaps

- spatial yet heavily abstracted
- algorithmically sophisticated
- unusually strong related work from cartography

[Stenomaps: Shorthand for shapes Arthur van Goethem, Andreas Reimer, Bettina Speckmann, Jo Wood. TVCG 20(12):2053-2062 (Proc. InfoVis 2014) 2014.]

Sets State of the Art Report

- with companion setviz.net site

Table 2: Selected strengths and weaknesses of the visual categories (Sect. 4). Euler diagram variants are not listed separately.

Category	Strengths	Weaknesses
Euler-based diagrams	Intuitive when well-matched (little training is required). Represent all standard set relations compactly.	Limited to few sets due to clutter and drawability issues. Desired properties not always possible (e.g. connectivity).
Overlays	Emphasize element and set distributions according to other data features (e.g. map locations).	Often limited in the number of elements and sets. Undesired layout artifacts (overlaps, crossing, shapes, etc.).
Node-link diagrams	Visually emphasize the elements as individual objects. Show clusters of elements having similar set memberships.	Limited scalability due to edge crossings. No representation of set relations in element-set diagrams.
Matrix-based techniques	Fairly scalable both in the number of elements and sets. Do not suffer from edge crossings or topological constraints.	Limited in the set relations they can represent. Revealed membership patterns are sensitive to ordering.
Aggregation-based	Highly scalable in the number of elements. Some techniques can show how attributes correlate with set membership.	Usually, do not emphasize sets and elements as objects. Limited in the set relations they can represent.
Scatter plots	Show clusters of sets according to mutual similarity. Clutter free and scalable when showing sets only.	Do not represent standard set relations. Dots are often perceived as elements not as sets.

Visualizing Sets and Set-typed Data: State-of-the-Art and Future Challenges, Bilal Alsalkh, Luana Micallef, Wolfgang Aigner, Helwig Hauser, Silvia Miksch, and Peter Rodgers. EuroVis State of The Art Report 2014.

SetViz.net
Visualizing Sets and Set-typed Data

1. Venn and Euler Diagrams

2. Variants of Euler Diagrams

3. Overlays

4. Node-Link Diagrams

5. Matrix-based Techniques

6. Aggregation-Based Techniques

7. Scatterplots

Next Time

- to read
 - VAD Ch. 10: Map Color and Other Channels
 - Representing Colors as Three Numbers, Maureen Stone, IEEE Computer Graphics and Applications, 25(4), July 2005, pp. 78-85.