Ch 9: Networks
Papers: Sets, Stenomaps, TopoFisheye

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CPSC 547, Information Visualization
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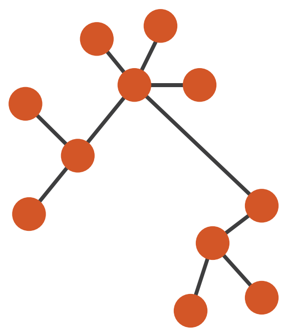
http://www.cs.ubc.ca/~tmm/courses/547-15

Arrange networks and trees

Arrange Networks and Trees

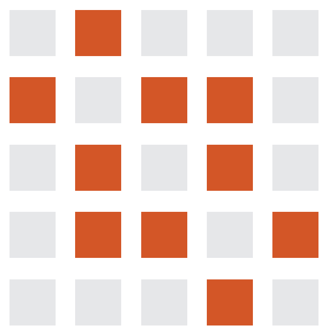
Node–Link Diagrams
Connection Marks

✔ NETWORKS ✔ TREES



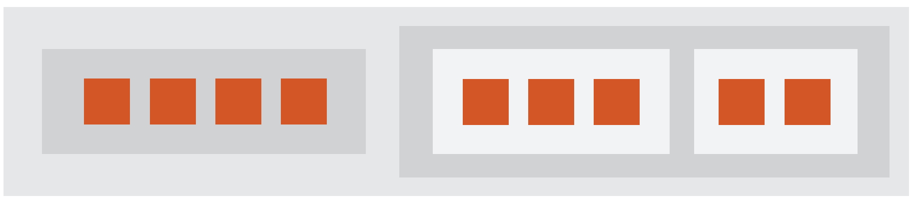
Adjacency Matrix
Derived Table

✔ NETWORKS ✔ TREES



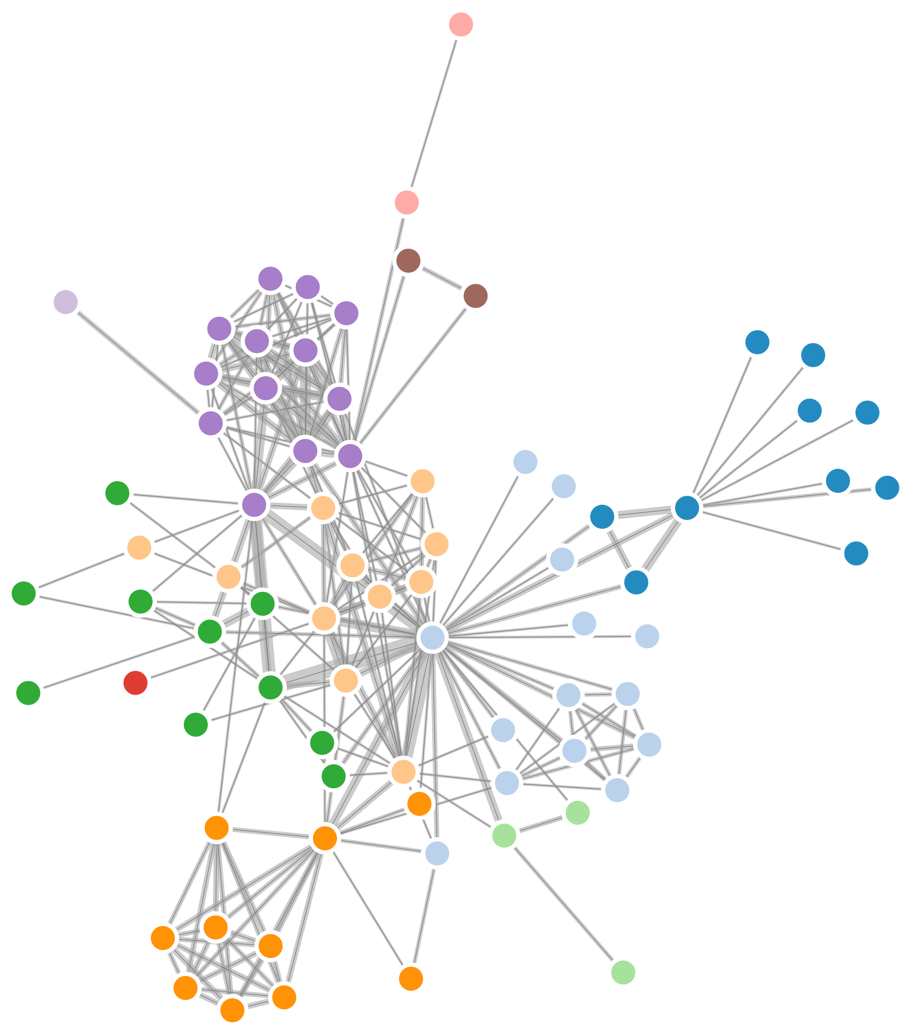
Enclosure
Containment Marks

✘ NETWORKS ✔ TREES



Idiom: **force-directed placement**

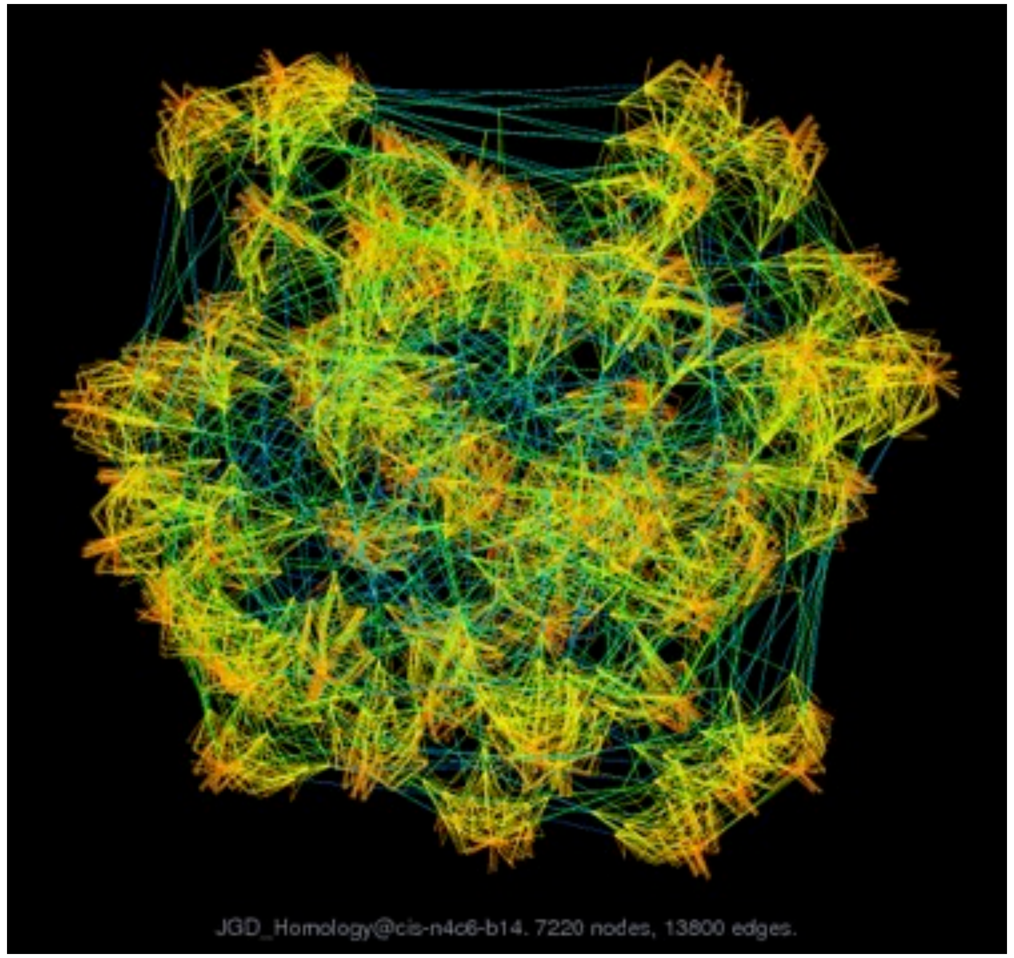
- visual encoding
  - link connection marks, node point marks
- considerations
  - spatial position: no meaning directly encoded
    - left free to minimize crossings
  - proximity semantics?
    - sometimes meaningful
    - sometimes arbitrary, artifact of layout algorithm
    - tension with length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



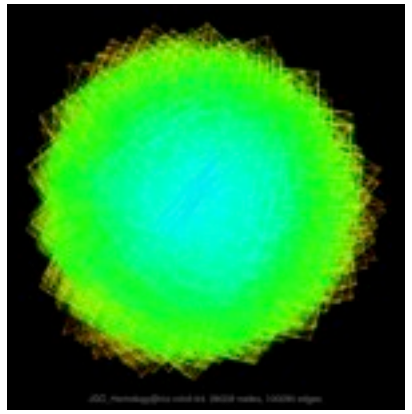
http://mbostock.github.com/d3/ex/force.html

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



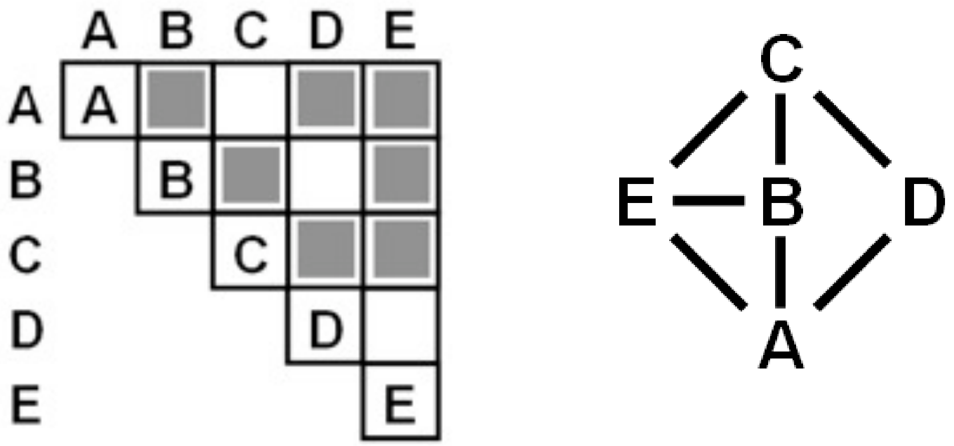
[Efficient and high quality force-directed graph drawing. Hu. The Mathematica Journal 10:37–71, 2005.]



http://www.research.att.com/yifanhu/GALLERY/GRAPHS/index1.html

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



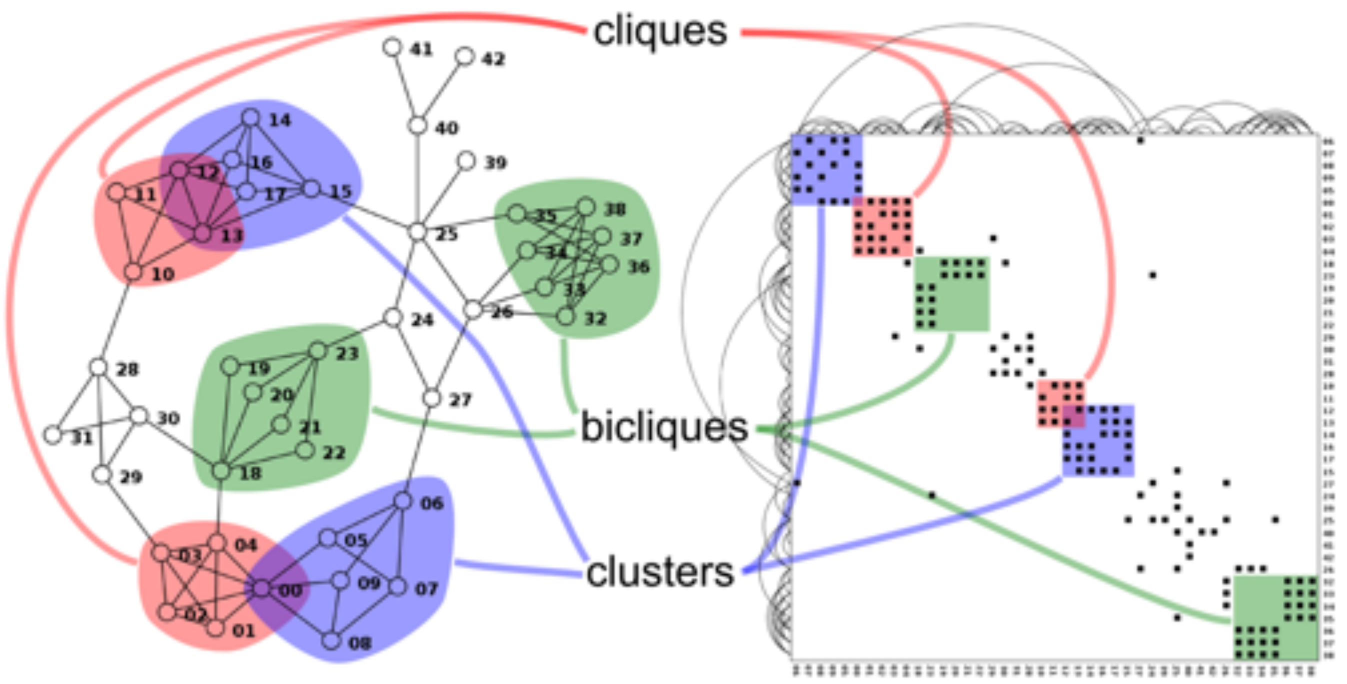
[NodeTrix: a Hybrid Visualization of Social Networks. Henry, Fekete, and McGuffin. IEEE TVCG (Proc. InfoVis) 13(6):1302-1309, 2007.]

[Points of view: Networks. Gehlenborg and Wong. Nature Methods 9:115.]

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!

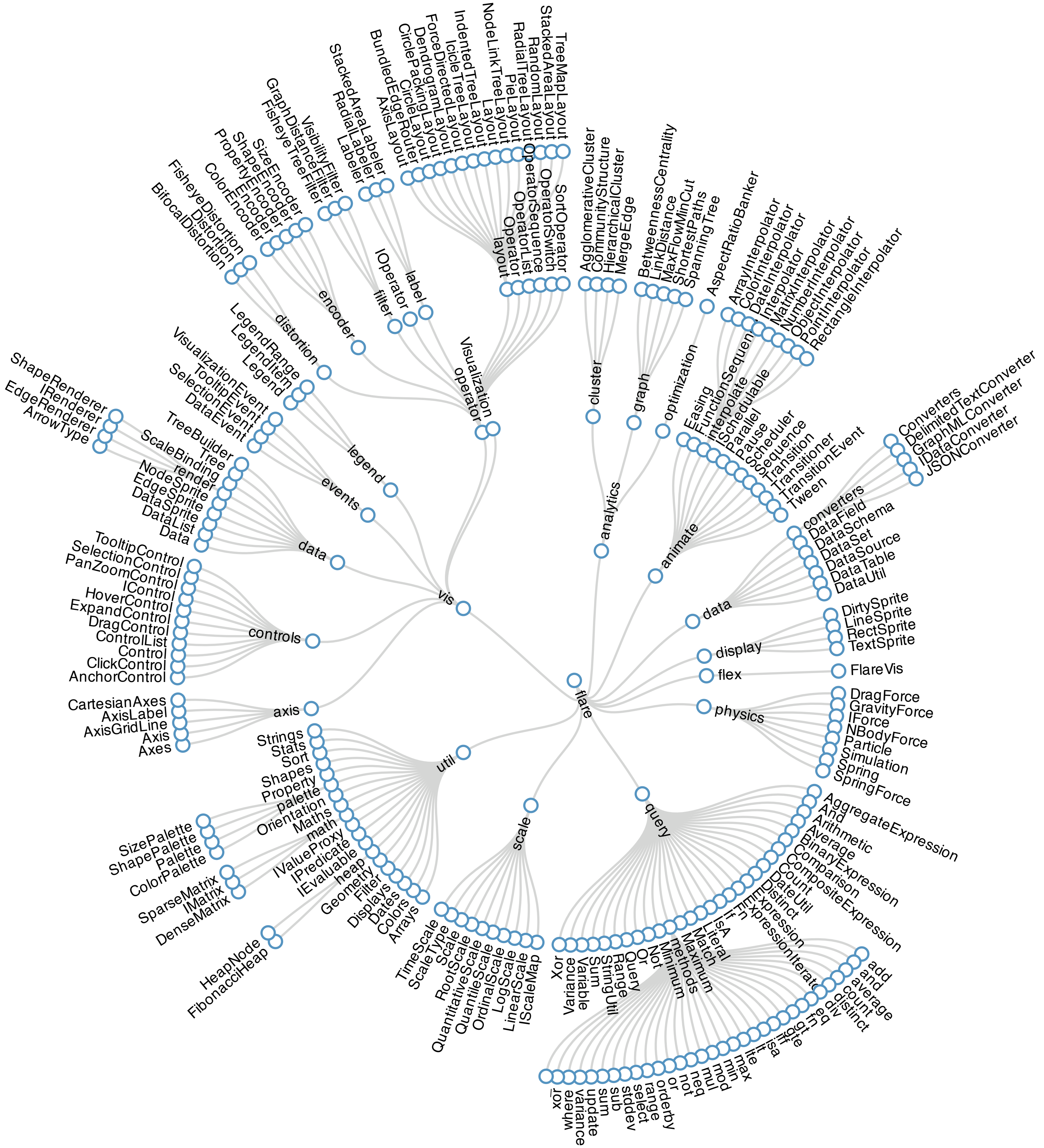
[On the readability of graphs using node-link and matrix-based representations: a controlled experiment and statistical analysis. Ghoniem, Fekete, and Castagliola. Information Visualization 4:2 (2005), 114–135.]



http://www.michaelmcguffin.com/courses/vis/patternsInAdjacencyMatrix.png

Idiom: **radial node-link tree**

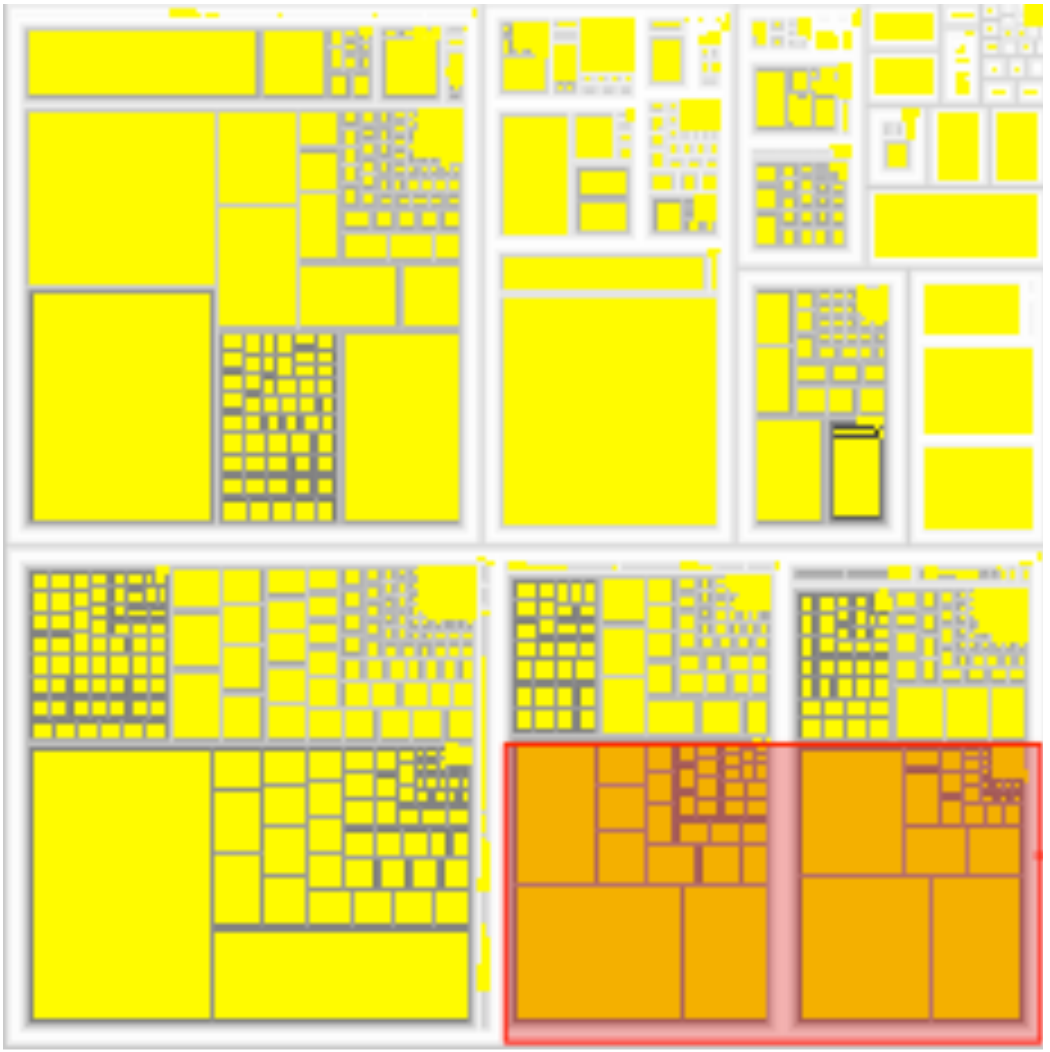
- data
  - tree
- encoding
  - link connection marks
  - point node marks
  - radial axis orientation
    - angular proximity: siblings
    - distance from center: depth in tree
- tasks
  - understanding topology, following paths
- scalability
  - 1K - 10K nodes



http://mbostock.github.com/d3/ex/tree.html

Idiom: **treemap**

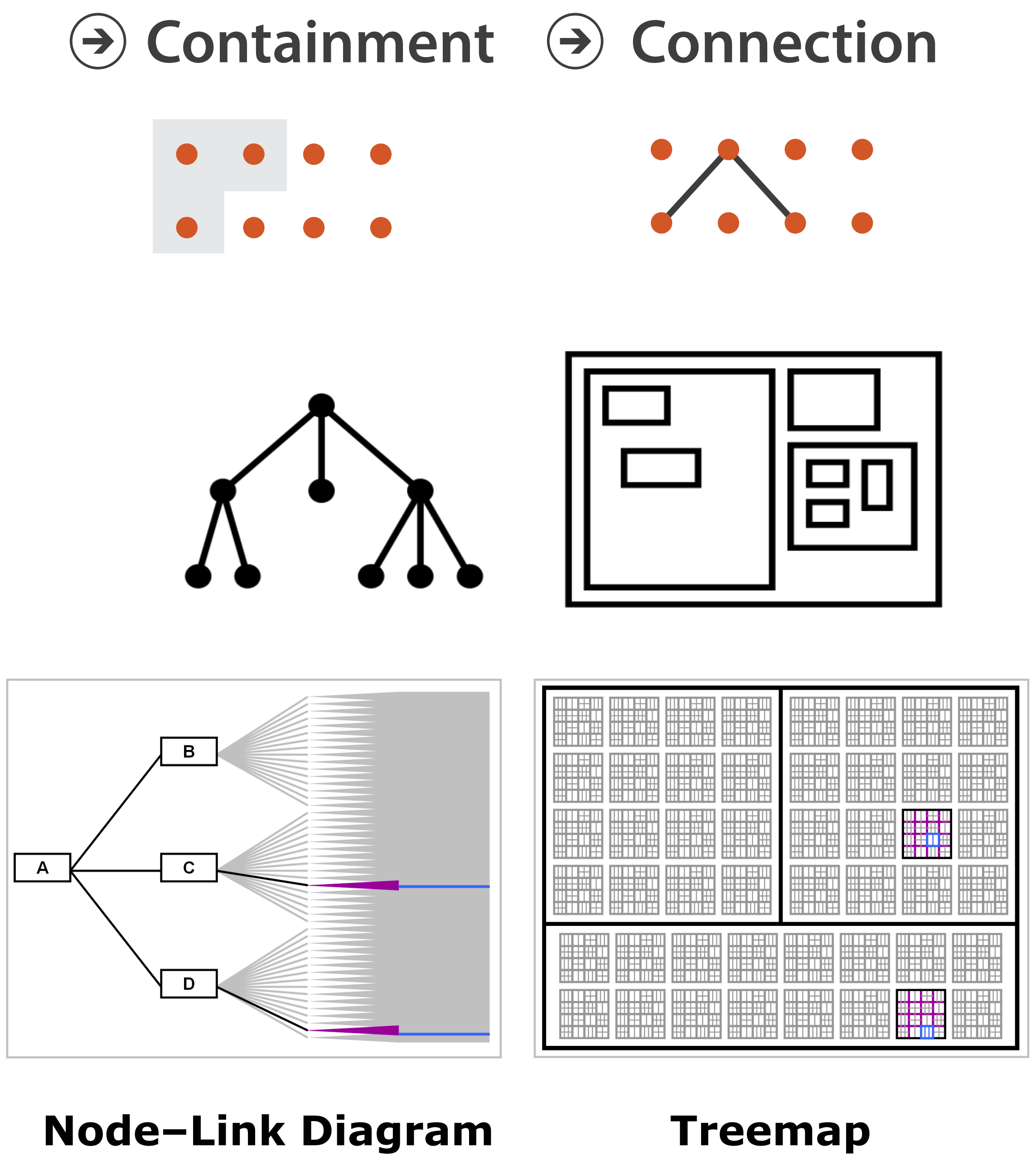
- data
  - tree
  - 1 quant attrib at leaf nodes
- encoding
  - area containment marks for hierarchical structure
  - rectilinear orientation
  - size encodes quant attrib
- tasks
  - query attribute at leaf nodes
- scalability
  - 1M leaf nodes



http://tulip.labri.fr/Documentation/3_7/userHandbook/html/ch06.html

Link marks: Connection and Containment

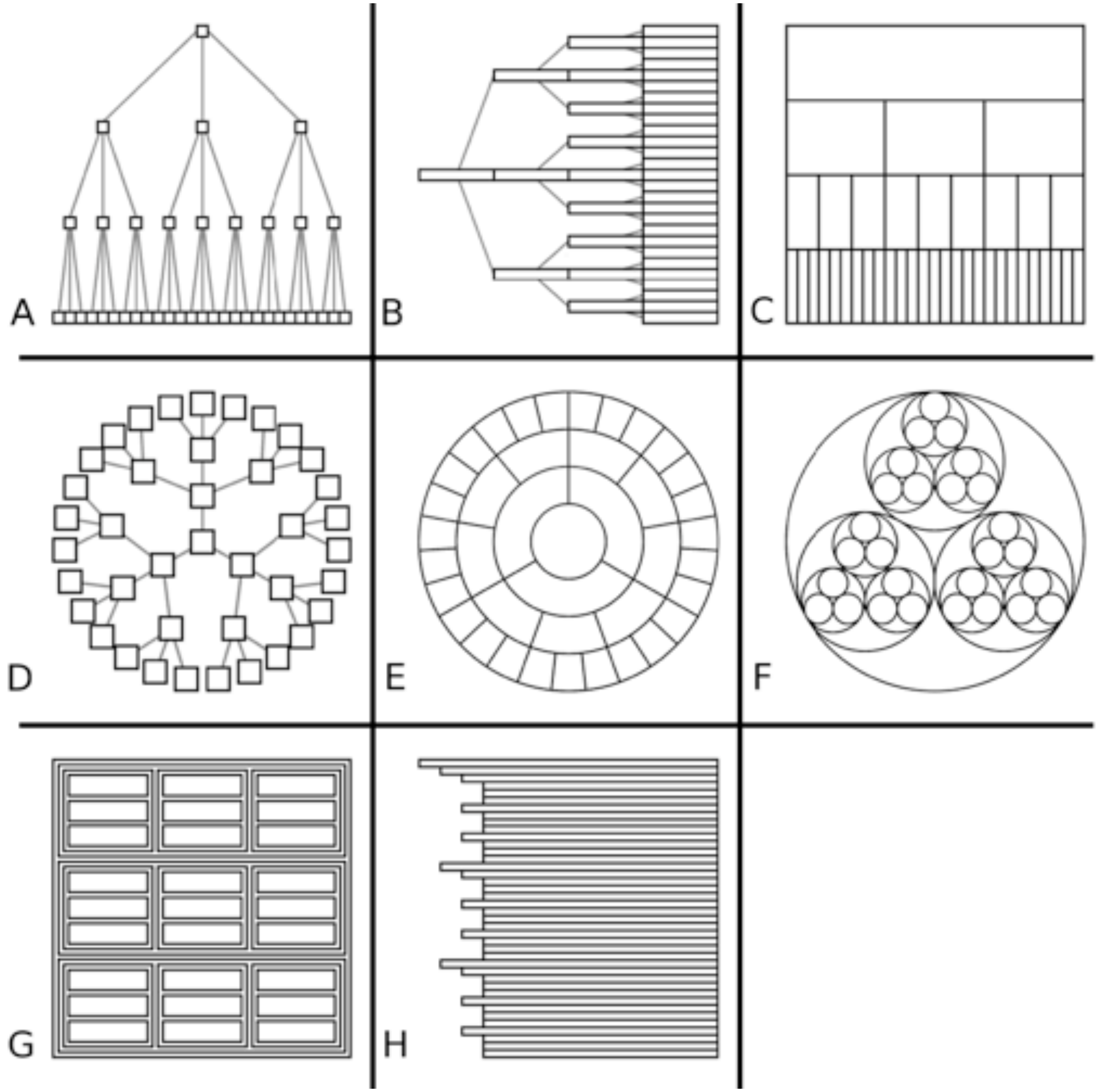
- marks as links (vs. nodes)
  - common case in network drawing
  - 1D case: connection
    - ex: all node-link diagrams
    - emphasizes topology, path tracing
    - networks and trees
  - 2D case: containment
    - ex: all treemap variants
    - emphasizes attribute values at leaves (size coding)
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



[Elastic Hierarchies: Combining Treemaps and Node-Link Diagrams. Dong, McGuffin, and Chignell. Proc. InfoVis 2005, p. 57-64.]

Tree drawing idioms comparison

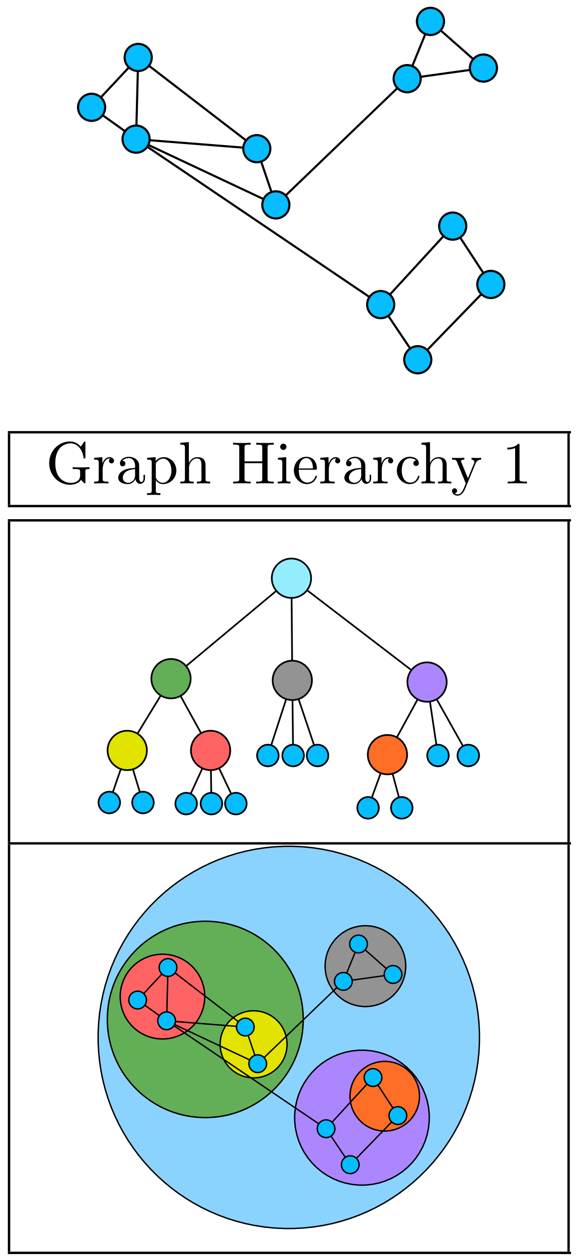
- data shown
  - link relationships
  - tree depth
  - sibling order
- design choices
  - connection vs containment link marks
  - rectilinear vs radial layout
  - spatial position channels
- considerations
  - redundant? arbitrary?
  - information density?
    - avoid wasting space



[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



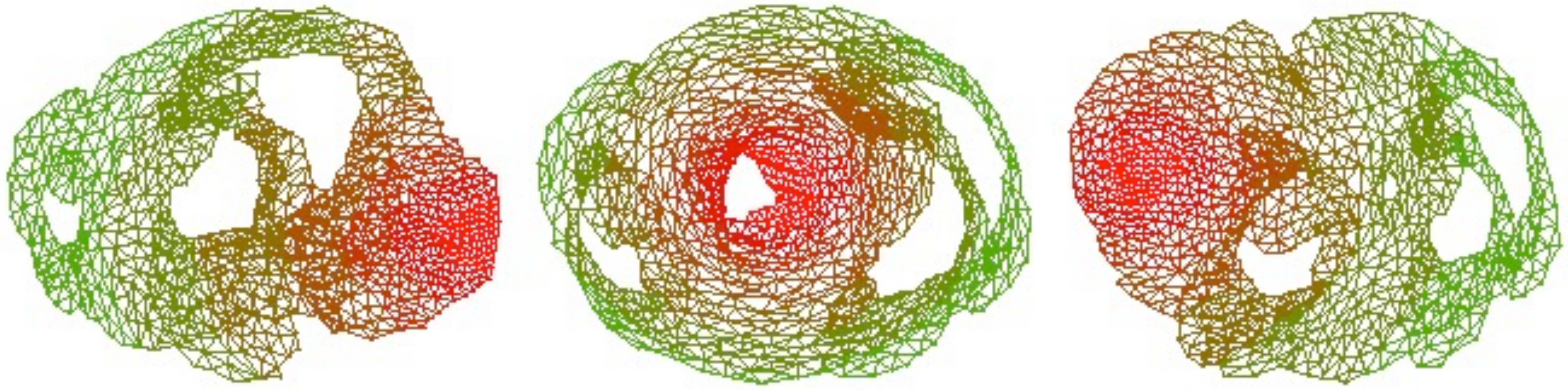
[GrouseFlocks: Steerable Exploration of Graph Hierarchy Space. Archambault, Munzner, and Auber. IEEE TVCG 14(4): 900-913, 2008.]

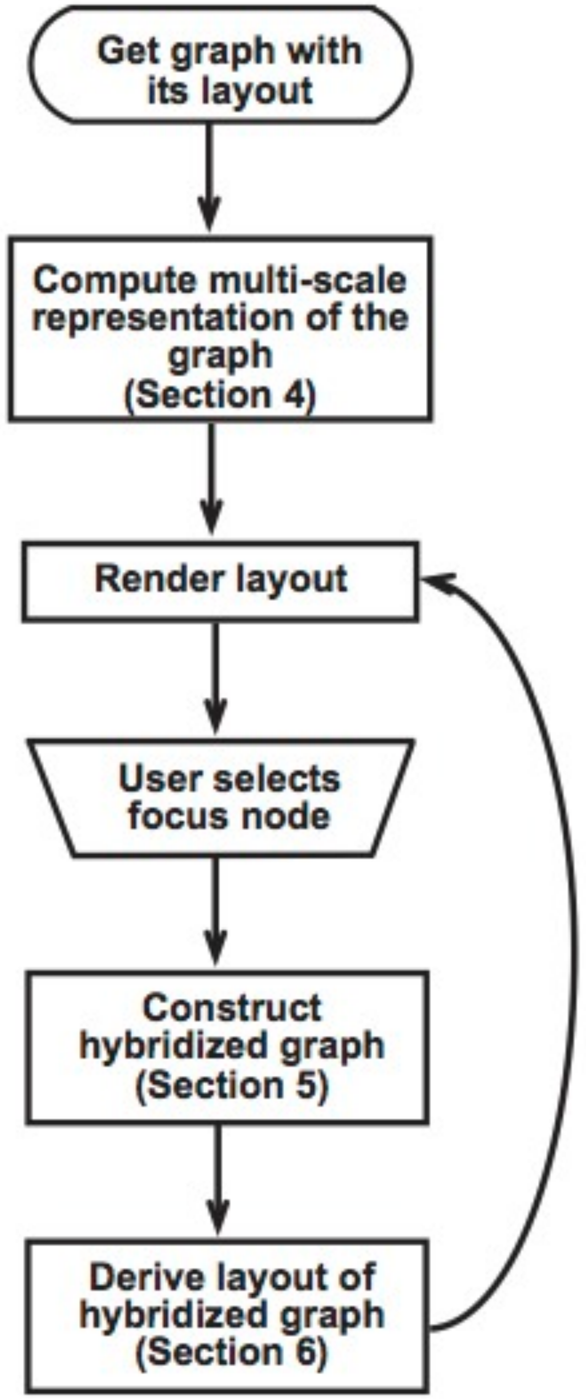
Further reading

- 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

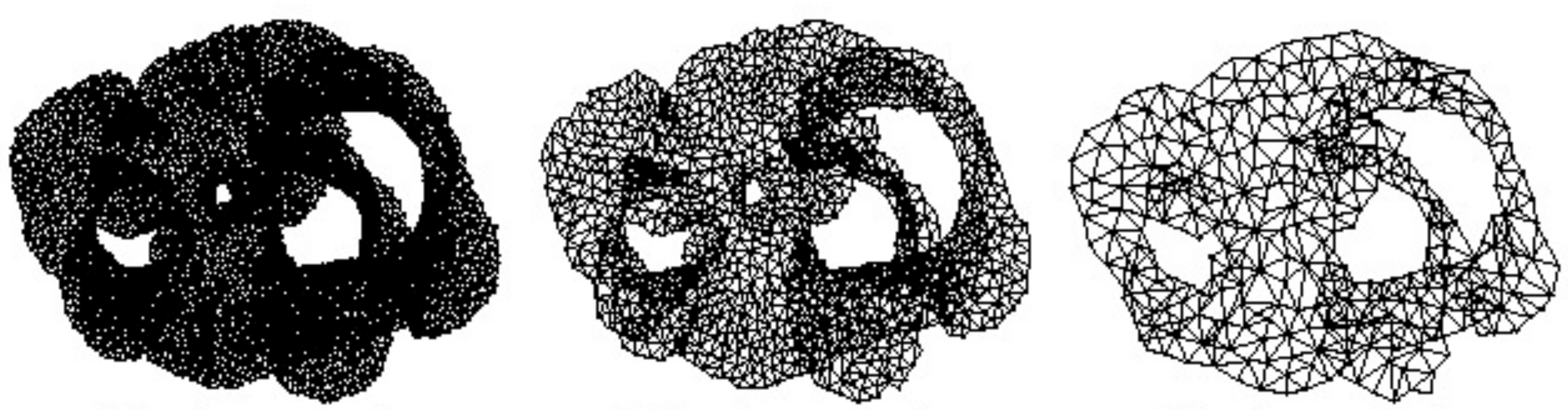




[Fig 4,8. Topological Fisheye Views for Visualizing Large Graphs. Gansner, Koren and North, IEEE TVCG 11(4), p 457-468, 2005]

Coarsening requirements

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

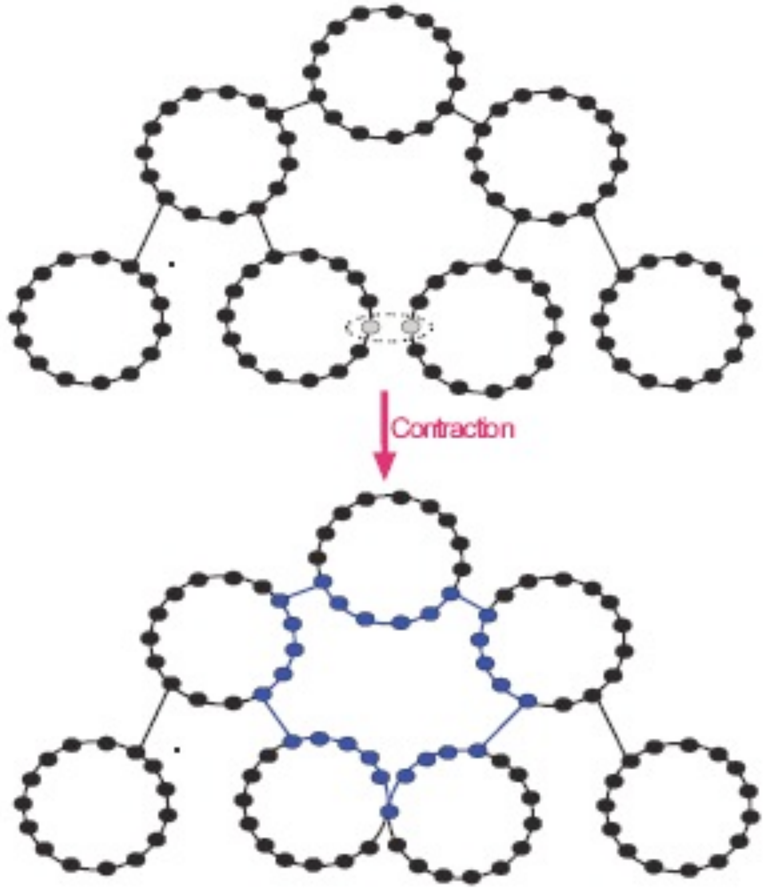


4394-node approximation 1223-node approximation 341-node approximation

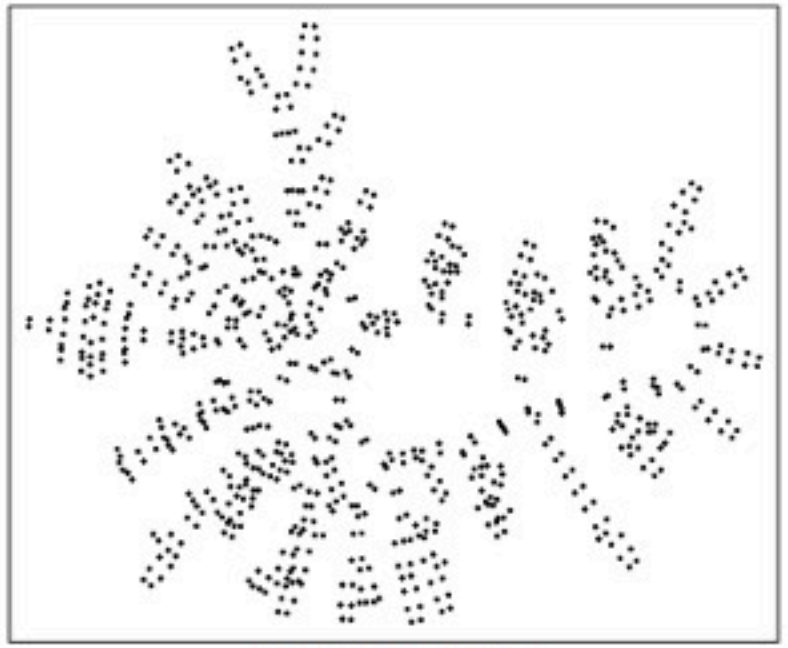
[Fig 3. Topological Fisheye Views for Visualizing Large Graphs. Gansner, Koren and North, IEEE TVCG 11(4), p 457-468, 2005]

Coarsening strategy

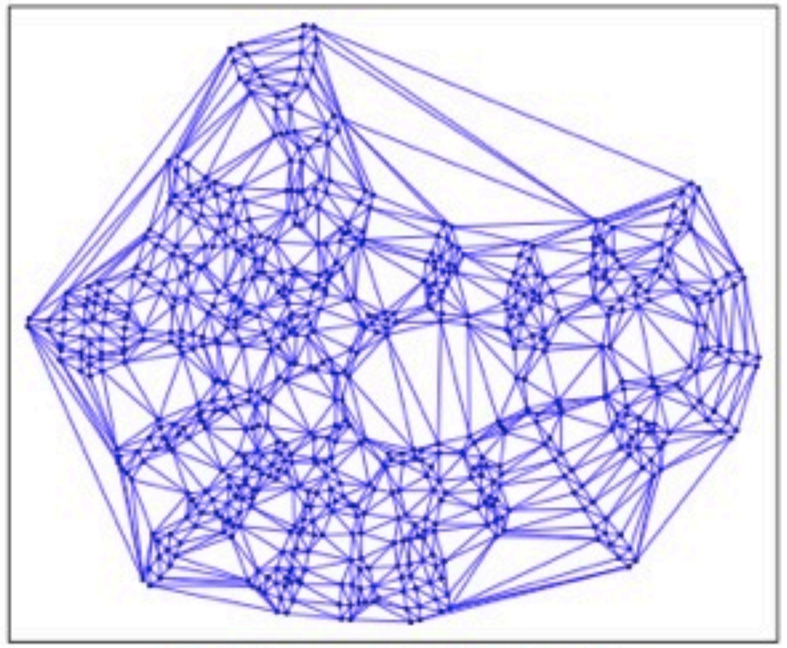
- must preserve graph-theoretic properties
- use both topology and geometry
  - topological distance (hops away)
  - geometric distance - but not just proximity alone!
    - just contracting nodes/edges could create new cycles
- derived data: proximity graph



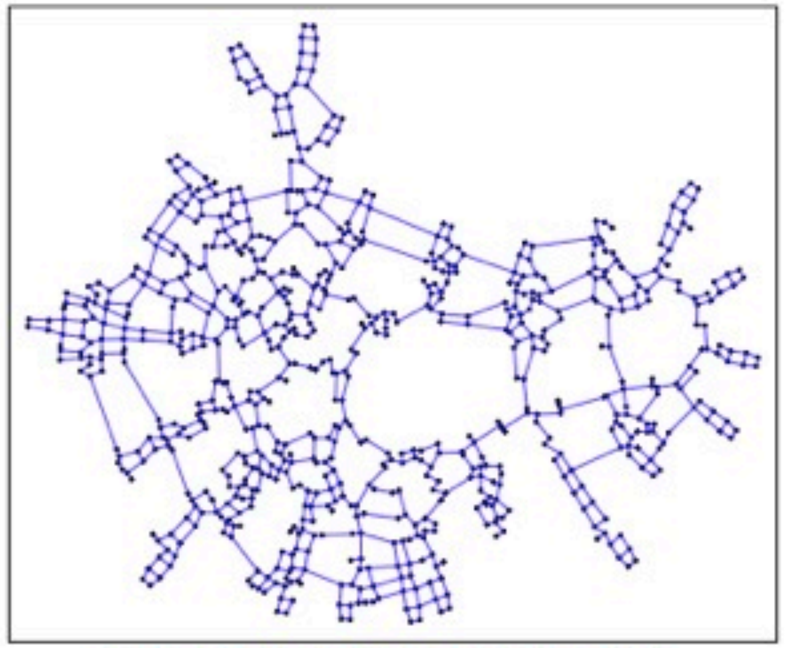
what **not** to do!



2-D point set



Delaunay triangulation



relative neighborhood graph

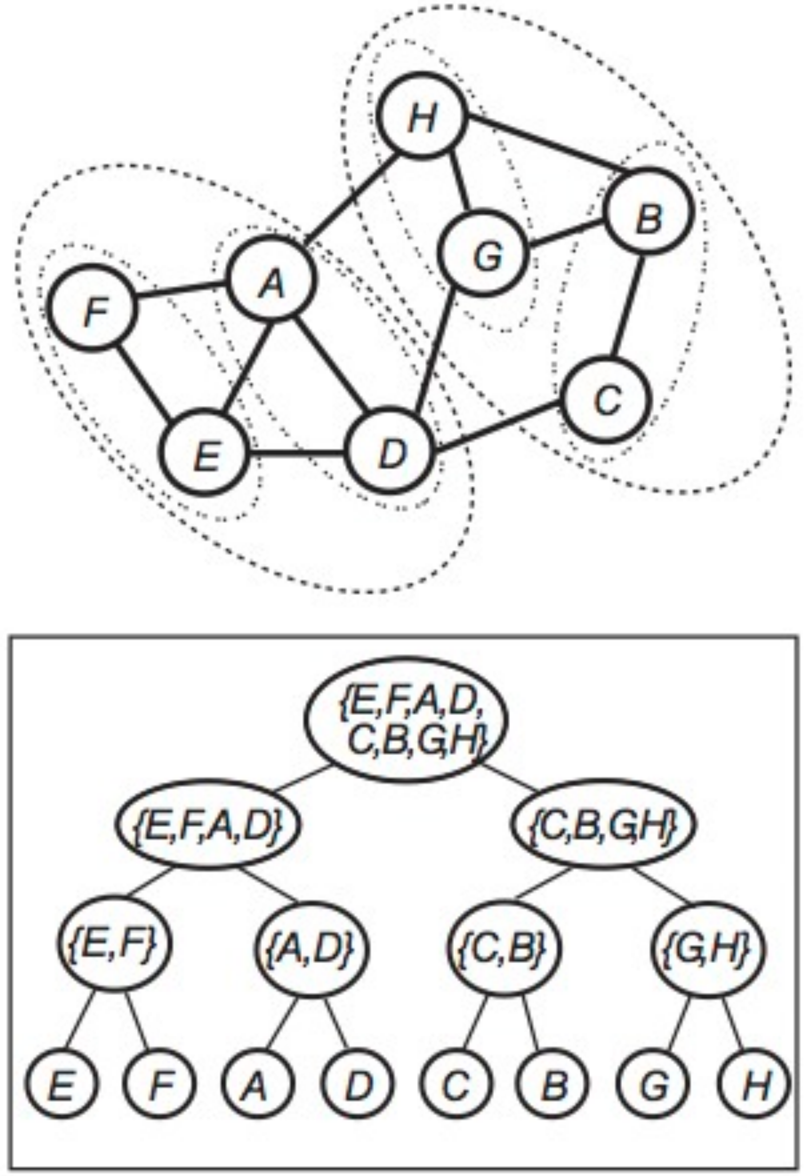
[Fig 10, 12. Topological Fisheye Views for Visualizing Large Graphs. Gansner, Koren and North, IEEE TVCG 11(4), p 457-468, 2005]

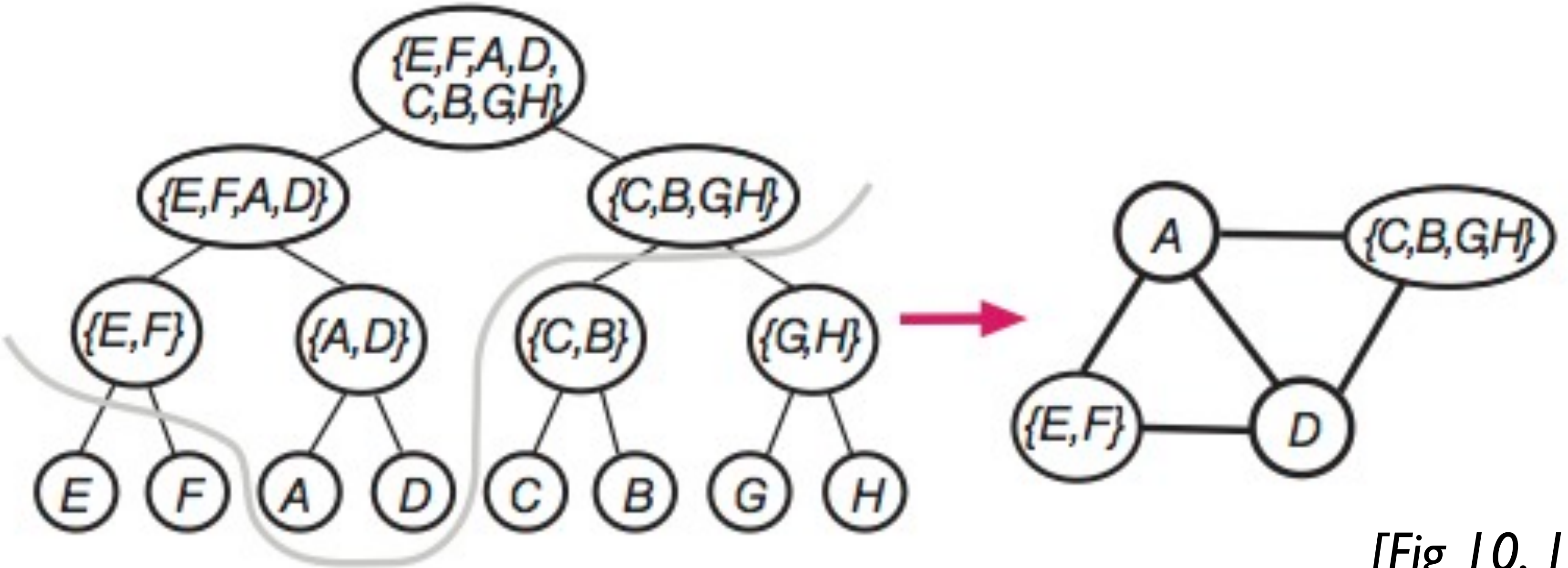
Candidate pairs: neighbors in original and proximity graph

- 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

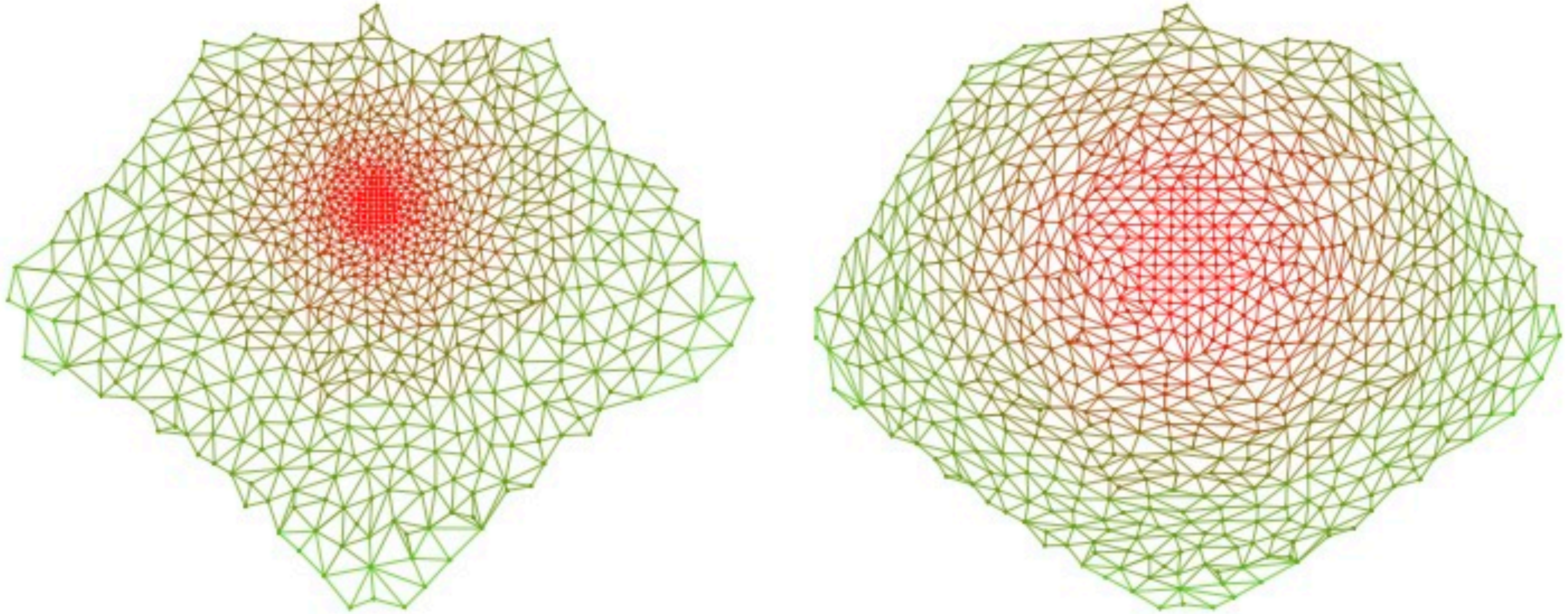


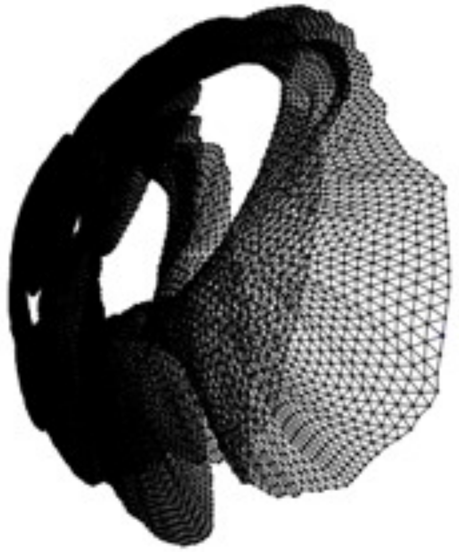


[Fig 10, 12. Topological Fisheye Views for Visualizing Large Graphs. Gansner, Koren and North, IEEE TVCG 11(4), p 457-468, 2005]

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





(b) default layout of hybrid graph **(c)** distorted layout of hybrid graph

[Fig 2,15. Topological Fisheye Views for Visualizing Large Graphs. Gansner, Koren and North, IEEE TVCG 11(4), p 457-468, 2005]

Stenomaps

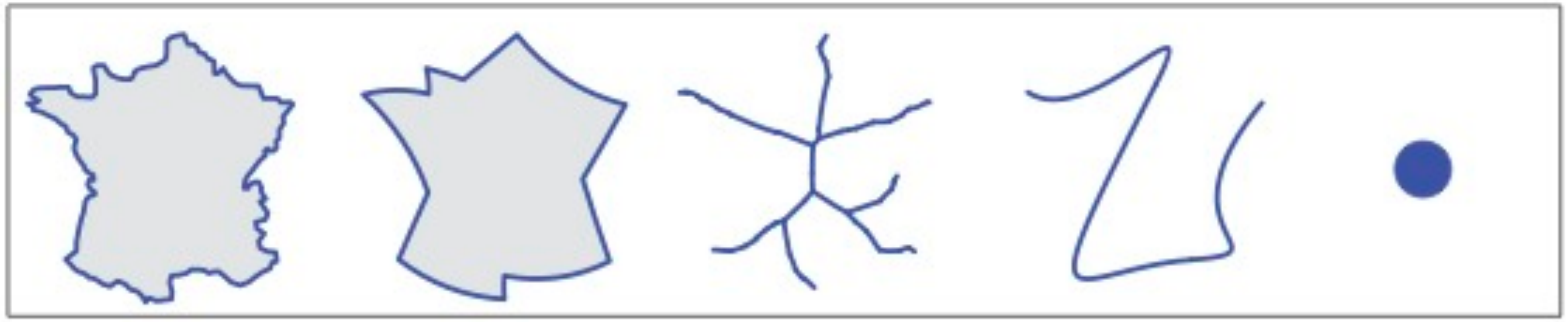


Fig. 1. Increasing the abstraction of France. From left to right: (a) un-transformed polygon, (b) curved schematization, (c) pruned medial axis, (d) stenomap glyph, (e) dot.

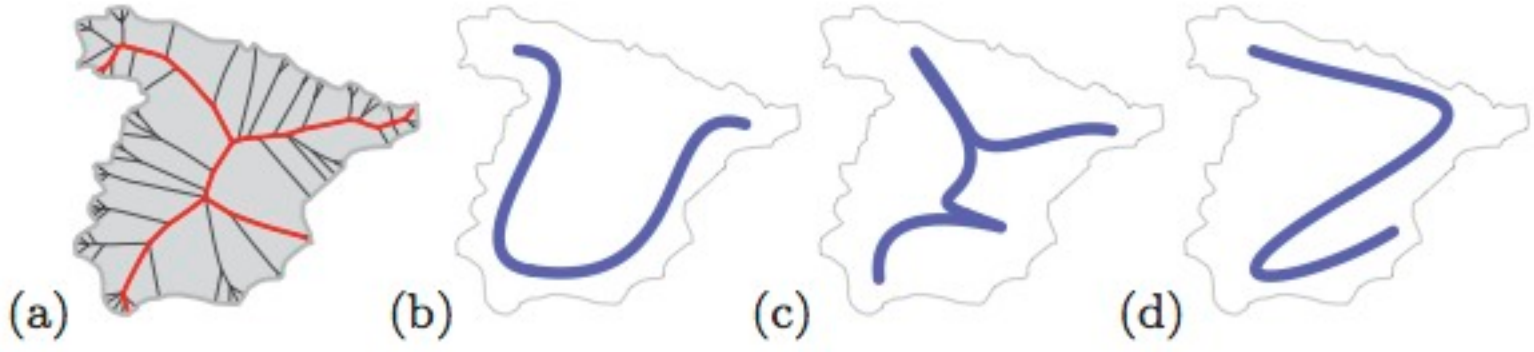


Fig. 2. Representing Spain as a glyph. (a) Polygon and (pruned) medial axis. (b) Border representation. (c) Collapse to medial axis. (d) Trade-off between border and area.

[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

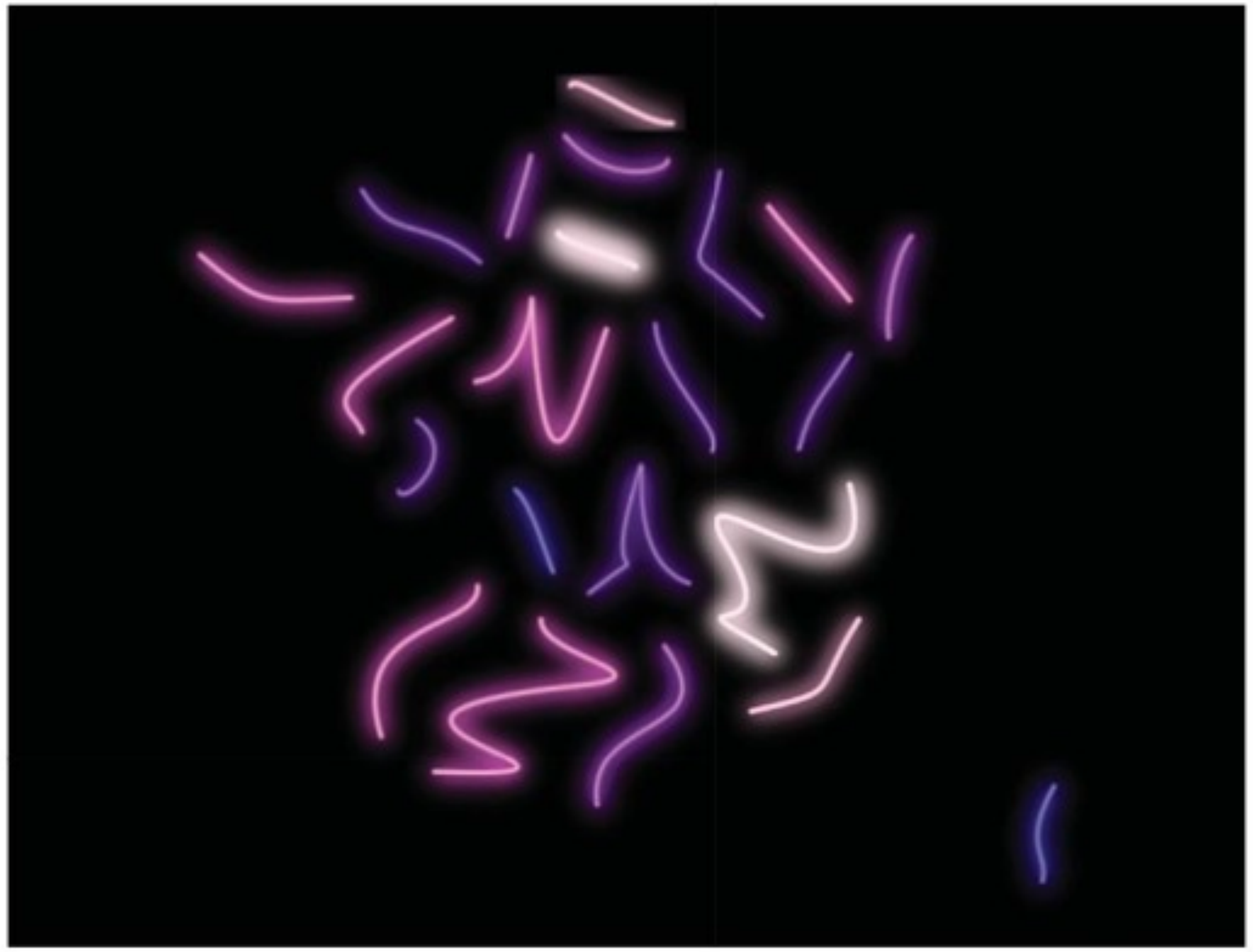


Fig. 15. Hurricane Katrina Prediction. Probability that center of storm will pass within 75 statute miles. Datasource: NOAA Hurricane Center.

[<u>Stenomaps: Shorthand for shapes</u> 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.]

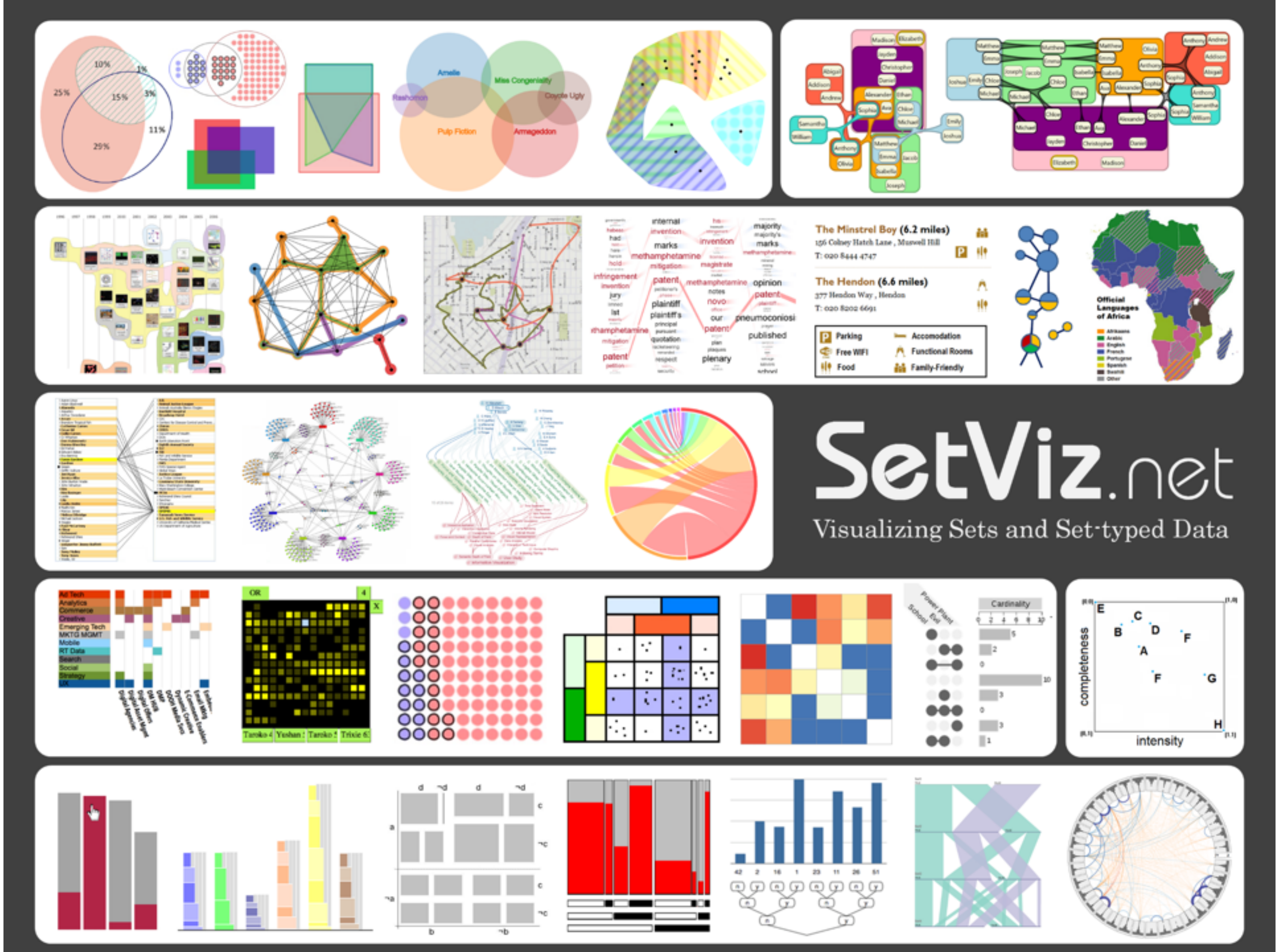
Sets State of the Art Report

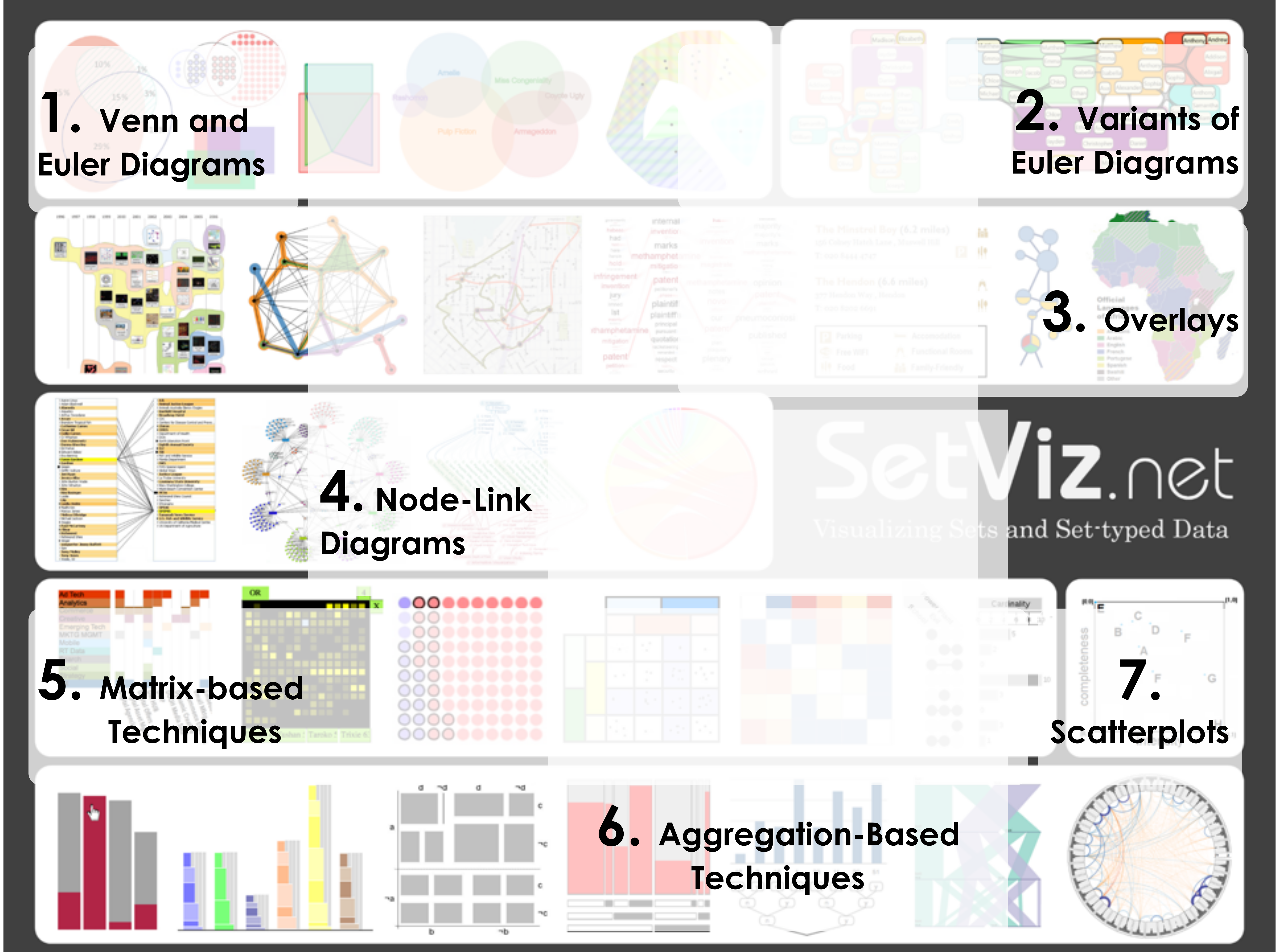
- with companion setviz.net site

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. convexity).
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 Alsallakh, 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
SetViz.net
Visualizing Sets and Set-typed Data
5. Matrix-based Techniques
7. Scatterplots
6. Aggregation-Based Techniques

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.