Comp/Phys/APSc 715

Information Visualization and Tufte

Preview Videos

- Vis 2012: ttg2012122061s
  - Crack propagation
- Vis2012: ttg2012122355s
  - Transfer function design
- Vis 2004: theisel.avi
  - Flow topology for time-varying 2D flow fields

Administrative

- Thursday: Meet in Sitterson 264
- Two weeks: Your presentations!
  - Final write-up due on day of final
- Have you completed your goals?
- Have you iterated your designs?
  - Better than best HW design?

Information Display and Spatial Embeddings

- The data we have looked at so far has existed in some natural spatial embedding
- Subset of the possible kinds of information that exist
- Key challenges in information visualization
  - How to embed in 2D or 3D?
  - How do you reduce high-dimensional data?
  - How do you convey relationships among entities?
- Choice of embedding often depends on goal
- Often, spatial embedding changes
  - Level-of-detail
  - Focus + context techniques magnify portions of data

Focus + Context

- May only want to show part of data in detail
- Knowing how the detailed data relates to the rest of the data set is still important
- Focus + context techniques attempt to do this
  - More screen space dedicated to showing one or more parts of the data
  - Rest of the data shown in less resolution

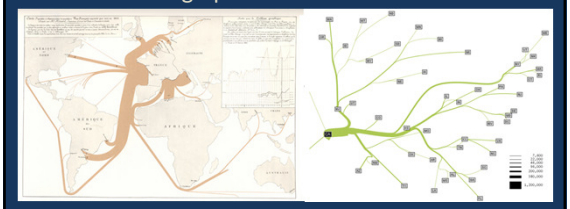
Interactive Data Analysis

- Tie data analysis into visualization interface
- Show results of queries/algorithms
- Allows pattern detection in subsets of the data
- Enable finding answers to different questions at different points in data exploration

Techniques for small data sets…

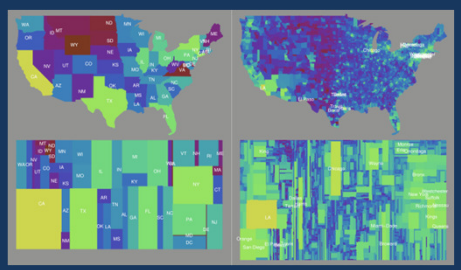
Flow Maps

- Phan et al., IEEE Vis 2005
- Quantifies movement of items between nodes in a graph



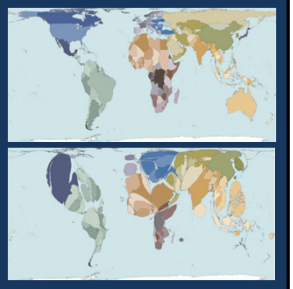
Cartograms 1

- Heilmann et al., InfoVis 2004
- Distort maps so area reflects population



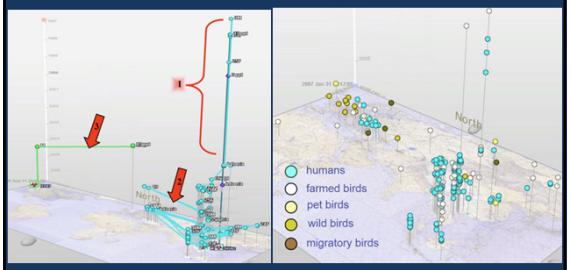
Cartograms 2

- Dorling, Barford, Newman, IEEE TVCG, 12(5), 2006
- Distorts geographic map based on scalar data values
- Net emigration over last 50 years



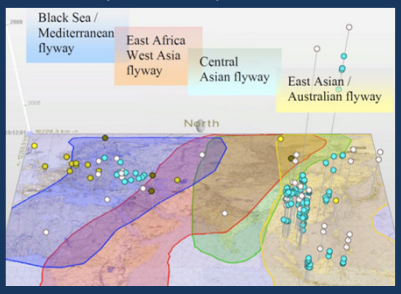
Tracking Avian Flu Outbreaks

- Proulx et al., IEEE VAST, 2006



Tracking Avian Flu Outbreaks

- Proulx et al., IEEE VAST, 2006



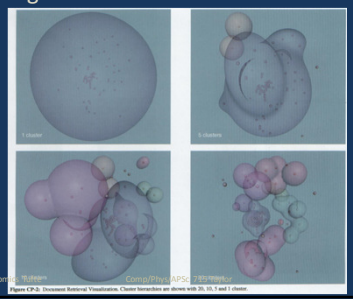
Multi-Dimensional Scaling

Multi-Dimensional Scaling

- Family of algorithms to reduce high-dimensional data down to 2D or 3D
  - So we can visualize it
  - Reduce complexity of higher-dimensional relationships
- Aims to preserve distances in higher dimensional space after the dimension reduction
  - Close things in high-dimension space are close in 2D or 3D
  - Far things remain far apart

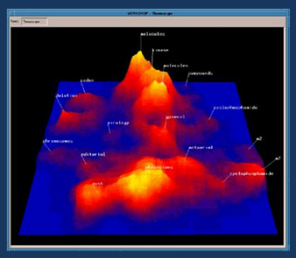
H-BLOBs

- Sprenger, Brunella, Gross; Vis 2000
- Splatting in 3D



ThemeView

- Card, SIGGRAPH '96



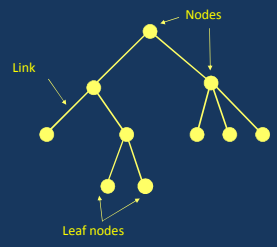
Tree Visualization

Tree Visualization

- Trees model hierarchical information very well
- Structure found in many areas
  - Corporation management hierarchy
  - Governments
  - Taxonomy
  - Data structures
- Many visualization techniques

Node-link Diagrams

Tree



Graph

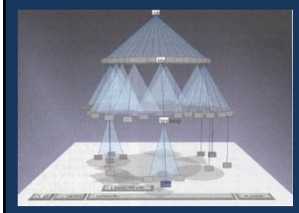
Visual Grammar of Node-Link Diagrams

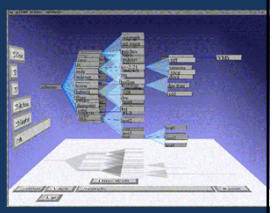
Graphical Code	Visual Instantiation	Semantics
1. Closed contour.		Entity, object, node.
2. Shape of closed region.		Entity type.
3. Color of enclosed region.		Entity type.
4. Size of enclosed region.		Entity value. Larger = more.
5. Partitioning lines within enclosed region.		Entity partitions are created, e.g., TreeMaps.
6. Attached shapes.		Attached entities. Part-of relations.
7. Shapes enclosed by contour.		Contained entities.
8. Spatially ordered shapes.		A sequence.
9. Linking line.		Relationship between entities.
10. Linking-line quality.		Type of relationship between entities.
11. Linking-line thickness.		Strength of relationship between entities.
12. Tab connector.		A fit between components.
13. Proximity.		Groups of components.

Figure 6.33 The visual grammar of diagram elements (node-link diagrams).

ConeTrees

- Robertson et al., Comm. ACM 36(4), pp. 57-71





Tree "Extruded" in 3D

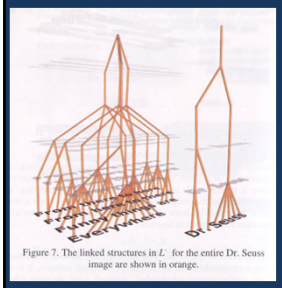
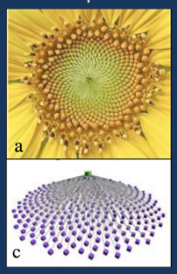


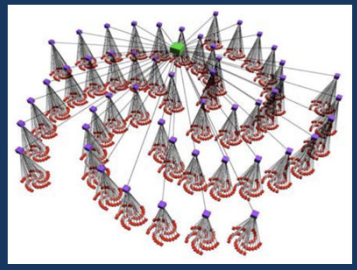
Figure 7. The linked structures in L' for the entire Dr. Seuss image are shown in orange.

- Wattenberg and Fisher, IEEE InfoVis 2003
- Tree structure showing salient features of text
- Tree extruded into 3D with varying levels of detail in text

Nature-Inspired Graph Layout

- Carpendale and Agarawala, Info Vis 2004





Showing Hierarchical Clusters

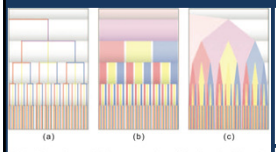


Fig. 3. Alternative graphical representations of the clustering hierarchy. (a) Dendrogram, (b) icicle plot and (c) buttresses.

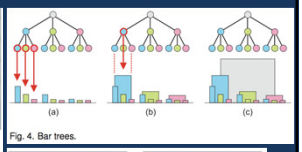
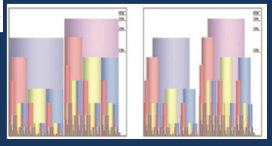


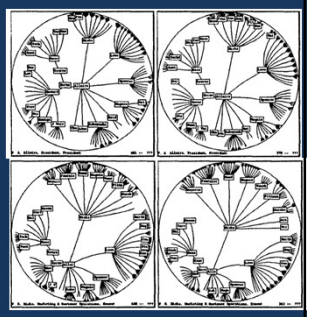
Fig. 4. Bar trees.



- Pretorius and van Wijk, TVCG 12(5), 2006

Hyperbolic Trees

- Lamping and Rao, UIST 1994
- Focus+context scheme for viewing large hierarchies
- Smooth animated changes between different foci



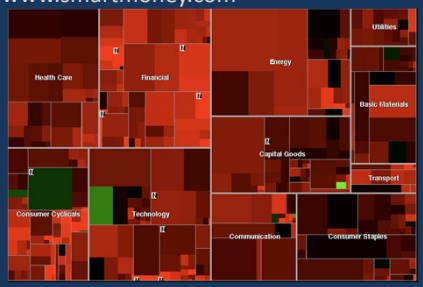
TreeMaps

Herman et. al. IEEE Trans on Vis & CG, 6(1), 2000

Fig. 6. Tree-map: rectangles with color belong to the same level of the (tree) hierarchy. (Adapted from Johnson and Schneiderman [72]).

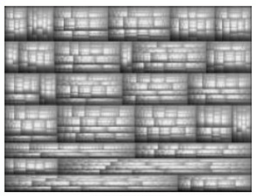
Tree Maps

- www.smartmoney.com

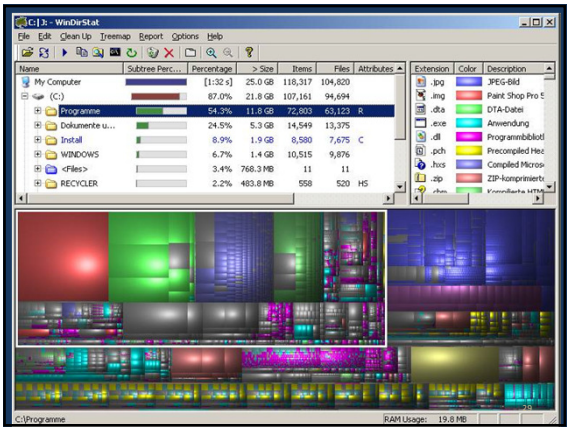


Cushion Maps

- Van Wijk and van de Wetering, InfoVis 1999
- Multiple levels of lighting group subtrees



$h = 0.5,\ f = 0.75$



Voronoi Tree Maps

- Balzer and Deussen, IEEE Vis 2005

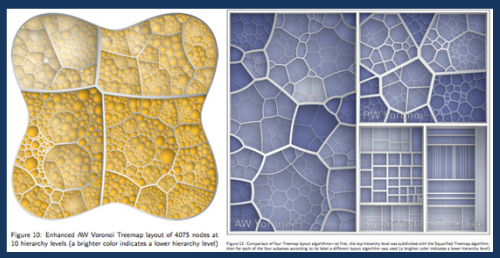
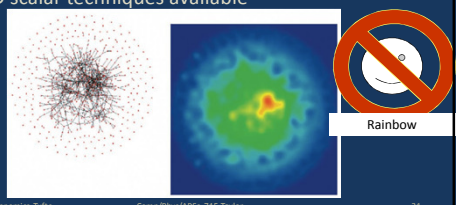


Figure 10: Enhanced AW Voronoi Treemap layout of 4075 nodes at 10 hierarchy levels (a brighter color indicates a lower hierarchy level)

GraphSplatting

- van Liere and de Leeuw, IEEE TVCG 9(2), 2003
- Add up 2D Gaussians centered at nodes
  - Density field
  - All 2D scalar techniques available



Visual Bibliography of Tree Vis (1) by Hans-Jorg Schulz

- http://www.informatik.uni-rostock.de/~hs162/treeposter/poster.html

Visual Bibliography of Tree Vis (2) by Hans-Jorg Schulz

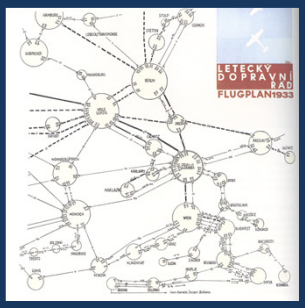
- http://www.informatik.uni-rostock.de/~hs162/treeposter/poster.html

Graph Visualization

Graph Visualization

- Goals:
  - Show all nodes clearly
  - Show all edges and avoid edge overlap

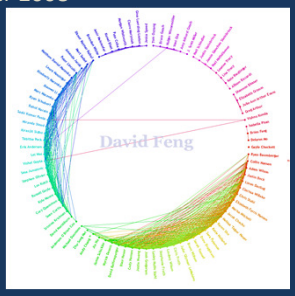
Airline Flight Network



- Czechoslovakia Air Transport Company flight network
- Edward R. Tufte, *Envisioning Information*

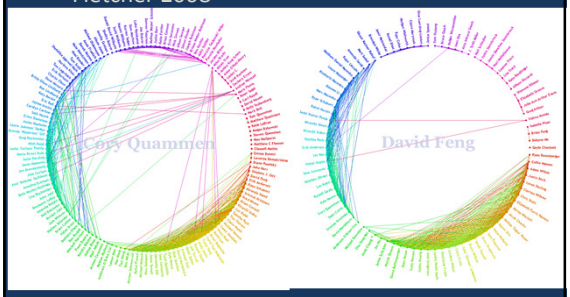
Facebook Friend Wheel

- Fletcher 2008



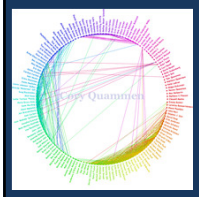
Facebook Friend Wheel

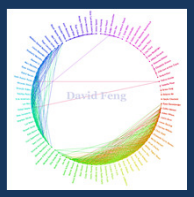
- Fletcher 2008



Facebook Friend Wheel

- Fletcher 2008





Russ Taylor

Radial Focus+Context Graphs

- Jankun-Kelly and Ma, IEEE InfoVis 2003
- For showing visual nodes (images, web pages)
- Level highlighting
  - More space allocated to level of interest

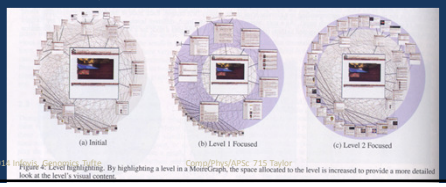
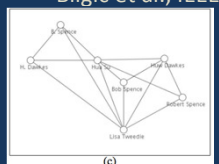
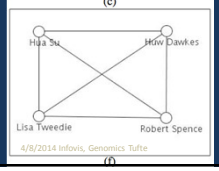


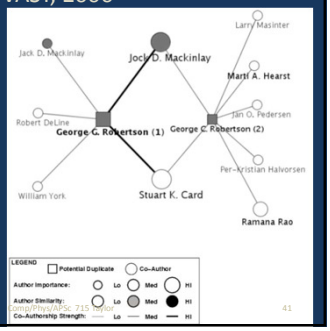
Figure 4: Level highlighting. By highlighting a level in a MoireGraph, the space allocated to the level is increased to provide a more detailed look at the level's visual content.

Social Network Identity Resolution

- Bilgic et al., IEEE VAST, 2006

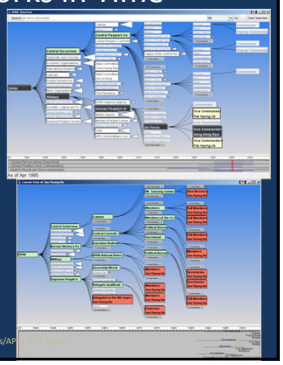






Social Networks in Time

- Card et al., VAST 2006
- Expand tree in regions of interest
- Highlight nodes matching search criteria
- Slider widget to change time
- Animation to show changes in time



Social Networking: Vizster

- Heer and Boyd, InfoVis 2005

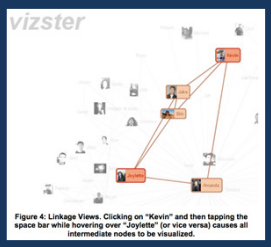


Figure 4: Linkage Views. Clicking on "Kevin" and then tapping the space bar while hovering over "Joylette" (or vice versa) causes all intermediate nodes to be visualized.

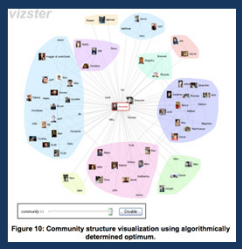


Figure 10: Community structure visualization using algorithmically determined optimum.

Social Network Vis with Matrices and Graphs

- Henry and Fekete, IEEE TVCG 12(5), 2006
- Reordered matrices better for some tasks
- Node-link diagrams better for others

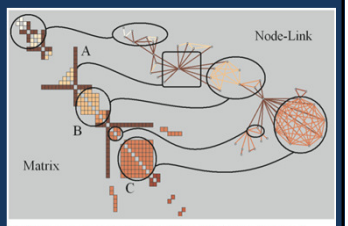
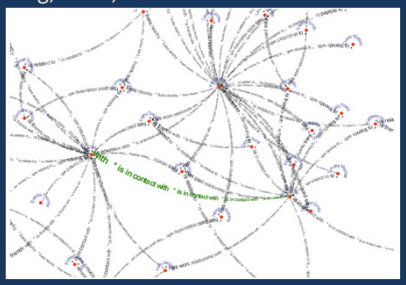


Fig. 3. Visual patterns in Matrix and Node-link representations of social networks. A represents an actor connecting several communities, B a community and C a clique (complete sub-graph).

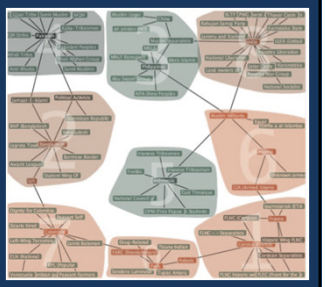
Semantic Relationships

- Wong, et al., IEEE VAST 2006



Graph Edge Reduction

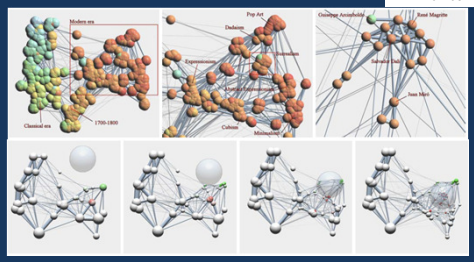
- Perer and Shneiderman, IEEE TVCG 12(5), 2006
- Grouping by country
- Interconnection among groups



Small World Graphs

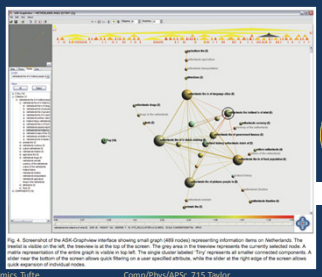
Rainbow

- van Ham and van Wijk, InfoVis 2004



Viewing Large Graphs

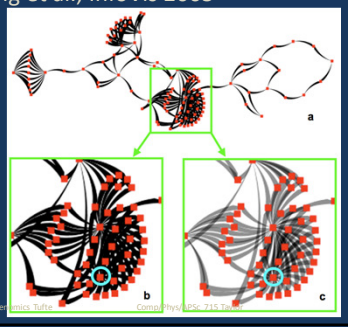
- Abello, van Ham, Krishnan, IEEE TVCG 12(5), 2006



Rainbow

Semi-transparent Lines

- Wong et al., InfoVis 2005



EdgeLens: Managing Edge Congestion in Graphs

- Wong, Carpendale, Greenberg, InfoVis 2003

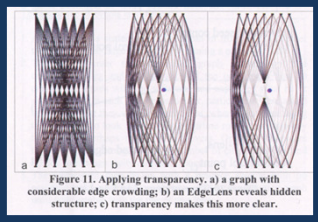


Figure 11. Applying transparency. a) a graph with considerable edge crowding; b) an EdgeLens reveals hidden structure; c) transparency makes this more clear.

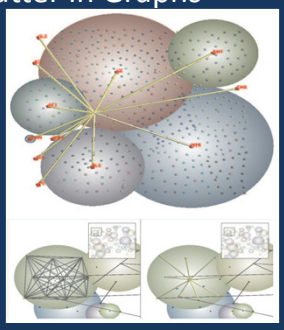
Topological Fish-Eye Lens for Large Graph Visualization

- Ganser, Koren, North, InfoVis 2004
- Approximates graph structure with less detail

Figure 5: This Internet map ($|V|$=87,931, $|E|$=87,930)) is too large to visualize as a flat structure. Two topological fisheye views are shown. The focused sections in red are the original graph. Peripheral areas, in green, are simplified.

Reducing Clutter in Graphs

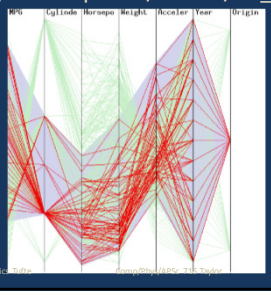
- Kumar and Garland, IEEE TVCG, 12(5) 2006
- Remove edges within clusters
- Replace edges in cliques with star edge glyphs



Parallel Coordinates

Parallel Coordinates

- http://davis.wpi.edu/~xmdv/vis_parcoord.html



Parallel Coordinates with Color Map

- Xie et al., IEEE VAST 2006

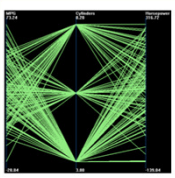


Figure 1: Parallel coordinates without quality information (the dataset is adapted from *cars*)

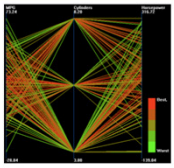
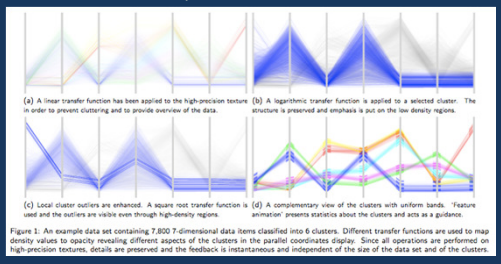


Figure 2: Parallel coordinates with quality information (record quality is mapped to the color of polylines)

Parallel Coordinates with Transfer Functions

- Johansson et al., InfoVis 2005



(a) A linear transfer function has been applied to the high-precision texture in order to prevent cluttering and to provide overview of the data.

(b) A logarithmic transfer function is applied to a selected cluster. The structure is preserved and emphasis is put on the low density regions.

(c) Local cluster outliers are enhanced. A square root transfer function is used and the outliers are visible even through high-density regions.

(d) A complementary view of the clusters with uniform bands. 'Feature animation' presents statistics about the clusters and acts as a guidance.

Figure 1: An example data set containing 7,800 7-dimensional data items classified into 6 clusters. Different transfer functions are used to map density values to opacity revealing different aspects of the clusters in the parallel coordinates display. Since all operations are performed on high-precision textures, details are preserved and the feedback is instantaneous and independent of the size of the data set and of the clusters.

Parallel Coordinates over Time

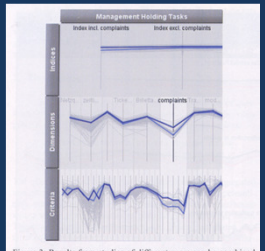
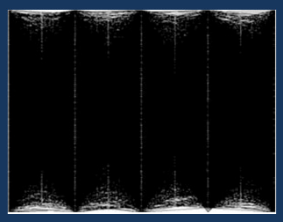


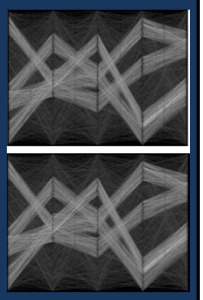
Figure 3: Results from studies of different years can be combined using a "fading out" effect (older years are colored with less saturation). Changes over time become quickly apparent on all aggregation levels.

- Brodbeck and Girardin, IEEE InfoVis 2003
- Fading out (lowering saturation) shows how data change through time

Showing Clusters in Parallel Coordinates

- Artero et al., IEEE Info Vis, 2004





Focus+Context in Parallel Coordinates

- Brodbeck and Girardin, IEEE InfoVis 2003
- Increase horizontal resolution in region of focus

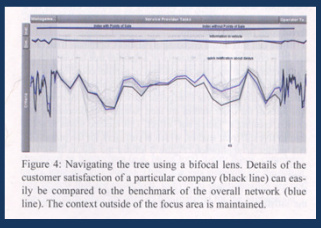
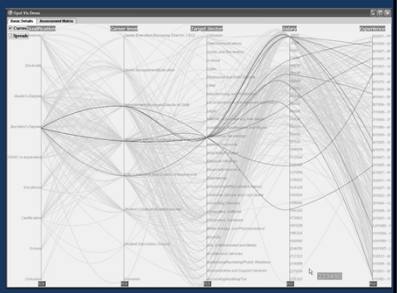


Figure 4: Navigating the tree using a bifocal lens. Details of the customer satisfaction of a particular company (black line) can easily be compared to the benchmark of the overall network (blue line). The context outside of the focus area is maintained.

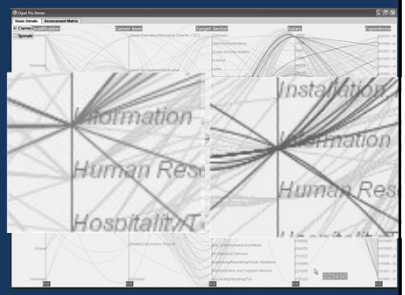
Curvy PC

- Graham and Kennedy IV'03
- Easier to follow (good continuity)
- Cubic splines
- Separates intersections



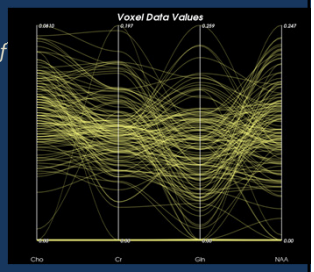
Curvy PC (2)

- Graham and Kennedy IV'03
- Easier to follow (good continuity)
- Cubic splines
- Separates intersections



Curvy PC (3)

- Moustafa and Wegman, *Graphics of large data sets*
- Zero-derivative, not just smooth
- Smooth, but maintain clustering



not actually their image, but same idea

Whisker and Star Plots

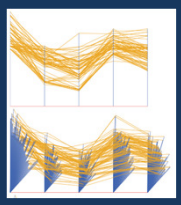
- Each angle encodes a different property of the data
- Star plots connect the lines

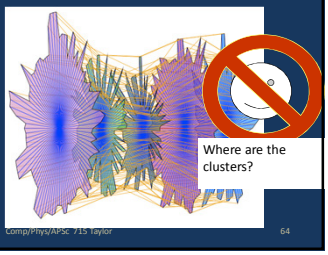
Whisker Plot

Star Plot

Star Glyphs + Parallel Coordinates

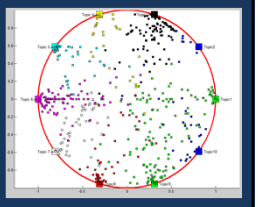
- Fanea, Carpendale, Isenberg, InfoVis 2005
- Star glyphs show how population varies in one dimension





RadViz

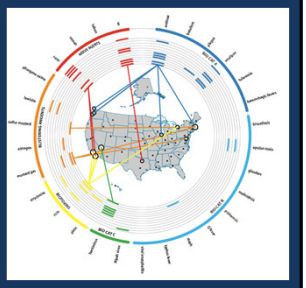
- Multiple axes from center to circle perimeter
- >2 axis, not perpendicular
- Interactive axis control
  - Points follow
  - Helps reveal clusters
- Novakova & Stepankova
  - SMO'06



Miscellaneous

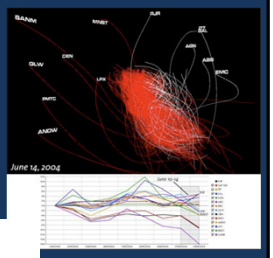
Situational Awareness Visualization

- Livnat et al., InfoVis 2005
- What, when, where?
- What - around circle
- When - which ring
- Where - indicated by spatial embedding inside rings



Showing Time-Varying Data With Flocking Boids

- Moere, InfoVis 2004
- Particle motion controlled by data values
- Attraction/repulsion based on similarity



Unpredictable spatial embedding

Theme River

- Havre, Hetzler, Nowell; InfoVis 2000

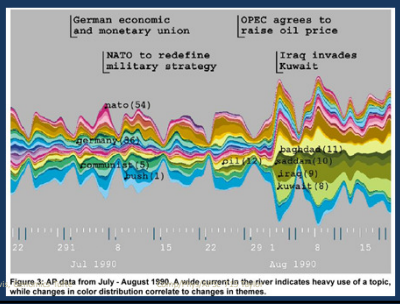
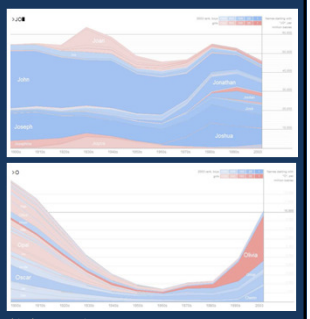


Figure 3: AP data from July - August 1990. A wide current in the river indicates heavy use of a topic, while changes in color distribution correlate to changes in themes.

NameVoyager

- Wattenberg, InfoVis 2005
- Shows baby name popularity over time in a stacked graph
- Thickness of strip indicates frequency of name



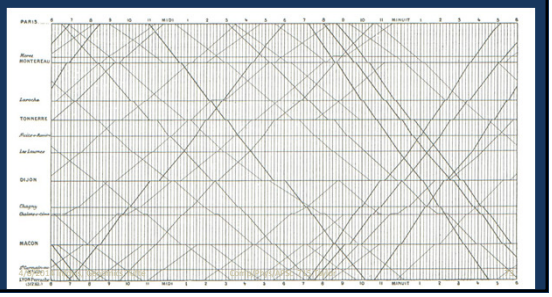
Tufte

Edward R. Tufte

- Three books on information display
  - The Visual Display of Quantitative Information
  - Envisioning Information
  - Visual Explanations
- Beautiful and terrible examples
- Rules of thumb
- Design guidelines

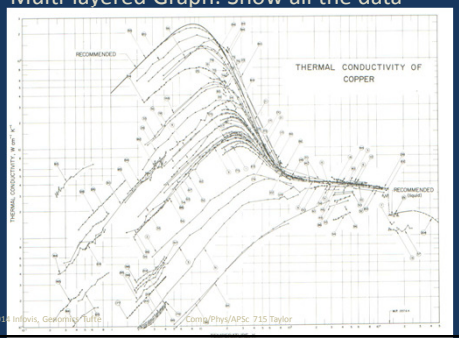
Tufte: Visual Display

- Train Schedule: Good visual organization



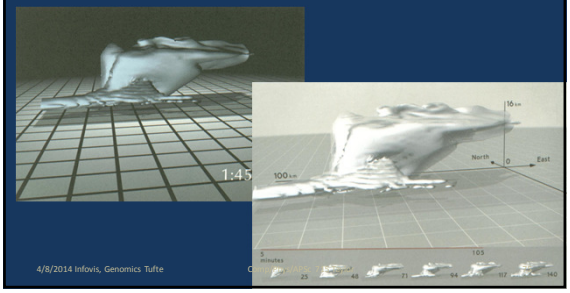
Tufte: Visual Display

- Multi-layered Graph: Show all the data



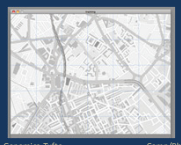
Tufte: Visual Explanations

- Storm Visualization Redesigned: Chartjunk



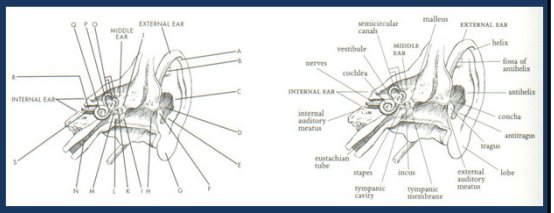
Aside: How strong a grid?

- Bartram, Cheung, Stone; TVCG 2011
  - Tried a variety of densities
  - Asked users "set too high"
  - Asked users "set too low"
  - 20% opaque within good range



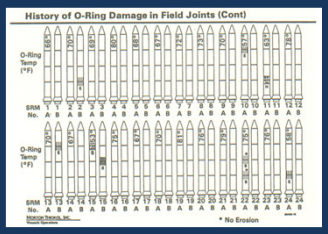
Tufte: Visual Explanations

- Medical Illustration Redesigned: Chartjunk
  - Finer call-out lines, label directly on diagram



Tufte: Visual Explanations

- O-Ring Damage Redesigned
  - Order by the important variable



Tufte: Visual Explanations

- O-Ring Damage Redesigned
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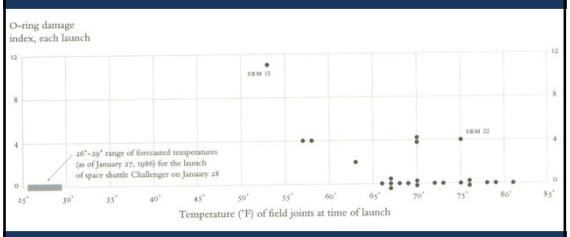

Credits

- Node-link diagram discussion: *Information Visualization* by Colin Ware