Information Visualization and Tufte

Preview Videos

• Vis 2004: robbins.mpg
  – Comparing two 2D time-varying neural responses
• Vis 2004: theisel.avi
  – Flow topology for time-varying 2D flow fields

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

- Distorts geographic map based on scalar data values
- Net emigration over last 50 years
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

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

Node-link Diagrams

- Tree
- Graph
- Nodes
- Link
- Leaf nodes
### Visual Grammar of Node-Link Diagrams

<table>
<thead>
<tr>
<th>Type</th>
<th>Node Orientation</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Discrimination</td>
<td>✔️</td>
<td>Enhancing clarity</td>
</tr>
<tr>
<td>2. Shape of node regions</td>
<td>✔️</td>
<td>Enhancing visual appeal</td>
</tr>
<tr>
<td>3. Color of node regions</td>
<td>✔️</td>
<td>Enhancing node distinction</td>
</tr>
<tr>
<td>4. Size of node regions</td>
<td>✔️</td>
<td>Enhancing node prominence</td>
</tr>
<tr>
<td>5. Link orientation</td>
<td>✔️</td>
<td>Enhancing link visibility</td>
</tr>
<tr>
<td>6. Link orientation</td>
<td>✔️</td>
<td>Enhancing link prominence</td>
</tr>
<tr>
<td>7. Link orientation</td>
<td>✔️</td>
<td>Enhancing link clarity</td>
</tr>
<tr>
<td>8. Link orientation</td>
<td>✔️</td>
<td>Enhancing link distinctness</td>
</tr>
<tr>
<td>9. Link orientation</td>
<td>✔️</td>
<td>Enhancing link presence</td>
</tr>
<tr>
<td>10. Link orientation</td>
<td>✔️</td>
<td>Enhancing link importance</td>
</tr>
<tr>
<td>11. Link orientation</td>
<td>✔️</td>
<td>Enhancing link connectivity</td>
</tr>
<tr>
<td>12. Link orientation</td>
<td>✔️</td>
<td>Enhancing link complexity</td>
</tr>
<tr>
<td>13. Link orientation</td>
<td>✔️</td>
<td>Enhancing link detail</td>
</tr>
</tbody>
</table>

**Visual Grammar of Node-Link Diagrams**

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

- Tree “Extruded” in 3D
- 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

- 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

Tree Maps
- www.smartmoney.com

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

- Balzer and Deussen, IEEE Vis 2005

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
Graph Visualization
Graph Visualization

• Huge topic in its own right
• 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

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
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
Social Network Vis with Matrices and Graphs

- Reordered matrices better for some tasks
- Node-link diagrams better for others

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

- van Ham and van Wijk, InfoVis 2004

Viewing Large Graphs

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

Semi-transparent Lines

- Wong et al., InfoVis 2005
EdgeLens: Managing Edge Congestion in Graphs

- Wong, Carpendale, Greenberg, InfoVis 2003

Topological Fish-Eye Lens for Large Graph Visualization

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

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

- [http://davis.wpi.edu/~xmdv/vis_parcoord.html](http://davis.wpi.edu/~xmdv/vis_parcoord.html)

Parallel Coordinates with Color Map

- Xie et al., IEEE VAST 2006
Parallel Coordinates with Transfer Functions
• Johansson et al., InfoVis 2005

Parallel Coordinates over Time
• 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

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

Whisker and Star Plots

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

Star Glyphs + Parallel Coordinates

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

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
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

• O-Ring Damage Redesigned
  – Order by the important variable
Credits

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