Uncertainty Part II: Node-Edge Graphs & Terrain

Today

• **Reading for Today**
  – “Representing Uncertainty in Graph Edges: An Evaluation of Paired Visual Variables”
  – Related Paper: "Quantitative Texton Sequences for Legible Bivariate Maps"

• Prof Franklin’s work on Observer Siting
  – An example of uncertainty visualization

• Emergency Management Visualization
  – Sean Kim’s masters project

• Readings for Tuesday after Break
Reading for Today

• “Representing Uncertainty in Graph Edges: An Evaluation of Paired Visual Variables” Guo, Huang, and Laidlaw, IEEE TCVG 2015

<table>
<thead>
<tr>
<th>Bertin’s Original Visual Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Position</strong></td>
</tr>
<tr>
<td><strong>Size</strong></td>
</tr>
<tr>
<td><strong>Shape</strong></td>
</tr>
<tr>
<td><strong>Value</strong></td>
</tr>
<tr>
<td><strong>Colour</strong></td>
</tr>
<tr>
<td><strong>Orientation</strong></td>
</tr>
<tr>
<td><strong>Texture</strong></td>
</tr>
</tbody>
</table>

Table 1: These are Bertin's visual variables

• Visual Variables:
    • location/position, size/width, color hue, color value/brightness, grain, orientation, and shape
  – J. L. Morrison [1974]
    • Color saturation, arrangement
  – Cleveland & McGill [1984]
    • Angle, volume curvature
  – A. M. MacEachren [1992]
    • Focus/fuzziness, resolution, transparency
  – M. Carpendale [2003]
    • Motion, depth, occlusion

• Encode “strength” (placeholder data)
  – Width, hue, or saturation

• Encode uncertainty using a visual variable
  – Lightness, fuzziness, grain, or transparency

Fig. 1: An illustration of how each of the seven visual variables progress with increasing data value.

• Their conclusions only apply to line based marks
• Which visual variables are most salient? Are most discriminable?
• Disassociativity of each pair of visual variables: Can you differentiate changes in one variable while ignoring changes in another variable?
• Are some visual variables more appropriate (more natural/intuitive?) for certain data?
• Evaluate by studying response time, accuracy
• How much can we (should we?) pack into a single visualization?
• Tangent: Are we good at multitasking?

• Random graphs
• Each edge one of 5 values for “strength” and “uncertainty”
• Locate one edge of a specific value (max or min) of strength or uncertainty that must be identified (or determined to be missing)
  – “find extremum”
  – “retrieve value”
  – “visual search”
• Which graph has overall higher strength or uncertainty?
  – “characterize distribution”
  – “identification-comparison”
  – “visual aggregation”
• Varied the relative discriminability of the two variables
  – Perception of the weaker one is better when they are more similar
• Large number of hypotheses
• 20 participants, 1 hour each, 5760 trials
  – Short teaching/training session with feedback on correctness
  – (personally don’t want to have to administer a user study!)
• Provide explicit design recommendations, useful reference
• Not surprised that lightness interferes with hue and width confused with fuzziness; Surprised that grain performed well
• Well written
  – clearly state hypotheses, justified their conclusions well
  – I could recreate the results from this paper
  – “open questions” instead of future work
• How would the results be different with people with visual training (not novices)?
• How would the results be different for colorblind users?
• Would have liked to see a real-world example of this graph style. And specifically high density graphs (requires thin edges).

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Optional Reading for Today:

• “Siting Observers on Terrain”
  Wm Randolph Franklin, RPI ECSE
Observers have a specified maximum straight line sight distance
Some observer placements see more (black)
Some are occluded
• Let’s place “observers” (e.g., cell phone towers) on a complex terrain
  – Where should they be placed to maximize coverage?
    • What if the observers need to see each other? (form a connected network for communication)
  – How much error is introduced because of the original sensor measurements (discrete sample points might miss significant ridges or valleys)?
  – How much error is introduced if the dataset is compressed for storage or transmission and then lossily reconstructed?
    • Erroneous visibility, Erroneous occlusions
  – Knowing the terrain and placement of “red team” observers what path should the “blue team” take to avoid being seen?
  – Knowing that it will be used to do siting tasks, can you design a better compression algorithm that reduces lossy artifacts that cause significant errors?
Regular grid of height samples

Query for occlusions along sight line

Data interpolation might be incorrect!

Hue = terrain height
Value (binary color/black) = visibility
Grain/texture = uncertainty

If height is changed by epsilon, the visibility flips!

The visibility of one half of the points in uncertain!
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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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• Visual.ly's Code of Ethics for Data Visualization Professionals
• Society of Professional Journalists' Code of Ethics