15 Views of a Node–Link Graph: An InfoVis Portfolio

Tamara Munzner

University of British Columbia
Department of Computer Science

Information Esthetics Lecture Series One
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15 Views of a Node–Link Graph: An InfoVis Portfolio
	node–link graph
  · common abstraction: nodes connected by edges
  · trees are special case: hierarchy with no cycles

infovis: information visualization
  · visual representation of abstract data
    computer–based: interactivity possible
  · help human perform some task more effectively
Information Esthetics

manifesto

- information content can enhance esthetic experience and esthetic consideration can enhance information content

successful infovis as example

- design guidelines for visual encoding as interplay of perception, cognition, esthetics, and data/task characterization
Visual Channels

visual attribute of geometric mark
  · position, color, size, shape, orientation, ...

separable vs. integral

| color position | color motion | color shape | size orientation | x-size | y-size | red-green | yellow-blue |

[Ware. Information Visualization: Perception for Design. Morgan Kaufmann 1999.]
Outline

Introduction

15 Views

• Traditional Graphs
• Nontraditional Representations
• Focus+Context Trees

Wrapup
1: Edge List

data: semantic network from Hofstadter book Godel, Escher, Bach
- nodes: topics
- links: discussion of ideas together in book

Turing – Halting problem
Halting problem – Infinity
Infinity – Paradoxes
Paradoxes – Lewis Carroll
Infinity – Lewis Carroll
Infinity – Unpredictably long searches
Infinity – Recursion
Infinity – Zeno
Infinity – Paradoxes
Lewis Carroll – Zeno
Lewis Carroll – Wordplay
Halting problem – Decision procedures
BlooP and FlooP – AI

Halting problem – Unpredictably long searches
BlooP and FlooP – Unpredictably long searches
BlooP and FlooP – Recursion
Tarski – Truth vs. provability
Tarski – Epimenides
Tarski – Undecidability
Paradoxes – Self-ref
Epimenides – Tarski
Epimenides – Paradoxes
Epimenides – Self-ref
[...]
Critique

strengths

· easy to create

weaknesses

· requires too much memory and cognition

· does not exploit human perceptual system
Visual External Representation

read off answers from node-link graph drawing

- connections drawn between nodes
- offload cognition to visual system

Diagram:

- Infinity
  - Zeno
    - Lewis Carroll
      - Wordplay
    - Epimenides
      - Self-ref
      - Truth vs. provability
    - Tarski
      - Undecidability
  - Paradoxes
  - Halting problem
    - Decision procedures
    - Turing
    - Unpredictably long searches
  - Recursion
    - BlooP and FlooP
  - AI
2: Hand-Drawn

data: GEB semantic network

strengths
  · high information density
    ratio of marks to whitespace
    foreground vs. background layer
  · subtleties of spatial layout

weaknesses
  · hours or days to create

3: Dot

data: semantic network

automatically compute positions for nodes, edges

strengths
  · fast: one second to create
  · careful routing of curved edges

weaknesses
  · low information density
  can't read labels

Graph Layout Criteria

minimize
  · crossings, area, bends/curves
Graph Layout Criteria

minimize
  - crossings, area, bends/curves

maximize
  - angular resolution, symmetry
Graph Layout Criteria

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  · crossings, area, bends/curves

maximize
  · angular resolution, symmetry

most criteria individually NP-hard
  · cannot just compute optimal answer
  · heuristics: try to find something reasonable
Graph Layout Criteria

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  · crossings, area, bends/curves

maximize
  · angular resolution, symmetry

most criteria individually NP-hard
  · cannot just compute optimal answer
  · heuristics: try to find something reasonable

criteria mutually incompatible

4: Force-Directed Placement
	nodes: repel like magnets
	edges: attract like springs

- start from random positions, run to convergence

encoding: geometric for graph proximity
Critique

strengths
  · intuitive model
  · many mathematical approaches

weaknesses
  · does not scale to large datasets
5: TopoLayout

multilevel decomposition and layout
  · automatic detection of topological features
  · chop into hierarchy of manageable pieces
  · lay out using feature–appropriate algorithms

[work in progress: Daniel Archambault, Tamara Munzner, and David Auber]
Multilevel Hierarchies

data: web sites, network backbones

- strengths: handles large class of graphs
- weaknesses: poor if no detectable features

[work in progress: Daniel Archambault, Tamara Munzner, and David Auber]
6: Animated Radial Layouts

dynamic graphs that change over time
  - minimize visual changes
  - stay true to current dataset structure
  [video: www.sims.berkeley.edu/~ping/gv]

Animation

polar interpolation

maintain neighbor order

Critique

strengths
  · smoother transitions

weaknesses
  · not scalable to large datasets
7: Constellation

data: semantic network from dictionary entry
   · nodes: English words, links: used together in entry
information density
   · design tradeoff with visual salience

[graphics.stanford.edu/papers/munzner_thesis/html/node11.html#noncanonfig]
Traditional Layout

avoid crossings
• considered "aesthetic criterion"
reason: avoid false attachments

ambiguity
artifact salience

[graphics.stanford.edu/papers/munzner_thesis/html/node10.html#tradlayoutfig]
Selective Emphasis

highlight sets of boxes and edges
  · additional perceptual channels based on interaction
avoid perception of false attachments
  · avoid hidden state
  · [video: graphics.stanford.edu/videos/const]
Critique

strengths
  · highly specialized
  · good information density in final version
  · perceptual layering successful

weaknesses
  · highly specialized
  · custom system design is expensive
Outline

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Wrapup
8: Treemaps

Data: filesystems, stock performance

Show structure with containment not connection

- size according to node attribute

Critique

strength: popout for extreme attributes

weaknesses: difficulties seeing structure


[www.smartmoney.com/marketmap]

9: Cushion Treemaps

data: filesystems
show structure with shading
  · scale parameter controls global vs. local

Critique

strengths
· shows more topological structure than plain treemaps
· keeps power to show attribute outliers
· allows color to be used to encode other info

weaknesses
· still considerably worse than node-link representation for showing topological structure
10: Themescapes

data: news stories, gene expression
- from graph to terrain

<table>
<thead>
<tr>
<th>Gene Names</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element 1</td>
<td></td>
</tr>
<tr>
<td>Element 2</td>
<td></td>
</tr>
<tr>
<td>Element 3</td>
<td></td>
</tr>
<tr>
<td>Element 4</td>
<td></td>
</tr>
<tr>
<td>Element 5</td>
<td></td>
</tr>
<tr>
<td>Element 6</td>
<td></td>
</tr>
</tbody>
</table>

Davidson et al. Cluster Stability and the Use of Noise in Interpretation of Clustering. InfoVis 01

Critique

strengths
  · terrain model intuitive for people
  · good for overview

weaknesses
  · possibly misleading implication of continuous data
typically made from discrete samples
11: Multilevel Call Matrices

data: large software project

link matrix vs. node-link network matrix

force-directed

layered subset (dot)

- position: box shows link between nodes in row/column
- color: calls not in specification in red

Abstraction Levels

matrices: uniform, recursive, stable

Critique

strengths: tasks successfully supported

- spotting unwanted calls in implementation but not specification

- previous summary shown to be incomplete

weaknesses

- matrix views poor for some tasks

Outline

Visual Encoding

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Wrapup
Focus+Context

combine overview, details into integrated view

· vs. single detail view

· vs. multiple linked windows
12: SpaceTree

data: org charts, species relationships
interaction: expand/contract
  · [demo: www.cs.umd.edu/hcil/spacetree]

strengths
  · animated transitions easy to follow
weakness
  · cannot have multiple areas of focus

13: 2D Hyperbolic Trees

data: org charts, web sites
  · node: document
  · link: hyperlink between pages
carefully chosen distortion
  · fisheye effect: single focus from hyperbolic geometry
  · [demo: ucjeps.berkeley.edu/map2.html]

Critique

strengths

- scales to over 10,000 nodes

weaknesses

- distortion poor for distance judgement tasks
- still possible to get lost in large graphs
14: H3

data: web sites, species relationships
3D fisheye from hyperbolic geometry
・ [demo: graphics.stanford.edu/~munzner/h3]


Critique

strengths

• scales to over 100,000 nodes

weaknesses

• distortion poor for distance judgement tasks
• still possible to get lost in large graphs
15: TreeJuxtaposser

data: species evolutionary relationships

task: side by side comparison

accordion drawing
  · guaranteed visibility of landmarks
  · stretch and squish navigation
  · [demo: olduvai.sf.net/tj]

Guaranteed Visibility

drawing colored marks
  · easy with small datasets
  · hard with big datasets

reasons a mark could be invisible
  · outside the window
  · underneath other marks
  · smaller than a pixel

benefits of GV
  · minimizes amount of navigation required
  · guides necessary navigation choices
  · provides visible landmarks
Critique

strengths

- scalability to millions of nodes
- guaranteed frame rate
- guaranteed visibility
- supports multiple focus areas

weaknesses

- stretch and squish navigation inappropriate for tasks requiring distance estimation
- computationally intensive

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Hard Problems

designing within huge space of possibilities

scalability
  · size of dataset
  · number of pixels
  · kinds of data

dynamic data

characterizing Focus+Context
  · how and when does it help
Grand Challenge

"visual Google for nontextual data"

not search for images

web search made available text data useable
  · for general and surprising uses beyond original intent

infovis browsing
  · could make available nontext data useful/visible
More Information

this talk
  · www.cs.ubc.ca/~tmm/talks.html#ie05

my grad course
  · www.cs.ubc.ca/~tmm/courses/infovis

conferences

  · InfoVis symposia: www.infovis.org/symposia.php
    IEEE Symposium on Information Visualization
  
  · Graph Drawing conferences: www.gd2005.org