15 Views of a Node–Link Graph: An Information Visualization Portfolio

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2 May 2006

Outline

Introduction

15 Views
- Traditional Graphs
- Nontraditional Representations
- Focus + Context Trees

Wrapup

1: Edge List

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

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

2: Hand-Drawn
data: GGB 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

maximize
- angular resolution, symmetry

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

- **minimize**
  - 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

![Diagram of good and bad graph layouts](image)


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**4: Force-Directed Placement**

- nodes: repel like magnets
- edges: attract like springs
- start from random positions, run to convergence
- encoding: geometric for graph proximity

![Force-directed graph layout example](image)


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**Critique**

- **strengths**
  - Intuitive model
  - Many mathematical approaches
- **weaknesses**
  - Does not scale to large datasets

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**5: TopoLayout**

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

![TopoLayout diagram](image)

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

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**Multilevel Hierarchies**

- data: web sites, network backbones
- strengths: handles large class of graphs
- weaknesses: poor if no detectable features

![Multilevel hierarchical layout example](image)

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

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**6: Animated Radial Layouts**

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

![Animated radial layout example](image)

**Animation**

polar interpolation

![Diagram](image1)

- maintain neighbor order


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**Critique**

**Strengths**

- smoother transitions

**Weaknesses**

- not scalable to large datasets

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**7: Constellation**

**Data**: semantic network from dictionary entry

- nodes: English words, links: used together in entry

- information density

- design tradeoff with visual salience


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**Traditional Layout**

- avoid crossings
  - considered "aesthetic criterion"

- reason: avoid false attachments

- ambiguity

- artifact salience

![Diagram](image3)

[graphics.stanford.edu/papers/munzerthesis/html/node28.html#radiallayoutfig]

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**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/corb)]

![Diagram](image4)

[graphics.stanford.edu/papers/munzerthesis/html/node38.html#radiusemphasisfig]

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**Critique**

**Strengths**

- highly specialized

- good information density in final version

- perceptual layering successful

**Weaknesses**

- highly specialized

- custom system design is expensive
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8: Treemaps

data: filesystems, stock performance

show structure with containment not connection

- size according to node attribute

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

strengths

weaknesses

Dawson et al. Cluster Stability and the Use of Noise in Interpretation of Clustemps, Invisvis 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
- position: box shows link between nodes in row/column
- color: calls not in specification in red

Force-directed
Layered subset (dot)

Abstraction Levels

Matrices: uniform, recursive, stable

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

Weaknesses
- see only small fraction of information in detail view


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


14: H3

Data: web sites, species relationships
3D fisheye from hyperbolic geometry
[Video/Demo: graphics.stanford.edu/~munzner/h3]

15: TreeJuxtaposer

Data: species evolutionary relationships
Task: side by side comparison accordion drawing
- guaranteed visibility of landmarks
- stretch and squash navigation
[Demo: olduval.st.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 squash navigation inappropriate for tasks
- requiring distance estimation
- computationally intensive

SequenceJuxtaposer

data: genomic sequences
task: side by side comparison
accordion drawing

[video/demo: oldsvai.sf.net/sj]

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Hard Problems

design within huge space of possibilities
evaluate whether and how systems help real users

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

dynamic data

More Information

this talk
- www.cs.ubc.ca/~tmm/talks.html#nih06

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

conferences
- IEEE InfoVis symposia: www.infovis.org/symposia.php
- Graph Drawing conferences: www.gd2005.org

NIH/NSF Visualization Research Challenges Report
- tab.computer.org/vggtc/vrc