Lecture 3, InfoVis MiniCourse

Navigation/Zooming, Focus+Context, Graphs/Trees, Scalability, Task-Centered Design

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Mini-Course Outline
- Perception
- Frameworks
- Color
- Space/Order
- Depth/Occlusion
- High Dimensionality
- Interaction
- Navigation/Zooming
- Focus+Context
- Graphs/Trees
- Scalability
- Task-Centered Design

Spatial Navigation
- real navigation only partially understood
  - compared to low-level perception, JNDS
  - 3D vs. 2D: we don’t fly, we walk!

- spatial memory / environmental cognition
  - city: landmark/path/whole
  - [The Image of the City, Kevin Lynch, MIT Press 1960]

- synthetic vs. real displays
  - even perception not always the same!

  Overestimation of heights in virtual reality is influenced more by perceived
distal size than by the 2-D versus 3-D dimensionality of the display.
Ekman and Poulson, Perception, 11, 103-112, 2002

Pad++
- “infinitely” zoomable user interface (ZUI)

Space-Scale Diagrams
- reasoning about navigation and trajectories

[Space-Scale Diagrams: Understanding Multiscale Interfaces
George Furnas and Ben Bederson. Proc. SIGCHI’95,

Viewing Window

1D Version

Pan–Zoom Trajectories

Joint Pan–Zoom Problem

Shortest Path

Shortest Path, Details
Speed-Dependent Automatic Zooming

- amount depends on how far to pan

[demo]
[www.ui.is.s.u-tokyo.ac.jp/~takeo/java/autozoom/autozoom.htm]
[video]
[www.ui.is.s.u-tokyo.ac.jp/~takeo/video/autozoom.mov]

Smooth and Efficient Zooming

uw space: u = pan, w = zoom
- horiz axis: cross-section through objects
- point = camera at height w above object
- path = camera path

Optimal Paths Through Space

at each step, cross same number of ellipses
- cross minimal number of ellipses total

Multiscale Display

What's This?

Fisheye Focus+Context View!

leads to next topic...
More Reading

Pad++: A Zooming Graphical Interface for Exploring Alternate Interface Physics
Bederson and Hedin, Proc UIST ’94

Space-Scale Diagrams: Understanding Multiscale Interfaces
George Furgus and Ben Bederson, Proc SIGCHI ’95

Speed-Dependent Automatic Zooming for Browsing Large Documents
http://www-us painting.ac.jp/~takesh/papers/uit9000.pdf

Smooth and Efficient Zooming and Panning.

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Intuition

move part of surface closer to eye

stretchable rubber sheet
borders tacked down

merge overview and detail into combined view

[1 Review and Taxonomy of Distortion-Oriented Presentation Techniques.

Bifocal

transformation magnification

[1 Review and Taxonomy of Distortion-Oriented Presentation Techniques]

Polyfocal: Continuous Mag

transformation magnification

[1 Review and Taxonomy of Distortion-Oriented Presentation Techniques]
**Fisheye Views: Continuous Mag**

Transformation magnification

1D 2D rect polar norm polar

[A Review and Taxonomy of Distortion-Oriented Presentation Techniques]

**Multiple Foci**

Same params diffr params

Polyfocal magnification function dips allow this

[Nonlinear Magnification Fields, Alan Keahey, Proc InfoVis 1997]

[Nonlinear Magnification Fields, Alan Keahey, Proc InfoVis 1997]

**Nonlinear Magnification Functions**

Transformation
- distortion
- magnification (derivative of transformation)

Directionality
- easy: compute transformation given magnification
- hard: compute magnification given transformation

New mathematical framework
- approximate integration, iterative refinement
- minimize “error mesh”

[Nonlinear Magnification Fields, Alan Keahey, Proc InfoVis 1997]

**Expressiveness**

Magnification is more intuitive control
- allow expressiveness, data-driven expansion

[Nonlinear Magnification Fields, Alan Keahey, Proc InfoVis 1997]

**2D Hyperbolic Trees**

Fisheye effect from hyperbolic geometry

[The Hyperbolic Browser: A Focus + Context Technique for Visualizing Large Hierarchies, John]

**3D Hyperbolic Graphs: H3**

3D hyperbolic geometry, tree as backbone

[Video]

[graphics.stanford.edu/videos/h3]

**Layout**

**Problem**
- General problem is NP-hard

**Solution**
- Tractable spanning tree backbone
- Match mental model "quasi-hierarchical"
- Use domain knowledge to construct select parent from incoming links
- Non-tree links on demand

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**Avoiding disorientation**

**Problem**
- Maintain user orientation when showing detail
- Hard for big datasets
- Exponential in depth: node count, space needed

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**Overview and detail**

**Two windows:** Add linked overview
- Cognitive load to correlate

**Solution**
- Merge overview, detail
- "Focus+context"

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**Progressive rendering**

Want fast update during user interaction
- Fill in details when user is idle

Guaranteed frame rate algorithm

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H3 discussion: scalability

focus+context layout
- cognitive limit: if graph diameter >> visible area

[http://www.caida.org/tools/measurement/skitter/vitz/hypvis/mrdhypog.t.hires.png]

TreeJuxtaposer

keep root, landmark locations visible
- move from local F+C to global F+C
- rubber sheet with borders tacked down
- guaranteed visibility
- (demo)


More Reading

http://www.ai.mcc.ai.edu/people/yuminy lavoro/leung94.pdf
Nonlinear Magnification Fields, Alan Kehley, Proc InfVis 1997
The Hyperbolic Browser: A Focus + Context Technique for Visualizing Large Hierarchies,
http://citeseer.ist.psu.edu/lamping95focusontext.html
H3: Laying Out Large Directed Graphs in 3D Hyperbolic Space.
http://www.cs.ubc.ca/~tmm/papers/tj

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Hermann survey

true survey, won't try to summarize here

nice abstraction work by authors
- Strahler skeletonization
- ghosting, hiding, grouping


Animated Radial Layouts

static radial layouts: known algorithm

**Dynamic Graph Layout**

- little previous work
  - DynaDAG [North, Graph Drawing 95]
  - DA-TU [Huang, Graph Drawing 98]

- minimize visual changes
- stay true to current dataset structure

[video]

**SpaceTree**

- focus+context tree
  - animated transitions

- semantic zooming

[demo]

**Animation**

- polar interpolation

- maintain neighbor order

[http://ballando.sims.berkeley.edu/papers/infvis01.html]

**Treemaps**

- containment not connection

- difficulties reading

**Cushion Treemaps**

- show structure with shading
  - scale parameter controls global vs. local


**Cushion Treemaps**

- application
  - SequoiaView, Windows app
  - hard drive usage
  - http://www.win.tue.nl/sequoia/

- treemap strength
  - showing an attribute
**Graphs: Matrix vs. Node–Link**

- Large software project, implementation vs. spec
- Link matrix vs. node network

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Force-directed</th>
<th>Layered subset</th>
</tr>
</thead>
</table>

**Matrices**

- Uniform, recursive, stable
- Subdivide by total component count, visible subcomponent count

**Zooming**

- Abstraction levels
- Linear interpolation plus crossfade trajectories: will read van Wijk 03 in week 6

**Additional Encoding**

- Color: call allowed by spec
- Color: local region closest red
- Transparency: call density

- Histograms: size distribution

**Tasks Successfully Supported**

- Visual categorization
  - E.g. libraries with mostly incoming calls
- Previous summary shown to be incomplete
- Spotting unwanted calls
- Determining component dependencies

**Multiscale Small–World Graphs**

More Reading

Graph Visualization in Information Visualization: a Survey.
http://citeseer.nj.nec.com/herman4graph.html

Animated Exploration of Graphs with Radial Layout.
http://bolland.cs.umass.edu/projects/infovis01.htm


http://www.irmm.fr/~fjoanicot/Publication/ACJ03.pdf

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Million Items Viz

scaling up treemaps
1000x1200 pixels, million items
* atomic object displayed as distinguishable contiguous area using one viz technique

[Interactive Information Visualization of a Million Items]
Jean-Daniel Fevotte and Catherine Plaisant, Proc InfoVis 2002

Rendering Techniques

shading not outline
* visually distinguish items with less pixels

show overlap
* calculate with stencil buffer

transparency, stereo
* only for interactive/transient exploring

[Interactive Information Visualization of a Million Items]
Jean-Daniel Fevotte and Catherine Plaisant, Proc InfoVis 2002

Interaction Techniques

flipping/blingking
dynamic queries
* assign depth
* change Z-buffer with slider
excentric labels

animated transitions
* stabilized layouts
* separate translation, scaling
* switching representations

[no video]

[Interactive Information Visualization of a]
Jean-Daniel Fevotte and Catherine Plaisant, Proc InfoVis 2002

Incremental Dynamic Queries

dynamic queries: user-controlled slider

[no video]
Data Structures

setup
  · data set
selection
  · picking particular range slider
querying
  · moving the slider
maximum hit set
  · state of other sliders
  · extreme range of this slider
  · precompute bins in the range so slider movement fast

Critique

good: complexity analysis
bad: far too little detail to replicate
  · nothing on incremental rendering
  · insufficient on computation data structures

More Reading

Interactive Information Visualization of a Million Items
http://www.cs.umass.edu/itcal/cgi-bin/hcl/n-pf?number=2002-01

Design and Evaluation of Incremental Data Structures and Algorithms
http://citeserv.ri.in.tugraz.at/servlet/Research.html

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Task Analysis

what is the user’s general job?
how might infovis help – specific tasks?
do humans need to keep model of complex data inside head?
  · if small dataset, maybe don’t need infovis
  · if humans don’t need to directly understand, automate instead of visualize!
working directly with users very helpful
  · driving problems keeps you honest
  · they know tasks
  · you know design possibilities

Methodology

iterative refinement
  · user is not always right
  · initial discussion is start, not end
scenario
  · exactly how would tool be used
  · detailed examples
mockup
  · sketch on paper what interface would look like
  · much less work than programming
  · can try and discuss several alternatives
cognitive walkthrough
  · think about places where users might make mistakes
Evaluation

adoption
  - is it used?
anecdotal
  - did somebody discover something?
formal user studies
  - large groups for statistical significance
  - show it was XX% faster or YY% fewer errors
  - cannot design good experiment without training!
collaborate with psychologist, HCI
informal usability evaluations
  - generally much faster

justify design given conceptual framework
  - visual encoding given task and data

More Reading

Task-Centered User Interface Design
Clayton Lewis and John Rieman

entire short book available online as shareware
http://hcilib.org/tcuid/