Lecture 3, InfoVis MiniCourse

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

LaBRI, University of Bordeaux
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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]

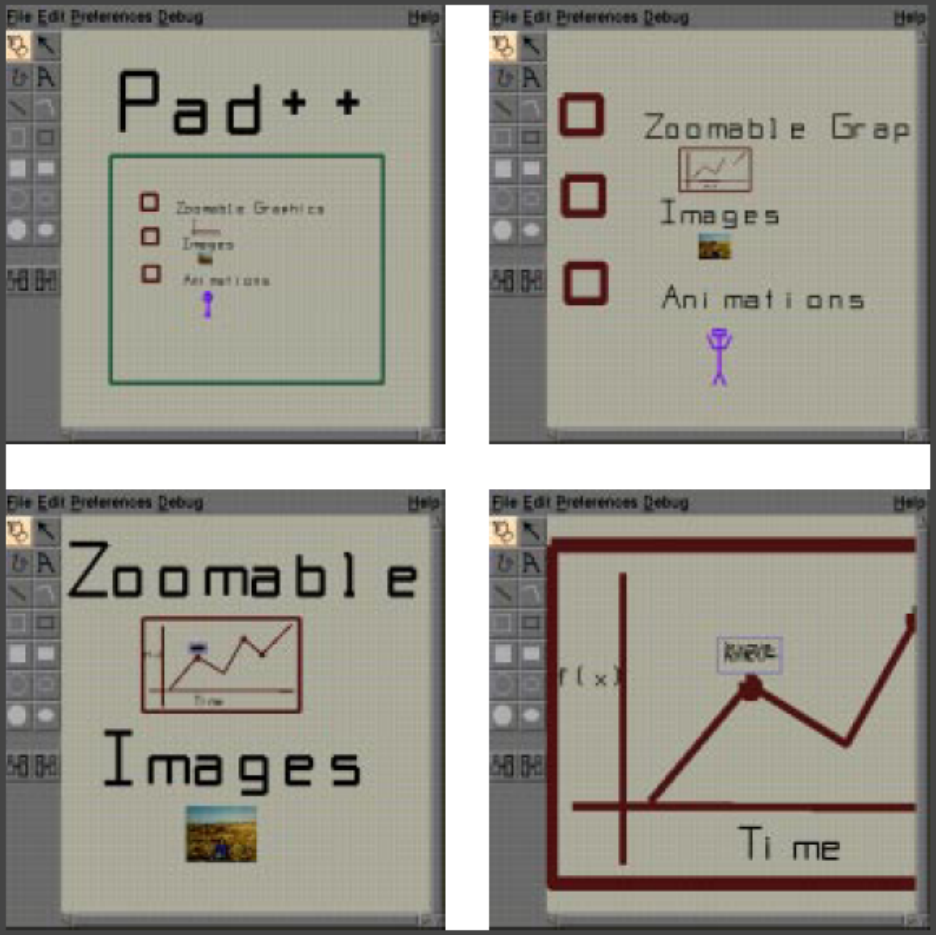
synthetic vs. real displays

- 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. Dixon and Proffitt. Perception, 31, 103-112, 2002]

Pad++

"infinitely" zoomable user interface (ZUI)



Space-Scale Diagrams

reasoning about navigation and trajectories

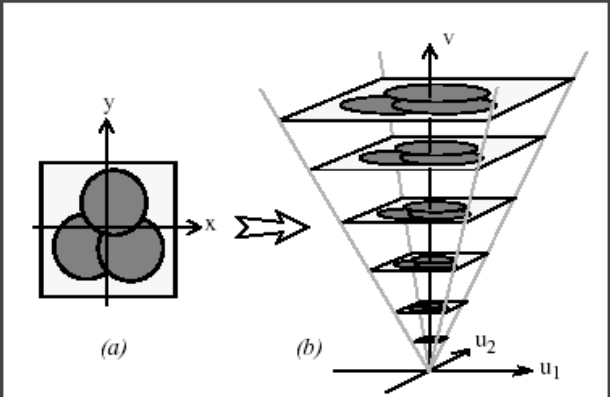
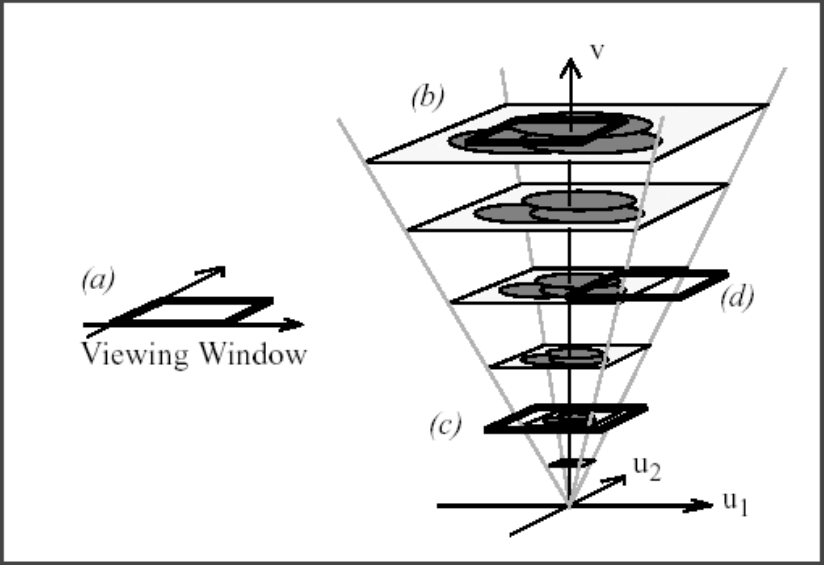


Figure 1. *The basic construction of a Space-Scale diagram from a 2D picture.*

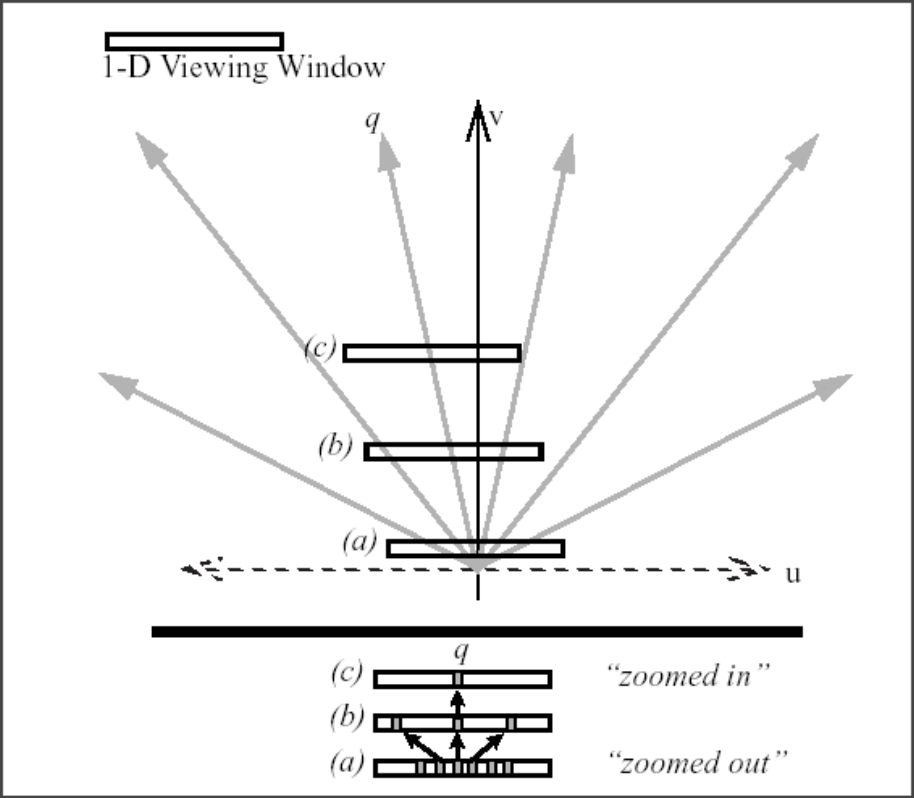
[Space-Scale Diagrams: Understanding Multiscale Interfaces
George Furnas and Ben Bederson, Proc SIGCHI '95.
www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf]

Viewing Window



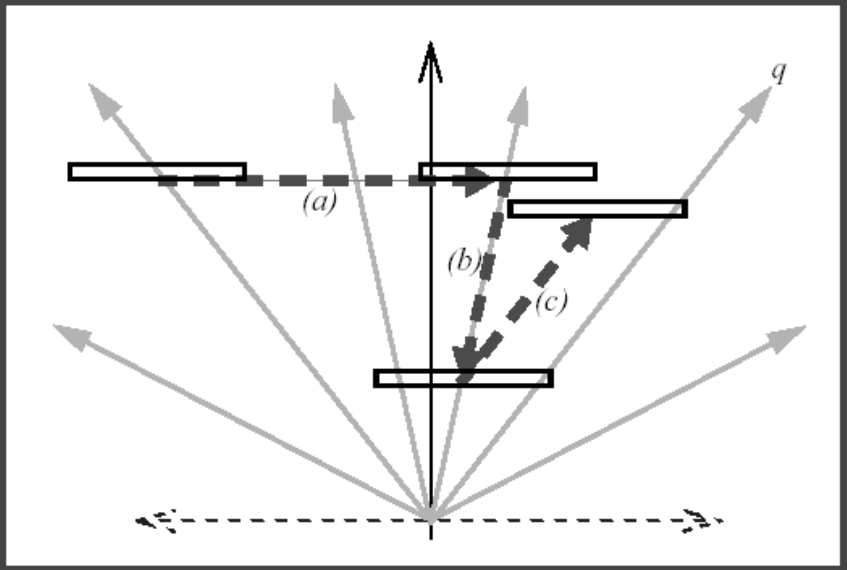
[www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf]

1D Version



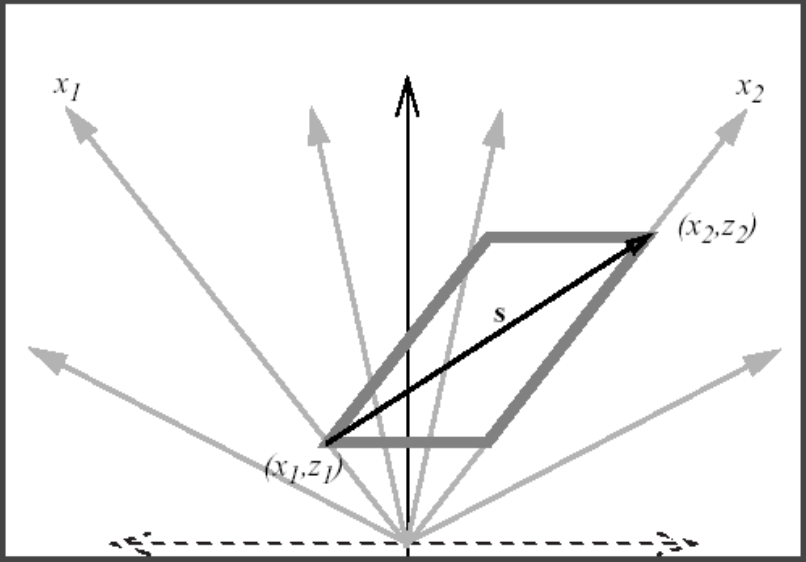
[www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf]

Pan-Zoom Trajectories



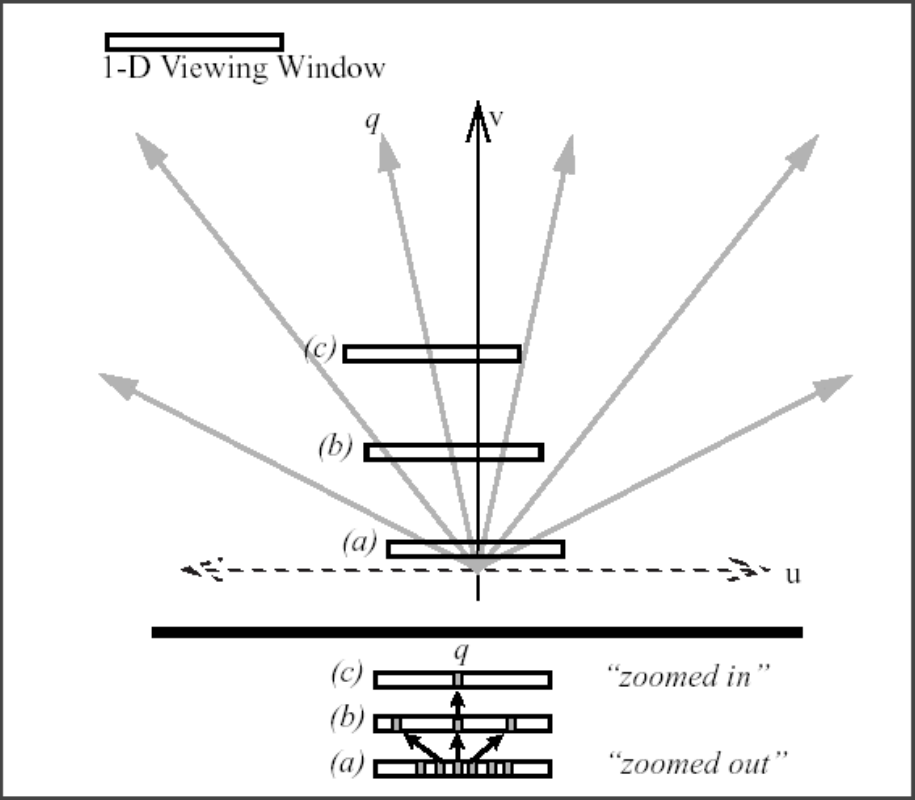
[www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf]

Joint Pan-Zoom Problem



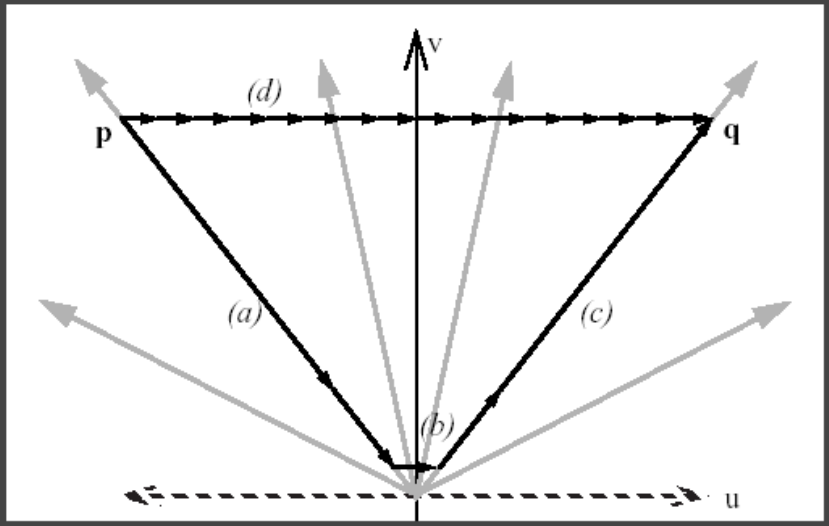
[www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf]

Shortest Path?



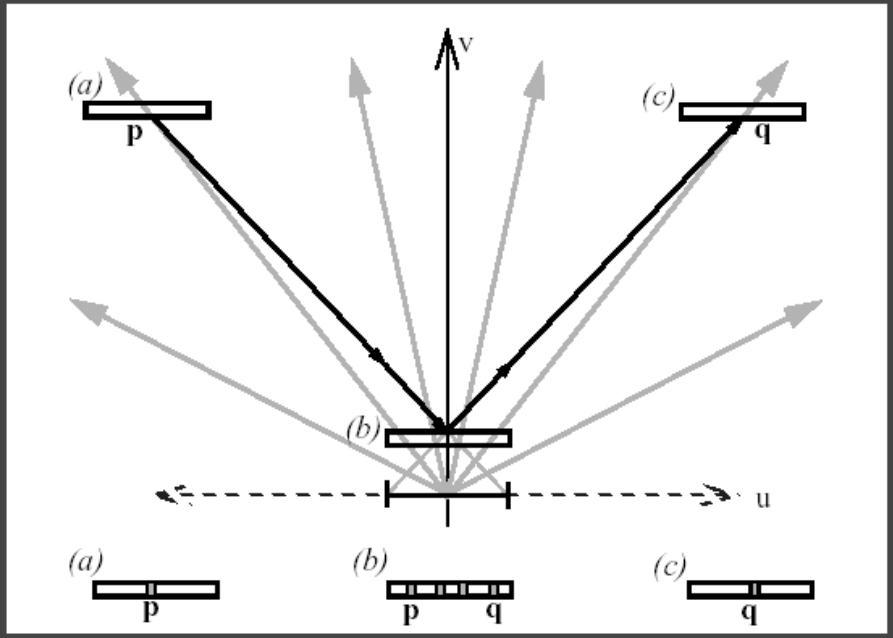
[www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf]

Shortest Path



[www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf]

Shortest Path, Details



[www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf]

Speed-Dependent Automatic Zooming

automatic zoom

- amount depends on how far to pan

[demo]

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

[video]

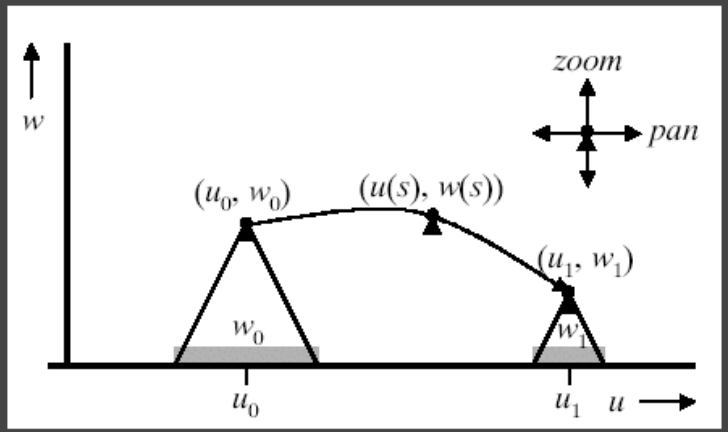
[www-ui.is.s.u-tokyo.ac.jp/~takeo/video/autozoom.mov]

[Speed-Dependent Automatic Zooming for Browsing Large Documents
Takeo Igarashi and Ken Hinckley, Proc. UIST'00, pp. 139-148.
www-ui.is.s.u-tokyo.ac.jp/~takeo/papers/uist2000.pdf]

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

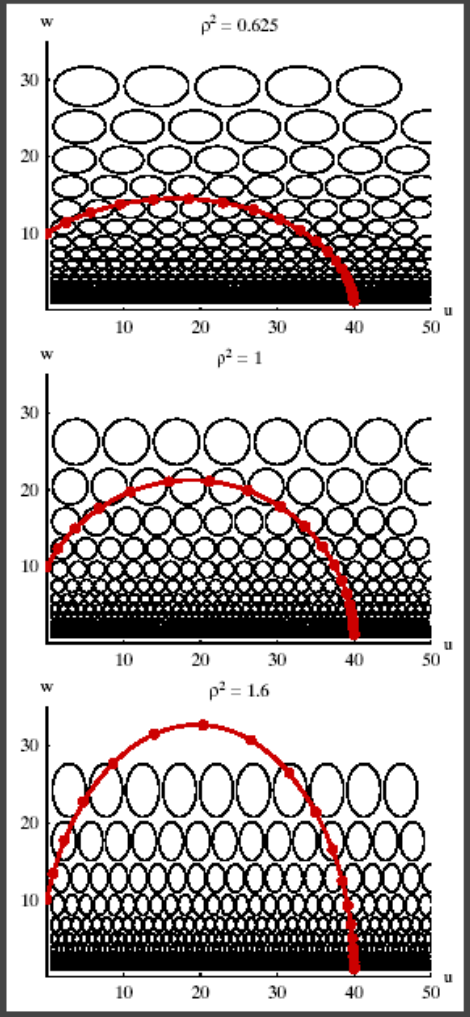


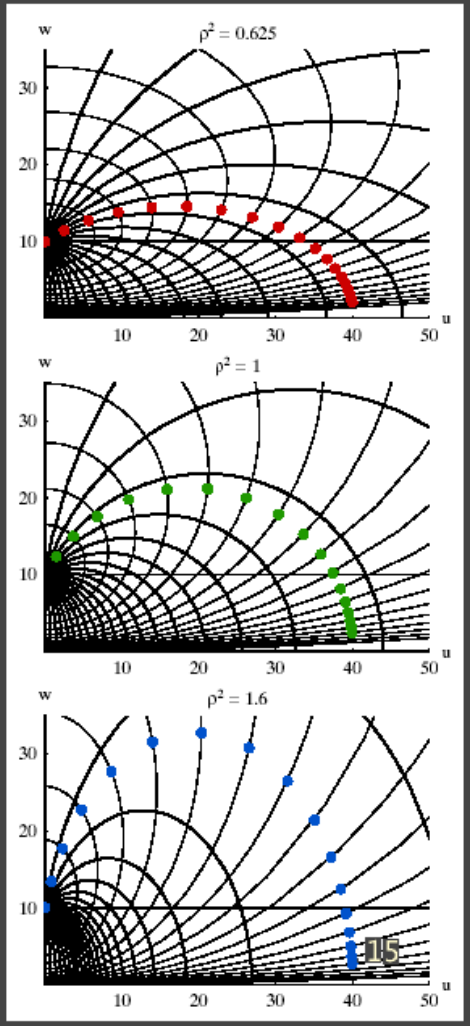
[Smooth and Efficient Zooming and Panning.
Jarke J. van Wijk and Wim AA Nuij. Proc InfoVis 2003.
http://www.win.tue.nl/~vanwijk/zoompan.pdf]

Optimal Paths Through Space

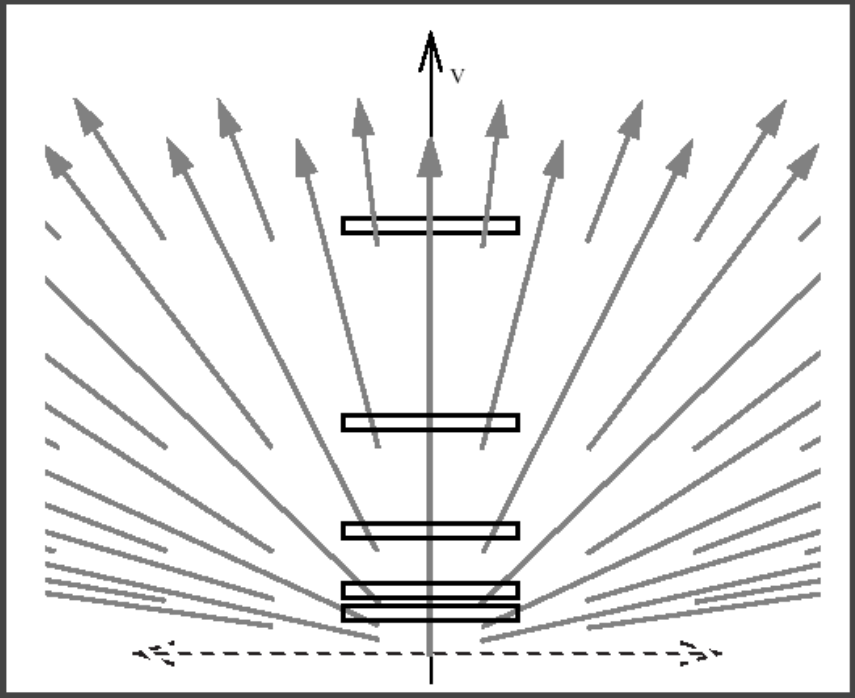
at each step, cross same number of ellipses

cross minimal number of ellipses total



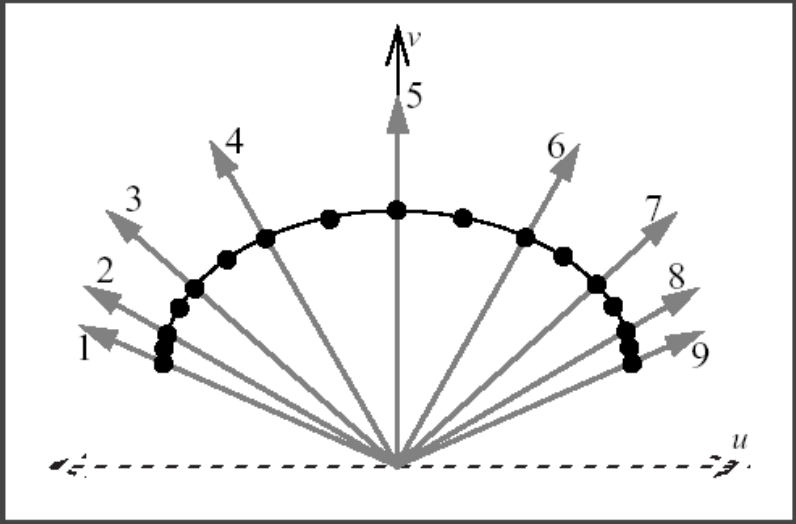


Multiscale Display



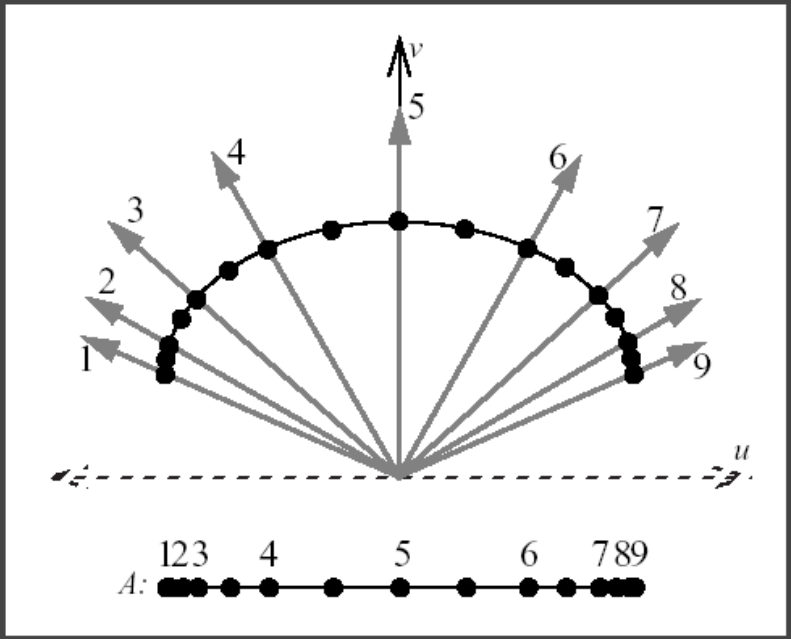
[www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf]

What's This?



[www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf]

Fisheye Focus+Context View!



leads to next topic...

[www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf]

More Reading

Pad++: A Zooming Graphical Interface for Exploring Alternate Interface Physics
Bederson and Hollan, Proc UIST 94
http://www.cs.umd.edu/hcil/pad++/papers/uist-94-pad/uist-94-pad.pdf

Space-Scale Diagrams: Understanding Multiscale Interfaces
George Furnas and Ben Bederson, Proc SIGCHI '95.
http://www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf

Speed-Dependent Automatic Zooming for Browsing Large Documents
Takeo Igarashi and Ken Hinckley, Proc. UIST'00, pp. 139-148.
http://www-ui.is.s.u-tokyo.ac.jp/~takeo/papers/uist2000.pdf

Smooth and Efficient Zooming and Panning.
Jarke J. van Wijk and Wim AA Nuij. Proc InfoVis 2003.
http://www.win.tue.nl/~vanwijk/zoompan.pdf

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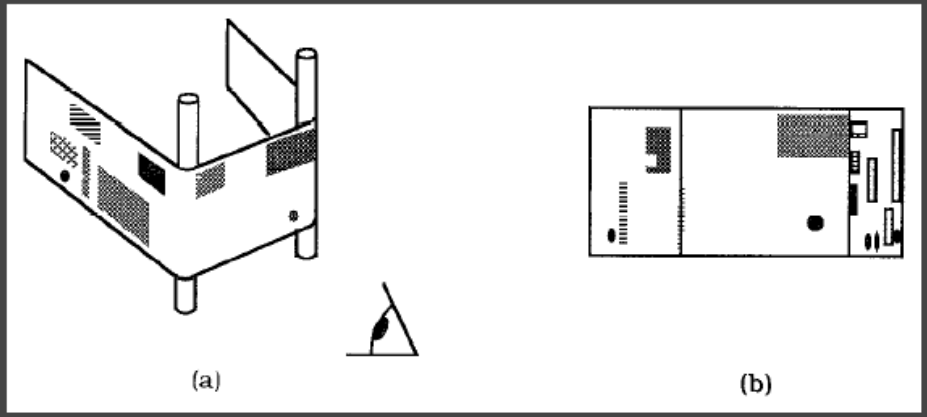
Task-Centered Design

Intuition

move part of surface closer to eye



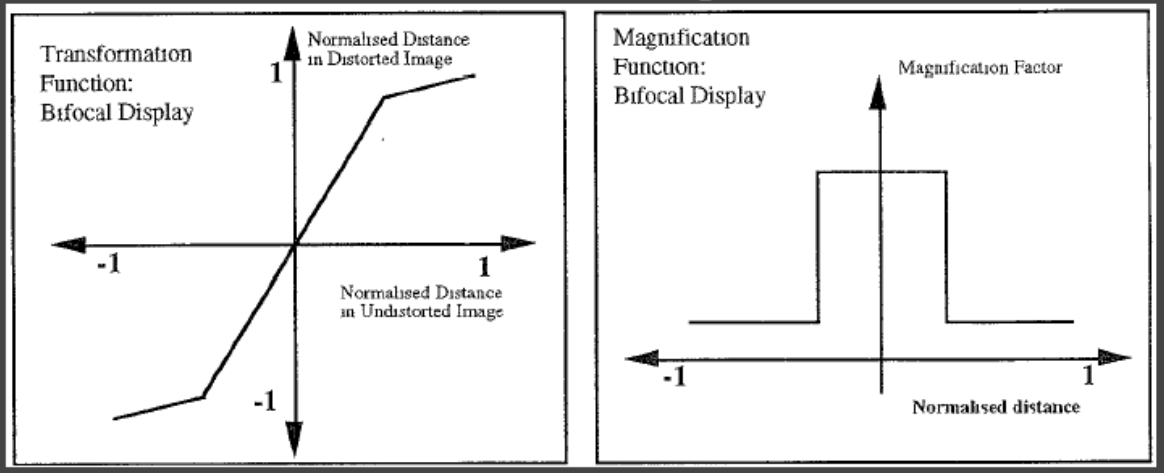
stretchable rubber sheet
borders tacked down

merge overview and detail into combined view

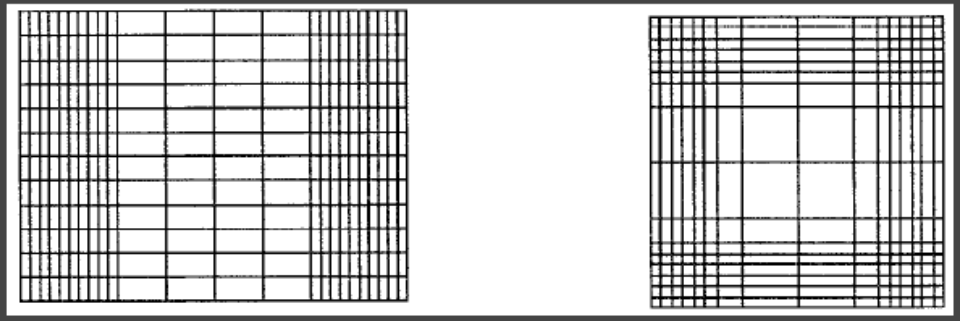
[A Review and Taxonomy of Distortion-Oriented Presentation Techniques. Leung and Apperley, www.ai.mit.edu/people/jimmylin/papers/Leung94.pdf]

Bifocal

transformation magnification



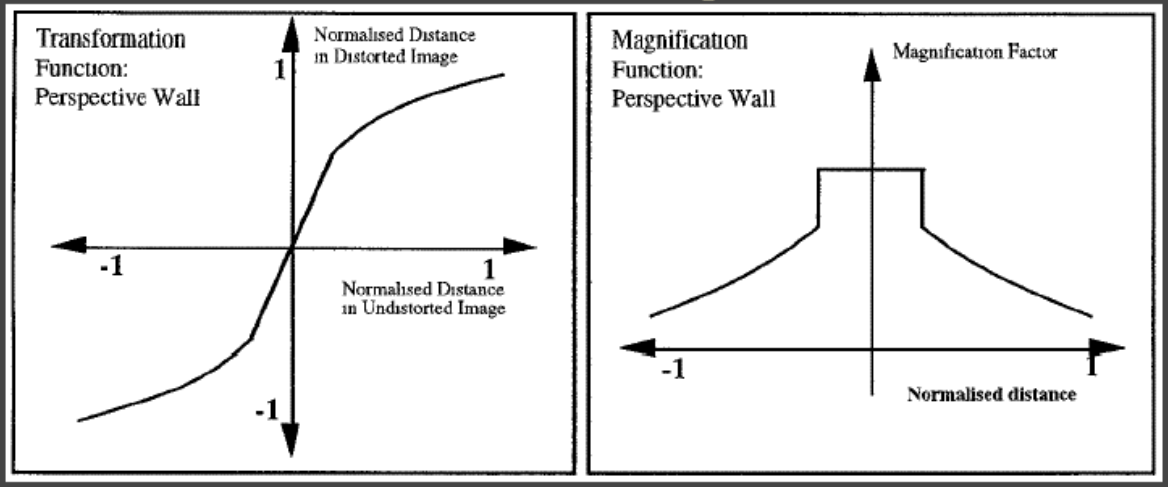
1D 2D



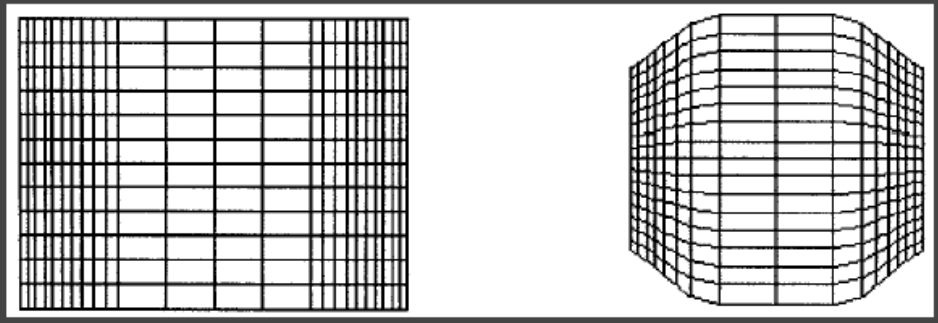
[A Review and Taxonomy of Distortion-Oriented Presentation Techniques]

Perspective Wall

transformation magnification



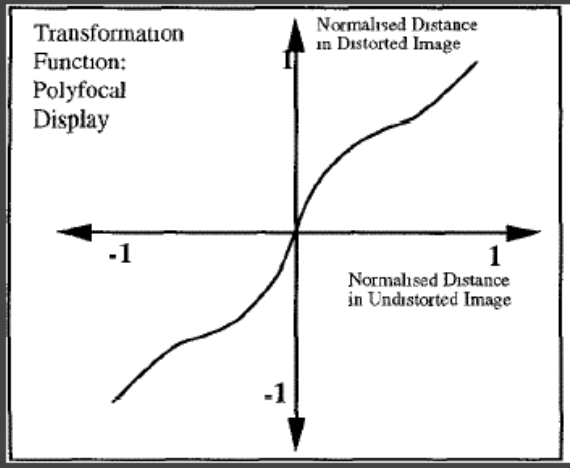
1D 2D



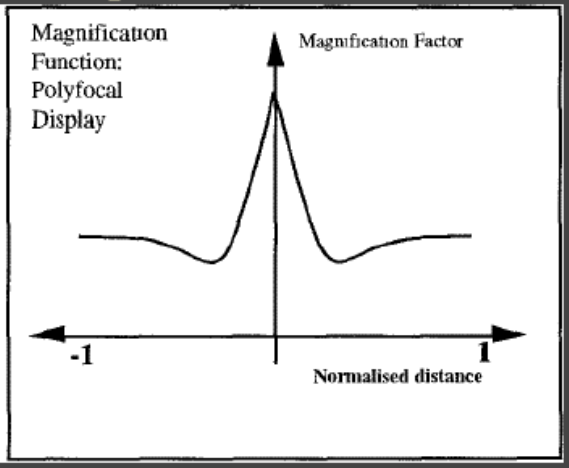
[A Review and Taxonomy of Distortion-Oriented Presentation Techniques]

Polyfocal: Continuous Mag

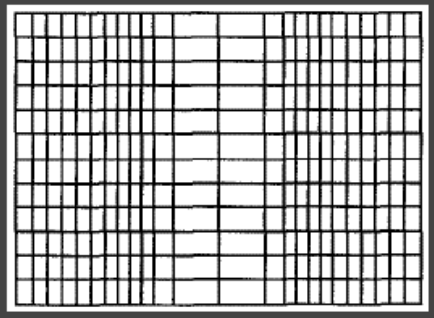
transformation



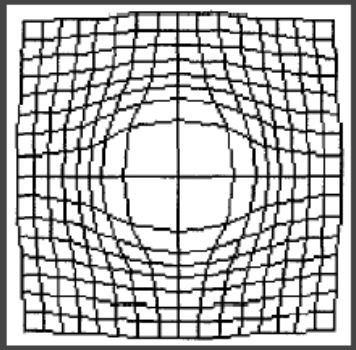
magnification



1D



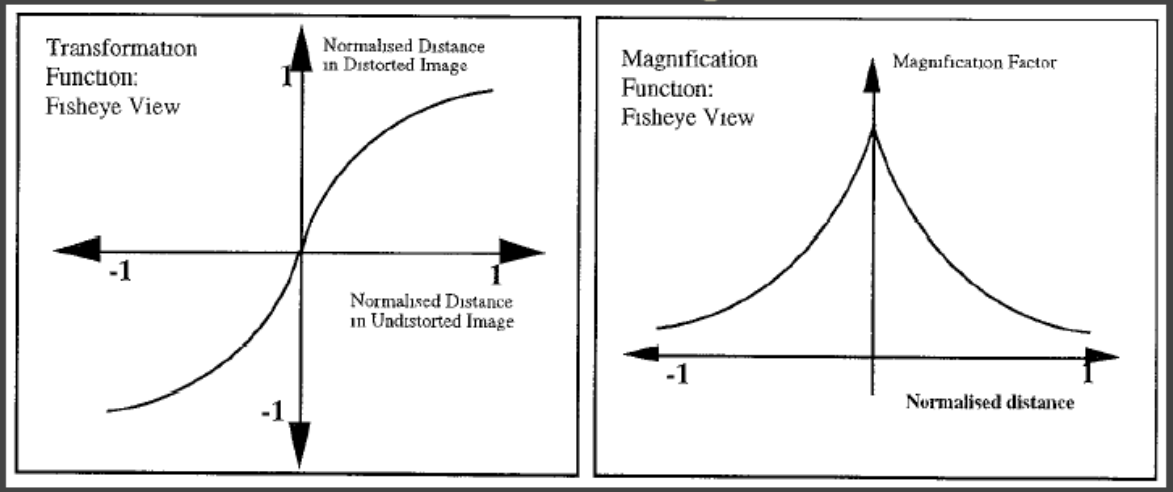
2D



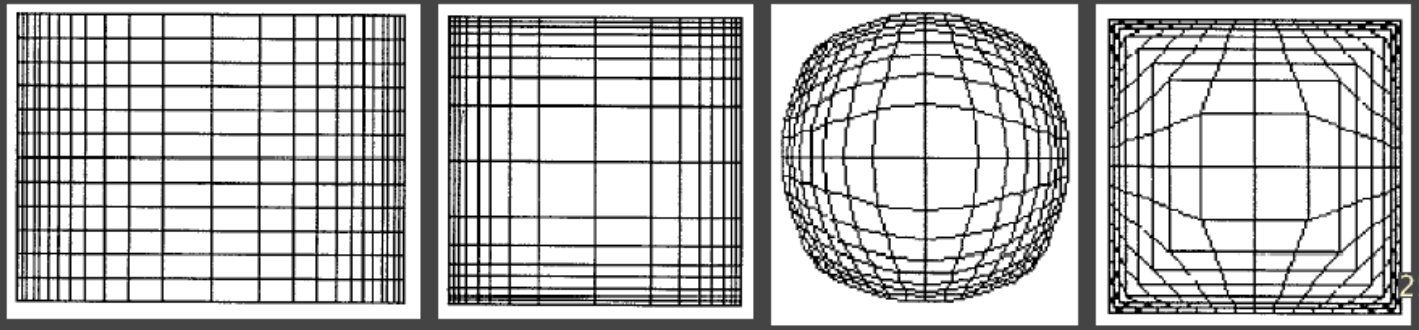
[A Review and Taxonomy of Distortion-Oriented Presentation Techniques]

Fisheye Views: Continuous Mag

transformation magnification



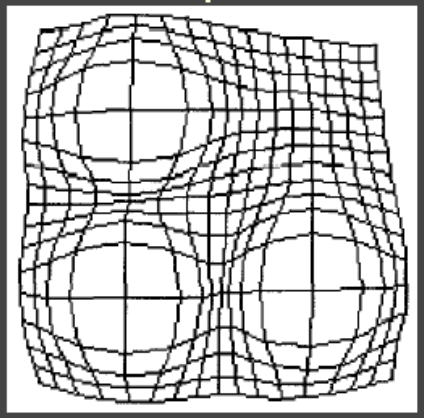
1D 2D rect polar norm polar



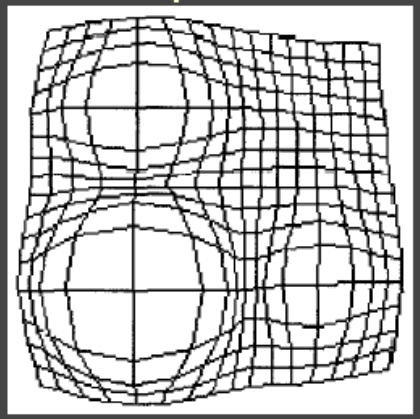
[A Review and Taxonomy of Distortion-Oriented Presentation Techniques]

Multiple Foci

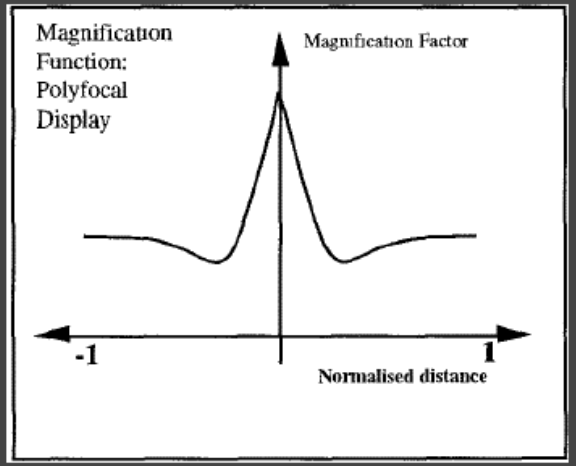
same params



diff params



polyfocal magnification function dips allow this



Nonlinear Magnification Functions

transformation
- distortion

magnification
- derivative of transformation

directionality
- easy: compute transformation given magnification derivative
- hard: compute magnification given transformation integration

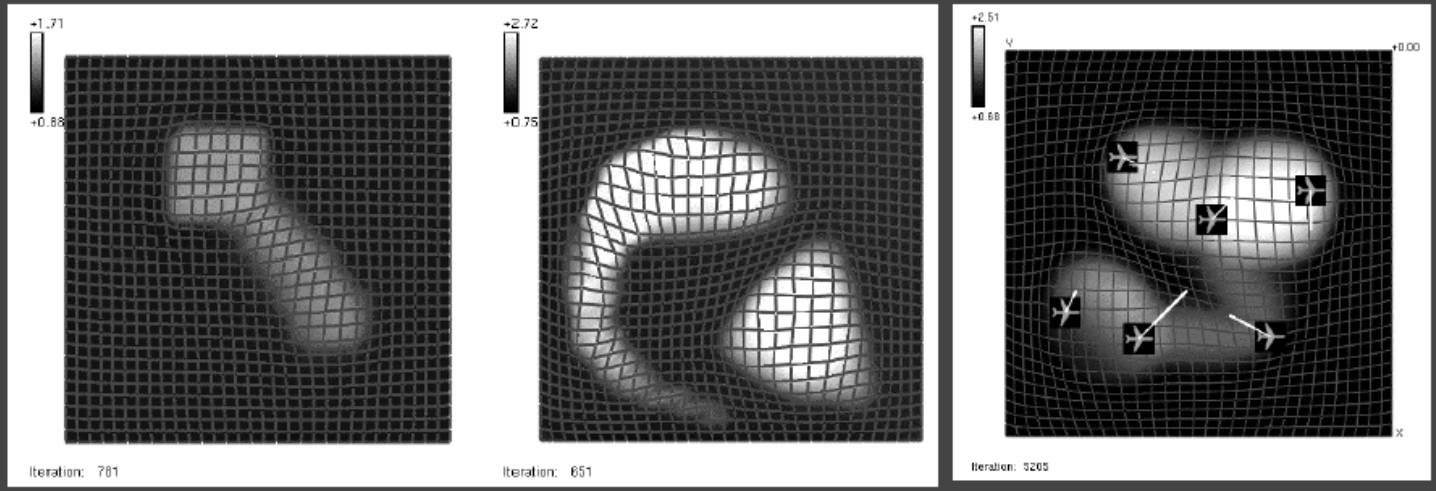
new mathematical framework
- approximate integration, iterative refinement
- minimize "error mesh"

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

Expressiveness

magnification is more intuitive control

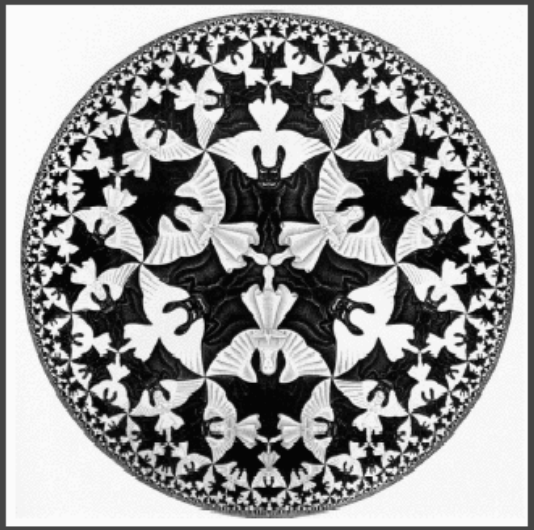
- allow expressiveness, data-driven expansion

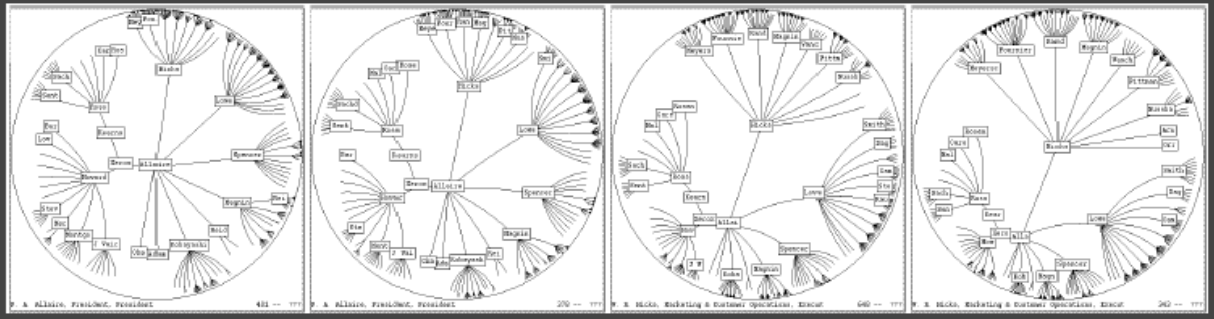


[Nonlinear Magnification Fields. Alan Keahey, Proc InfoVis 1997
ftp://ftp.cs.indiana.edu/pub/tkeahey/papers/infovis.97.pdf]

2D Hyperbolic Trees

fisheye effect from hyperbolic geometry



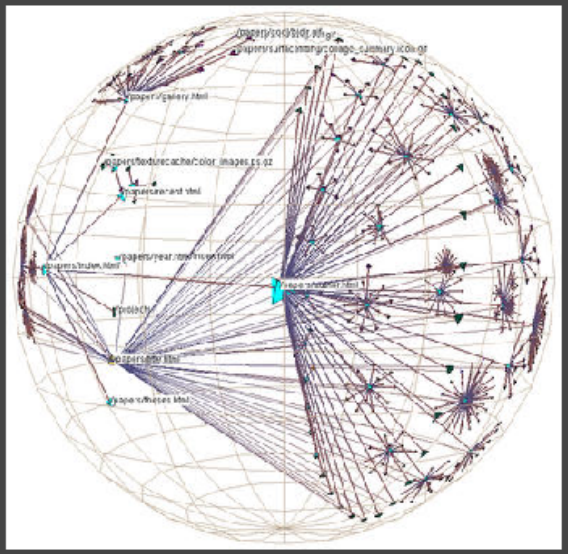


[The Hyperbolic Browser: A Focus + Context Technique for Visualizing Large Hierarchies. John

3D Hyperbolic Graphs: H3

3D hyperbolic geometry, tree as backbone

[video]
[graphics.stanford.edu/videos/h3]

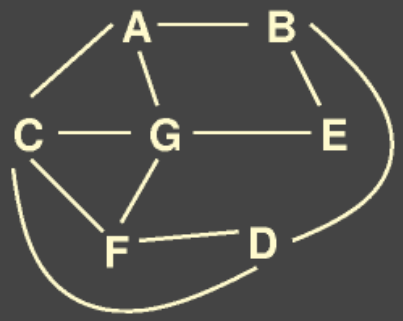


[H3: Laying Out Large Directed Graphs in 3D Hyperbolic Space.
Tamara Munzner, Proc InfoVis 97. http://graphics.stanford.edu/papers/h3]

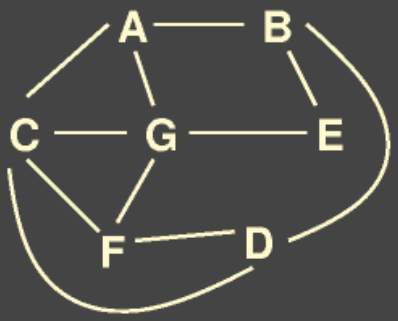
Layout

problem

- general problem is NP-hard



Layout



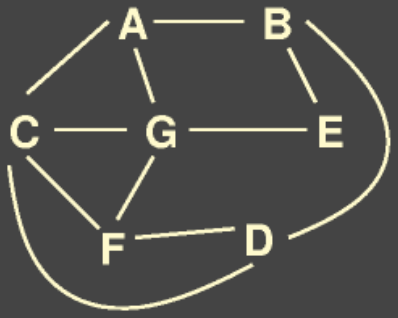
problem

- 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

Layout



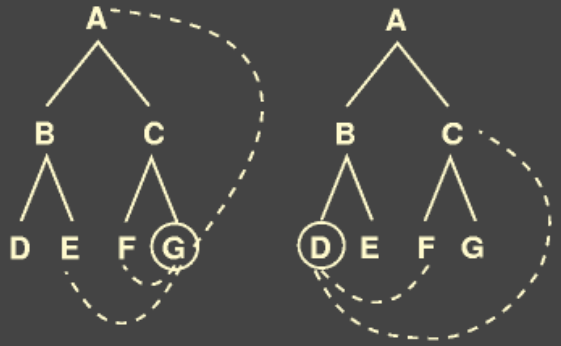
problem

- 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

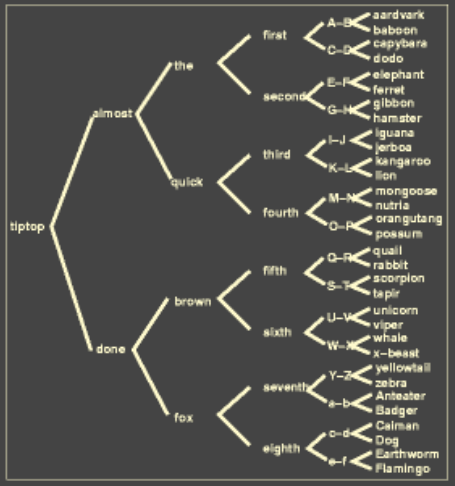


Avoiding disorientation

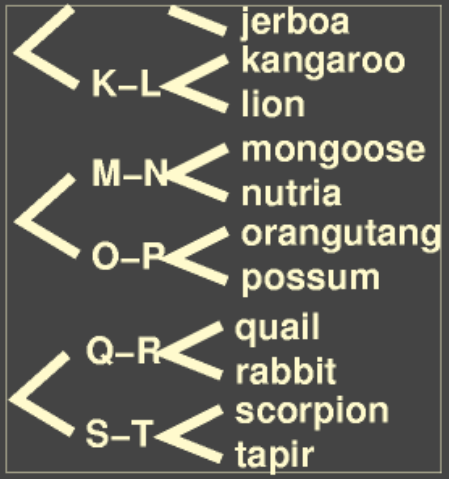
problem

- maintain user orientation when showing detail
- hard for big datasets

exponential in depth: node count, space needed



global overview

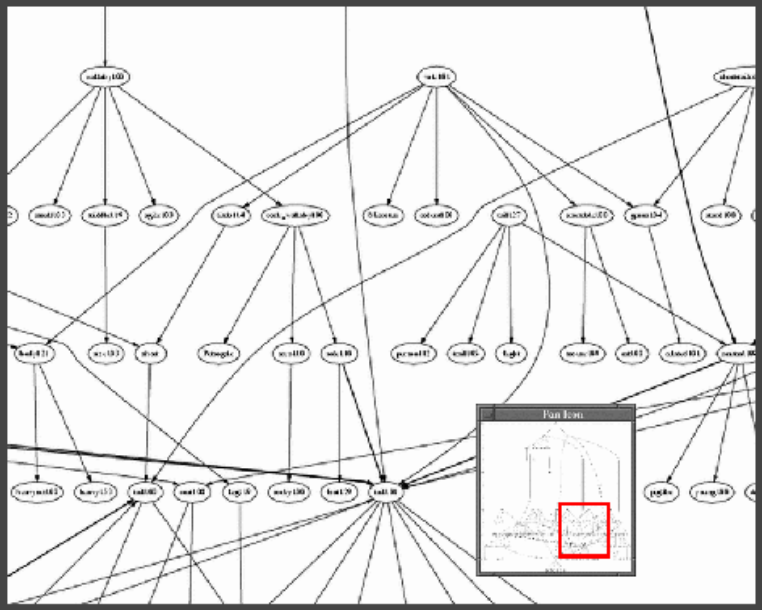


local detail

Overview and detail

two windows: add linked overview

- cognitive load to correlate



solution

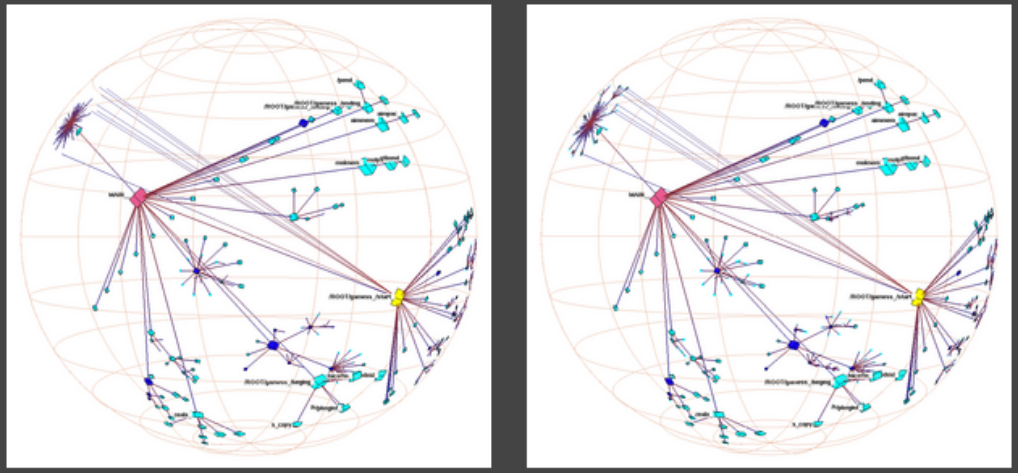
- merge overview, detail
- "focus+context"

Progressive rendering

want fast update during user interaction

- fill in details when user is idle

guaranteed frame rate algorithm

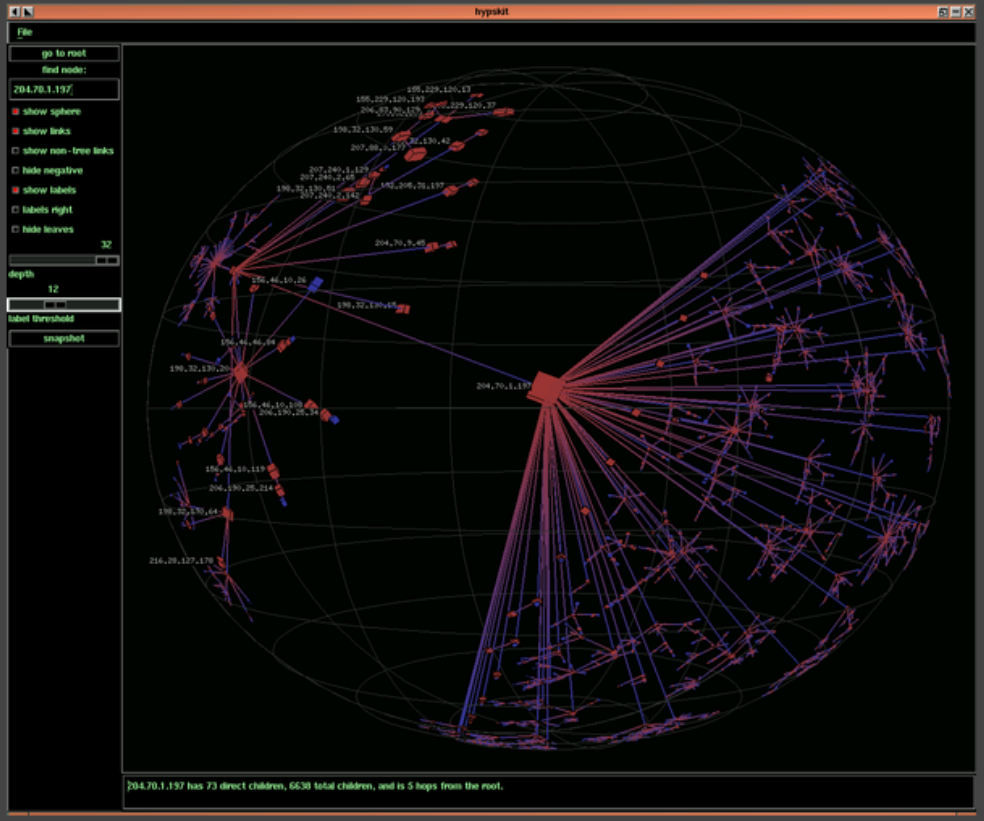


[Drawing Large Graphs with H3Viewer and Site Manager. Tamara Munzner Proc. Graph Drawing 98, http://graphics.stanford.edu/papers/h3draw]

H3 discussion: scalability

focus+context layout

- cognitive limit: if graph diameter >> visible area

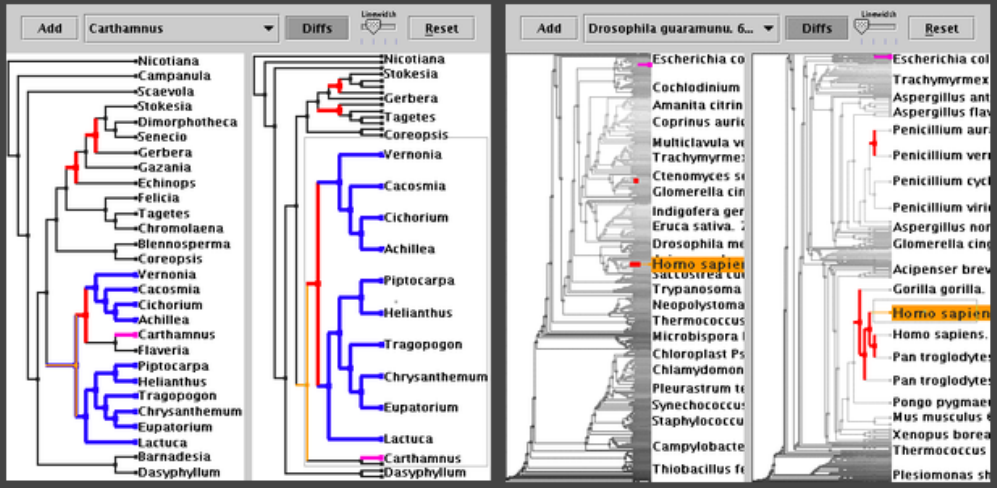


[http://www.caida.org/tools/measurement/skitter/viz/hypview/mrtdhypgui_hires.gif]

TreeJuxtaposer

keep root, landmark locations visible

- move from local F+C to global F+C
- rubber sheet with borders tacked down
- guaranteed visibility
- [demo]



[TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility. Munzner et al. SIGGRAPH 2003. http://www.cs.ubc.ca/~tmm/papers/tj]

More Reading

A Review and Taxonomy of Distortion-Oriented Presentation Techniques.
Y.K. Leung and M.D. Apperley, ACM Transactions on Computer-Human Interaction, Vol. 1, No. 2, June 1994, pp. 126-160.
http://www.ai.mit.edu/people/jimmylin/papers/Leung94.pdf

Nonlinear Magnification Fields. Alan Keahey, Proc InfoVis 1997
ftp://ftp.cs.indiana.edu/pub/tkeahey/papers/infovis.97.pdf

The Hyperbolic Browser: A Focus + Context Technique for Visualizing Large Hierarchies.
John Lamping and Ramana Rao, Proc SIGCHI '95.
http://citeseer.nj.nec.com/lamping95focuscontext.html

H3: Laying Out Large Directed Graphs in 3D Hyperbolic Space.
Tamara Munzner, Proc InfoVis 97. http://graphics.stanford.edu/papers/h3

Drawing Large Graphs with H3Viewer and Site Manager. Tamara Munzner
Proc. Graph Drawing 98, http://graphics.stanford.edu/papers/h3draw

TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility. Munzner et al. SIGGRAPH 2003.
http://www.cs.ubc.ca/~tmm/papers/tj

Mini-Course Outline

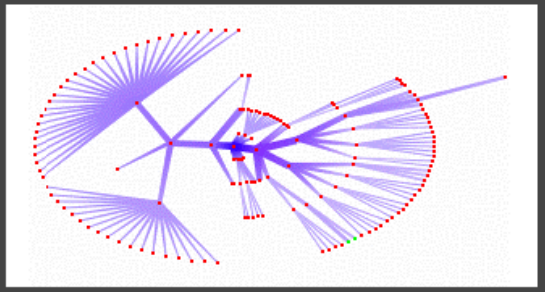
Perception
Frameworks
Color
Space/Order
Depth/Occlusion
High Dimensionality
Interaction
Navigation/Zooming
Focus+Context
Graphs/Trees
Scalability
Task-Centered Design

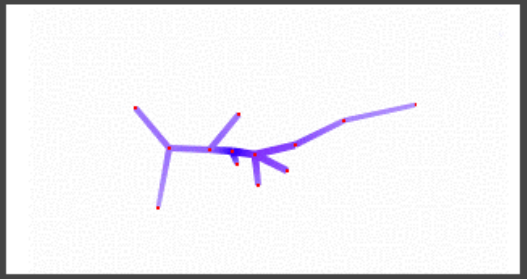
Hermann survey

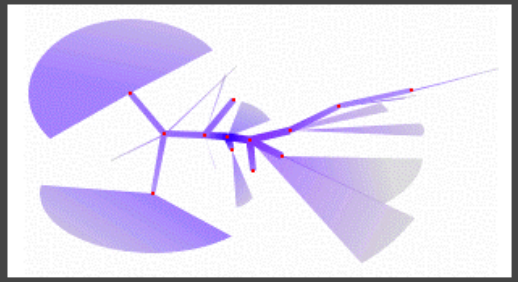
true survey, won't try to summarize here

nice abstraction work by authors

- Strahler skeletonization
- ghosting, hiding, grouping



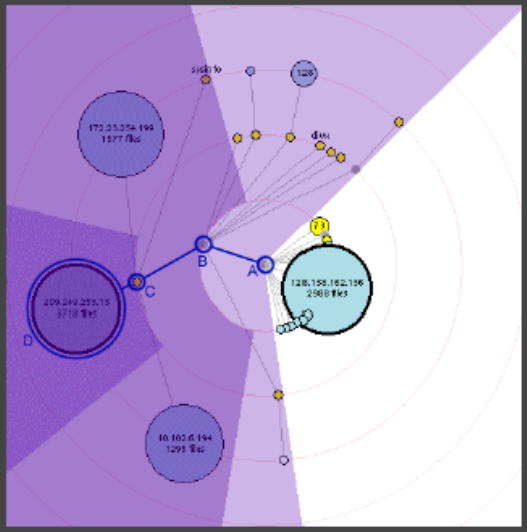




[Graph Visualisation in Information Visualisation: a Survey. Ivan Herman, Guy Melancon, M. Scott Marshall. IEEE Transactions on Visualization and Computer Graphics, 6(1), pp. 24–44, 2000. http://citeseer.nj.nec.com/herman00graph.html]

Animated Radial Layouts

static radial layouts: known algorithm



[Animated Exploration of Graphs with Radial Layout.
Ka-Ping Yee, Danyel Fisher, Rachna Dhamija, and Marti Hearst, Proc. InfoVis 2001.
http://bailando.sims.berkeley.edu/papers/infovis01.htm]

Dynamic Graph Layout

little previous work

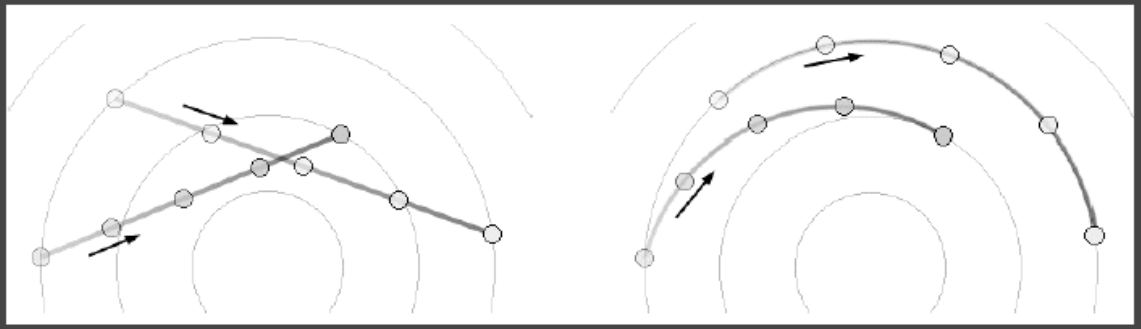
- DynaDAG [North, Graph Drawing 95]
- DA-TU [Huang, Graph Drawing 98]

minimize visual changes
stay true to current dataset structure

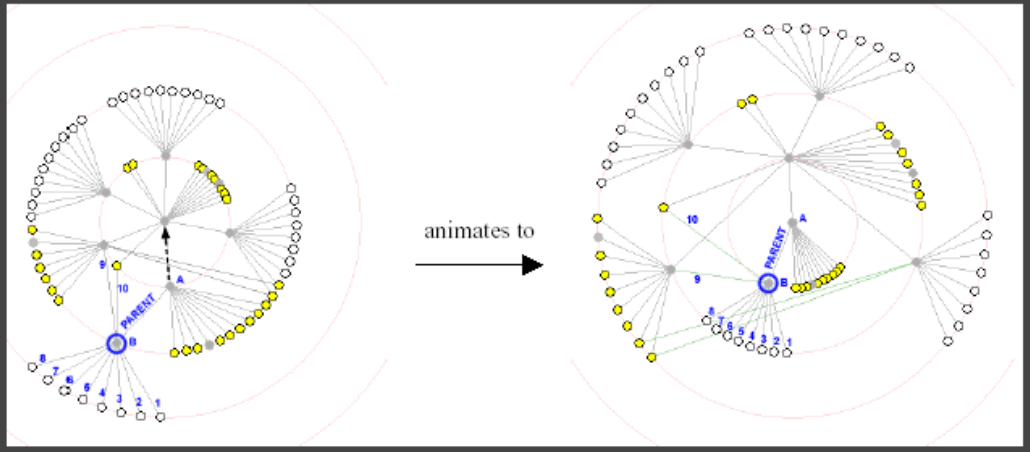
[video]

Animation

polar interpolation



maintain neighbor order

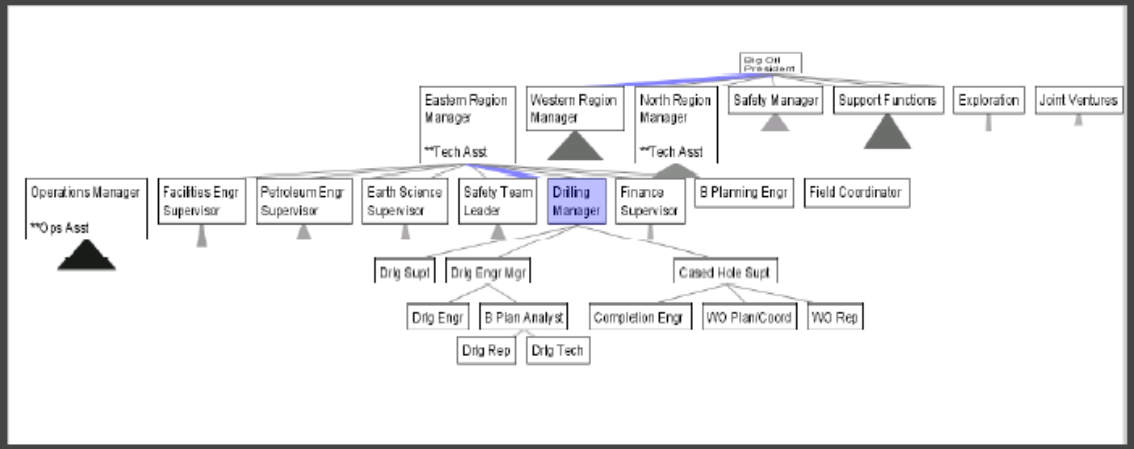


[http://bailando.sims.berkeley.edu/papers/infovis01.htm]

SpaceTree

focus+context tree

- animated transitions



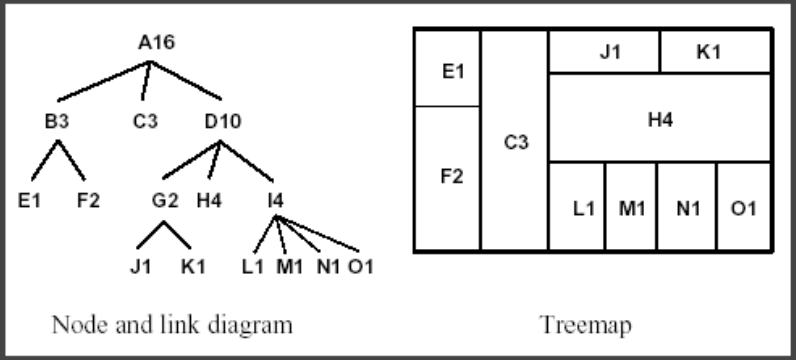
semantic zooming

[demo]

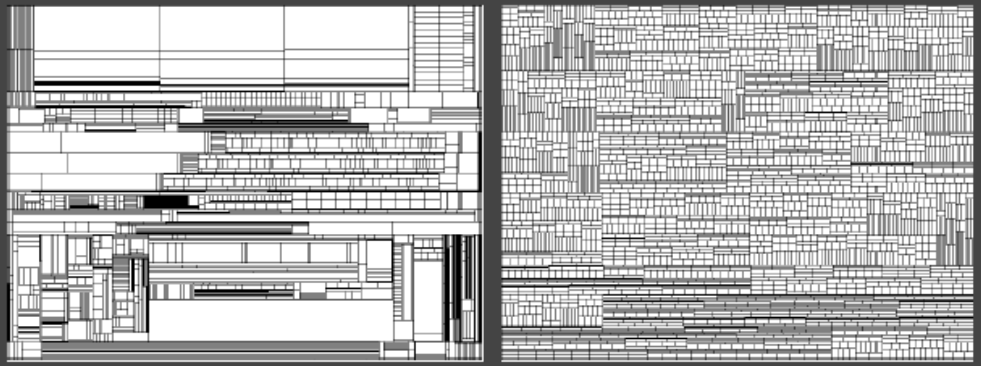
[SpaceTree ftp://ftp.cs.umd.edu/pub/hcil/Reports-Abstracts-Bibliography/2002-05html/2002-05.pdf]

Treemaps

containment not connection



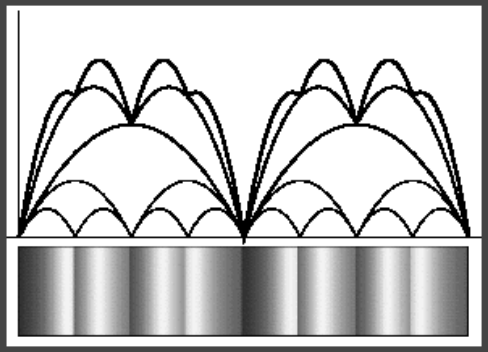
difficulties reading

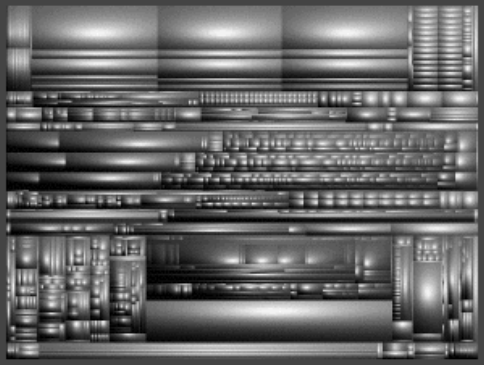


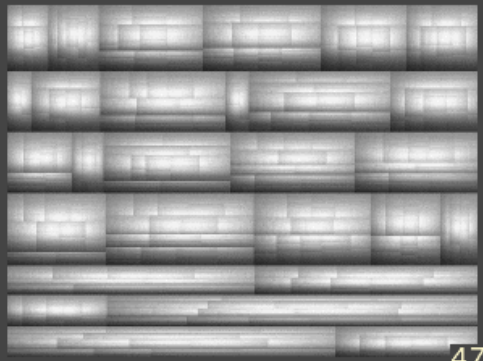
Cushion Treemaps

show structure with shading

- scale parameter controls global vs. local







[Cushion Treemaps. Jack J. van Wijk and Huub van de Wetering, Proc InfoVis 1999, pp 73–78.
http://www.win.tue.nl/~vanwijk/ctm.pdf]

Cushion Treemaps

application

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

treemap strength

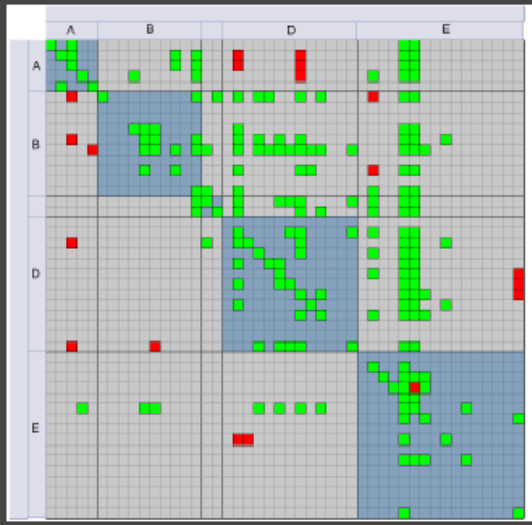
- showing an attribute

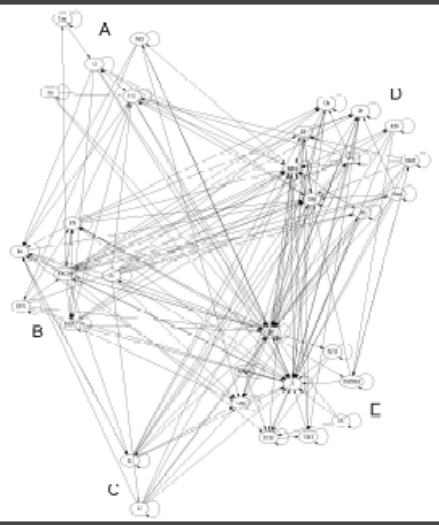
Graphs: Matrix vs. Node-Link

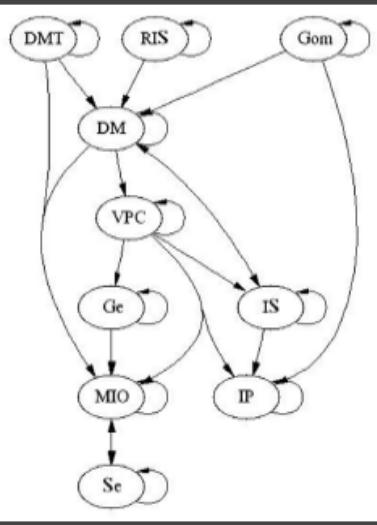
large software project, implementation vs. spec

link matrix vs. node network

matrix force-directed layered subset







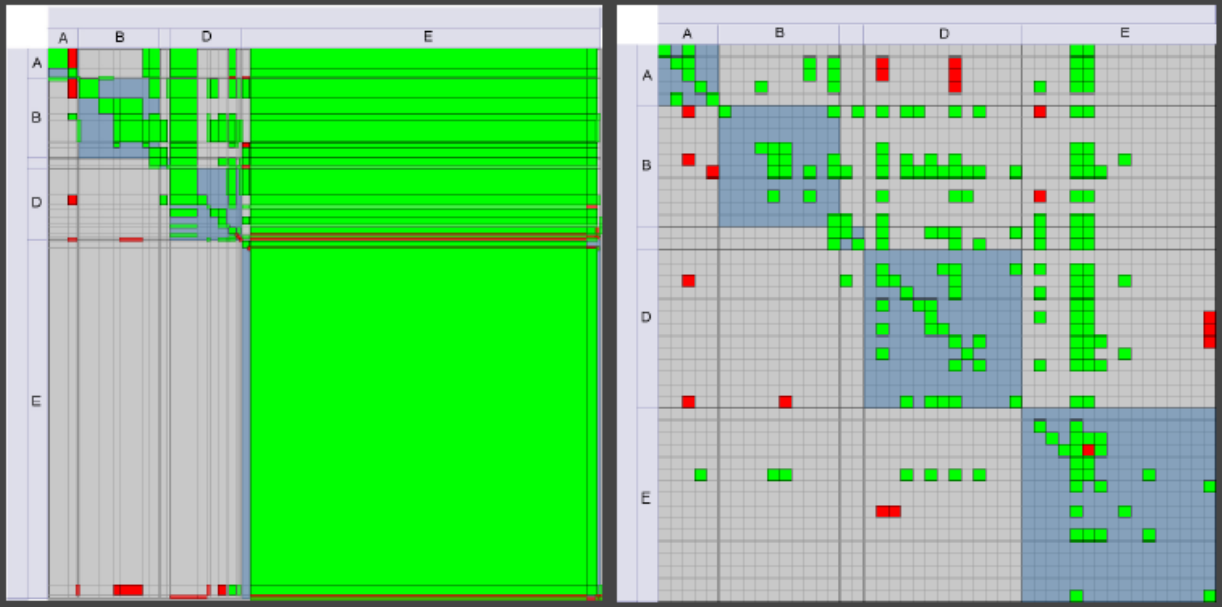
[Using Multilevel Call Matrices in Large Software Projects. Frank van Ham, Proc. InfoVis 2003, pp.227-232]

Matrices

uniform, recursive, stable
subdivide by

total component count

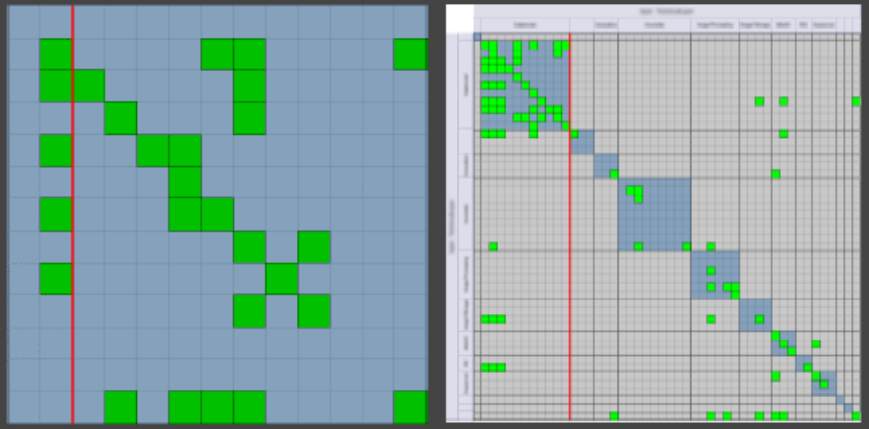
visible subcomponent count



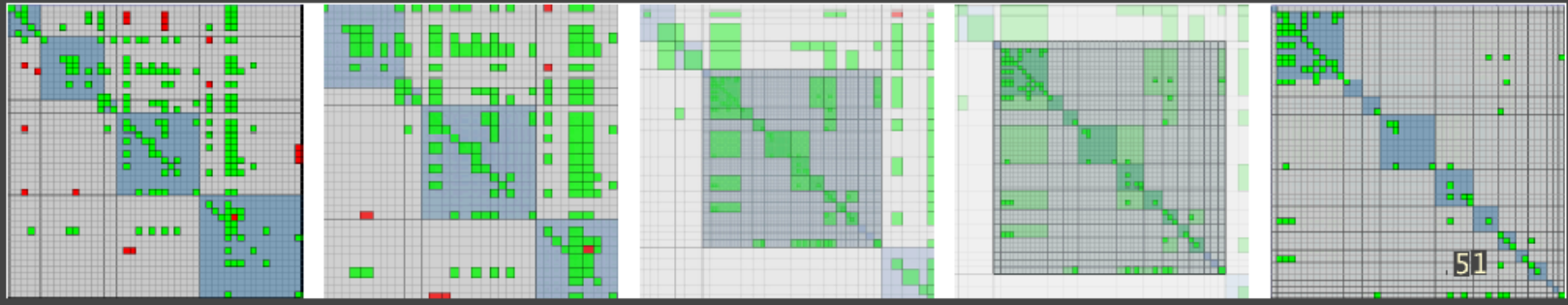
[Using Multilevel Call Matrices in Large Software Projects.
Frank van Ham, Proc. InfoVis 2003, pp.227–232]

Zooming

abstraction levels



linear interpolation plus crossfade
trajectories: will read van Wijk 03 in week 6



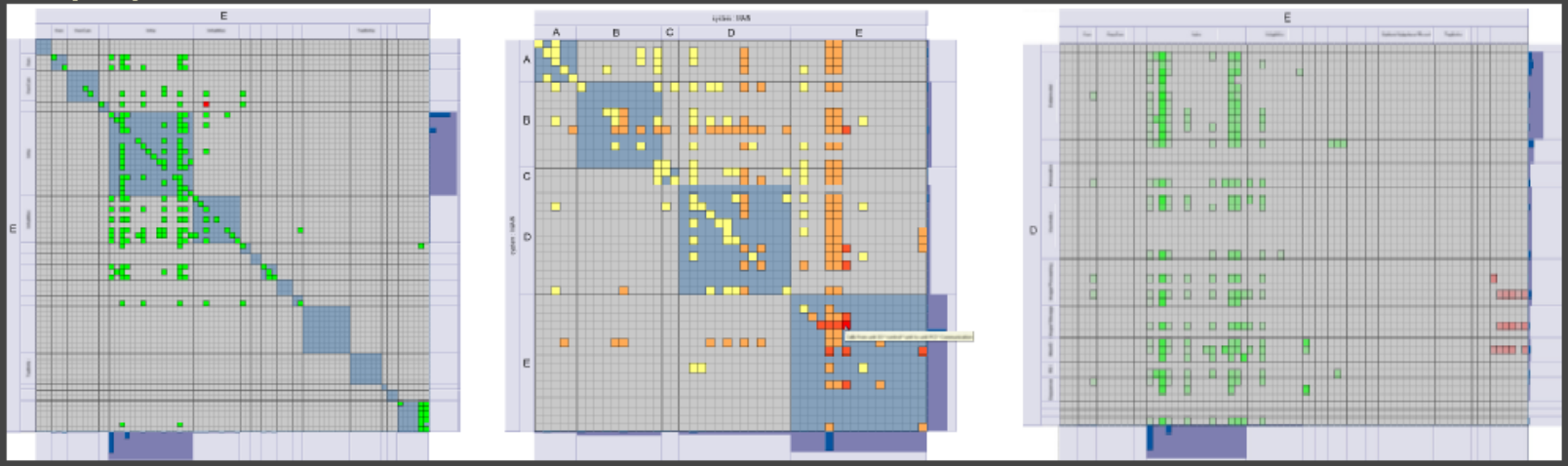
[Using Multilevel Call Matrices in Large Software Projects, van Ham]

Additional Encoding

color:
call allowed
by spec

color:
local region
closest red

transparency:
call density



histograms: size distribution

[Using Multilevel Call Matrices in Large Software Projects.
Frank van Ham, Proc. InfoVis 2003, pp.227–232]

Tasks Succesfully Supported

visual categorization

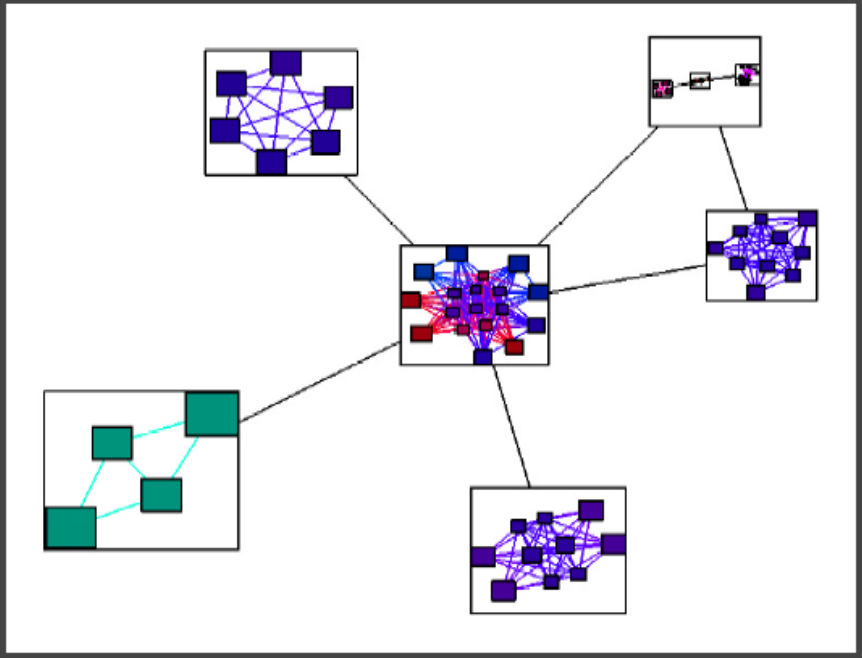
- i.e. libraries with mostly incoming calls

previous summary shown to be incomplete

spotting unwanted calls

determining component dependencies

Multiscale Small-World Graphs



[Multiscale Visualization of Small World Networks. David Auber, Yves Chiricota, Fabien Jourdan, Guy Melancon, Proc. InfoVis 2003.]

More Reading

Graph Visualisation in Information Visualisation: a Survey.
Ivan Herman, Guy Melancon, M. Scott Marshall.
IEEE Transactions on Visualization and Computer Graphics, 6(1), pp. 24-44, 2000.
http://citeseer.nj.nec.com/herman00graph.html

Animated Exploration of Graphs with Radial Layout.
Ka-Ping Yee, Danyel Fisher, Rachna Dhamija, and Marti Hearst, Proc InfoVis 2001.
http://bailando.sims.berkeley.edu/papers/infovis01.htm

SpaceTree: Supporting Exploration in Large Node Link Tree, Design Evolution and Empirical Evaluation. Catherine Plaisant, Jesse Grosjean, and Ben B. Bederson. Proc. InfoVis 2002. ftp://ftp.cs.umd.edu/pub/hcil/Reports-Abstracts-Bibliography/2002-05html/2002-05.pdf

Cushion Treemaps. Jack J. van Wijk and Huub van de Wetering,
Proc InfoVis 1999, pp 73-78. http://www.win.tue.nl/~vanwijk/ctm.pdf

Using Multilevel Call Matrices in Large Software Projects.
Frank van Ham, Proc. InfoVis 2003, pp.227-232

Multiscale Visualization of Small World Networks.
David Auber, Yves Chiricota, Fabien Jourdan, Guy Melancon, Proc. InfoVis 2003.
http://www.lirmm.fr/~fjourdan/Publication/ACJM03.pdf

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Graphs/Trees
Scalability
Task-Centered Design

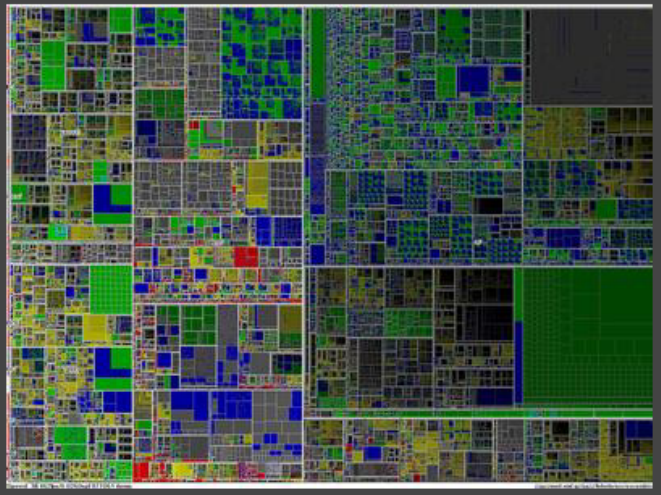
Million Items Viz

scaling up treemaps

- 1600x1200 pixels, million items

item

- atomic object displayed as distinguishable contiguous area using one viz technique

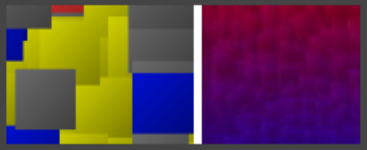


[Interactive Information Visualization of a Million Items
Jean-Daniel Fekete and Catherine Plaisant, Proc InfoVis 2002
http://www.cs.umd.edu/local-cgi-bin/hcil/rr.pl?number=2002-01]

Rendering Techniques

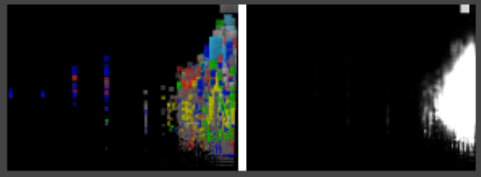
shading not outline

- 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 Fekete and Catherine Plaisant, Proc InfoVis 2002
http://www.cs.umd.edu/local-cgi-bin/hcil/rr.pl?number=2002-01]

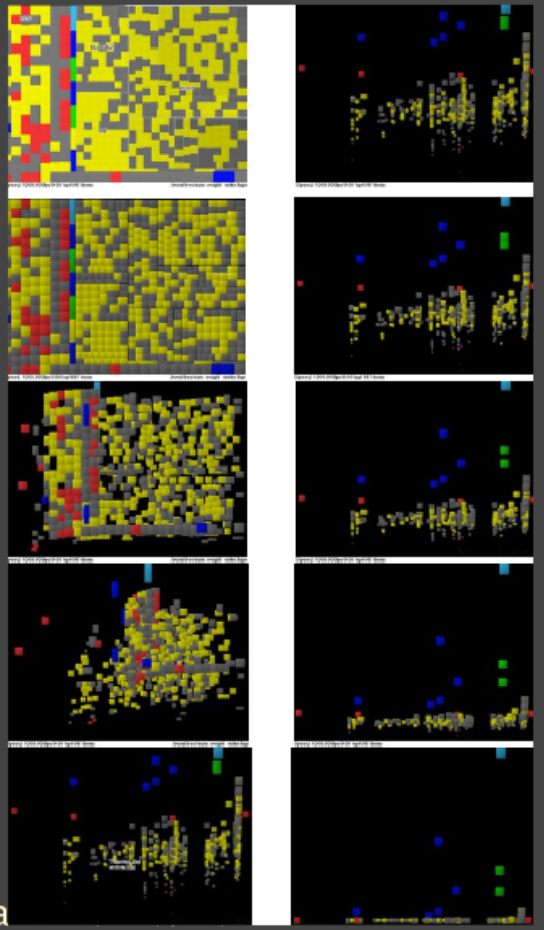
Interaction Techniques

flipping/blinking
dynamic queries
- assign depth
- change Z-buffer with slider

excentric labels

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

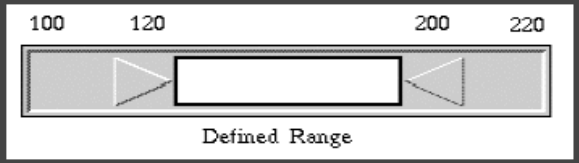
[no video]

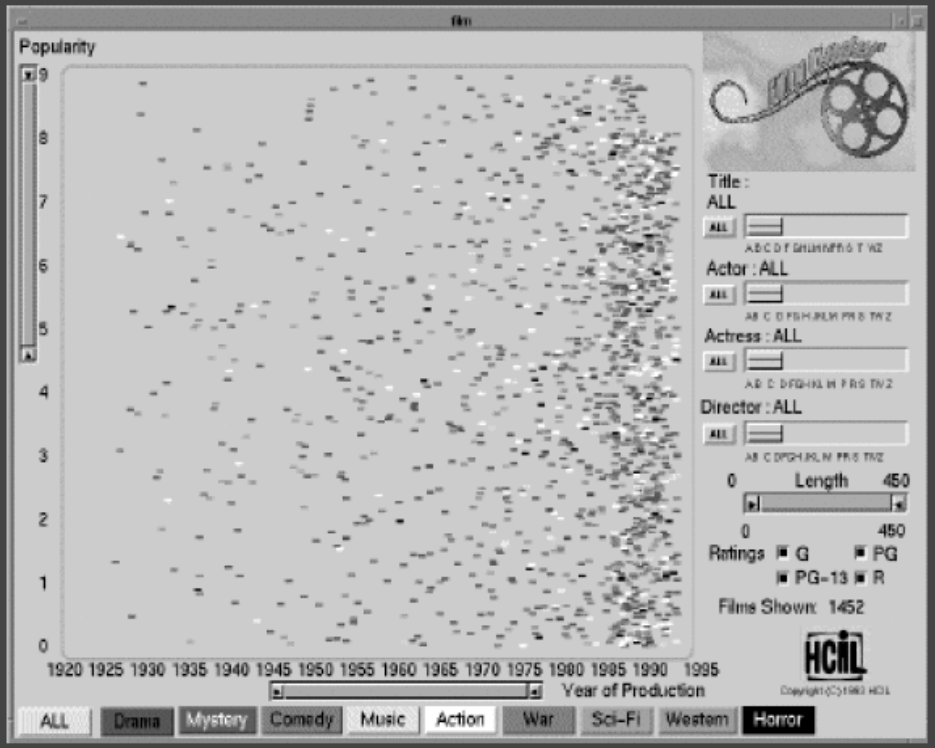


[Interactive Information Visualization of a
Jean-Daniel Fekete and Catherine Plaisant, Proc InfoVis 2002
http://www.cs.umd.edu/local-cgi-bin/hcil/rr.pl?number=2002-01]

Incremental Dynamic Queries

dynamic queries: user-controlled slider





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.
Jean-Daniel Fekete and Catherine Plaisant, Proc InfoVis 2002
http://www.cs.umd.edu/local-cgi-bin/hcil/rr.pl?number=2002-01

Design and Evaluation of Incremental Data Structures and Algorithms for Dynamic Query Interfaces. Egemen Tanin, Richard Beigel, Ben Shneiderman, Proc. InfoVis 1997
http://citeseer.nj.nec.com/tanin97research.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://hcibib.org/tcuid/