Lecture 18: Focus+Context

Visualization
SFU Cmpt 467/767, Fall 2010

Tamara Munzner

UBC Computer Science

Fri, 19 November 2010

Required Reading

A review of overview+detail, zooming, and focus+context interfaces. Andy Cockburn, Amy Karlson, and Benjamin B. Bederson. ACM Computing Surveys 41(1), 2008. (continued)

H3: Laying Out Large Directed Graphs in 3D Hyperbolic Space. Tamara Munzner, Proc InfoVis 97.

Recreational 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

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

Yet More Reading

Generalized Fisheye Views. Furnas. CHI 86.

A Fisheye Follow-up: Further Reflection on Focus + Context. Furnas. CHI 06.

TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility. Munzner, Guimbretiere, Tasiran, Zhang, and Zhou. SIGGRAPH 2003. http://www.cs.ubc.ca/~tmm/papers/tj

Real-time rendering in curved spaces. Weeks. IEEE Computer Graphics and Applications, Nov-Dec 2002.

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

A Guide to Visual Multi-Level Interface Design From Synthesis of Empirical Study Evidence. Lam and Munzner. UBC Computer Science Technical Report TR-2010-11, October 2010. http://www.cs.ubc.ca/cgi-bin/tr/2010/TR-2010-11

Survey: Unified Framework

- taxonomy
  - overview+detail: spatial separation
  - zooming: temporal separation
  - focus+context: integrated

  - cue-based: selectively highlight/suppress
    - crosscutting
- empirical study results
  - low-level task: target acquisition
  - high-level task: explore search space

A review of overview+detail, zooming, and focus+context interfaces. Andy Cockburn, Amy Karlson, and Benjamin B. Bederson. ACM Computing Surveys 41(1), 2008.

Overview+Detail

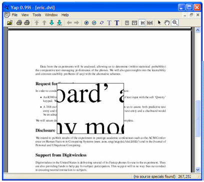
A review of overview+detail, zooming, and focus+context interfaces. Andy Cockburn, Amy Karlson, and Benjamin B. Bederson. ACM Computing Surveys 41(1), 2008.

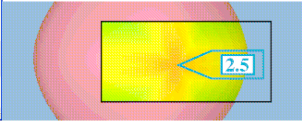
Survey: Overview+Detail

- multiple views: same data, different resolution
  - spatial separation between views
- linked navigation
  - shortcut navigation, thumbnail to detail
  - explore overview without changing detail
    - if fully synchronized could not explore
  - detail changes immediately shown in overview

Terminology Issue

- their defn: lens as O+D
  - since O and D separated in z/depth
  - nonstandard usage, I'm not a fan
- common use: lens as F+C
  - Toolglass and Magic Lenses, Bier/Stone/Pier/Buxton/DeRose

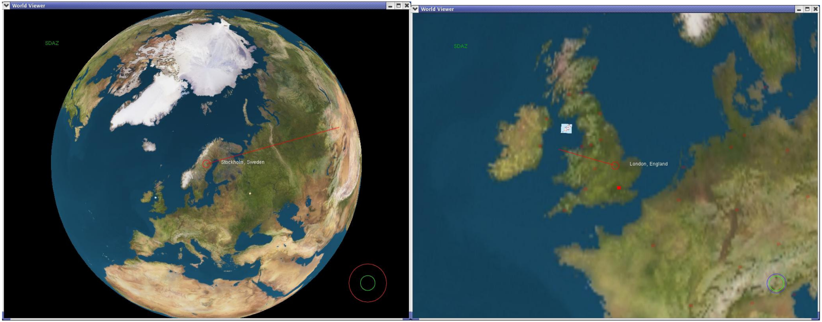




A review of overview+detail, zooming, and focus+context interfaces. Andy Cockburn, Amy Karlson, and Benjamin B. Bederson. ACM Computing Surveys 41(1), 2008.
Toolglass and magic lenses: the see-through interface. Eric A. Bier, Maureen C. Stone, Ken Pier, William Buxton, and Tony D. DeRose. Proc. SIGGRAPH'93, pp. 73-76.

Survey: Zooming

- single window, changing view
  - temporal multiplexing
  - not side by side views: pix below from different times



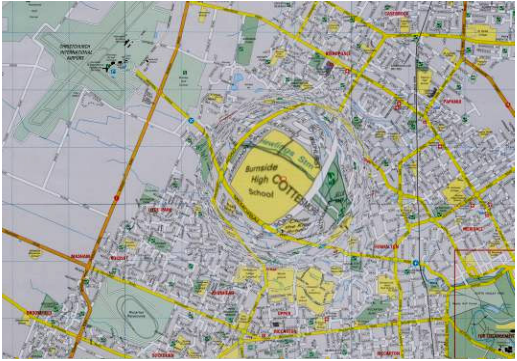
A review of overview+detail, zooming, and focus+context interfaces. Andy Cockburn, Amy Karlson, and Benjamin B. Bederson. ACM Computing Surveys 41(1), 2008.

Zooming

- standard zooming
  - hard to make intuitive zoomout control
- semantic zooming
  - different representations at different scales
  - zoomable user interfaces (ZUIs)
- space-scale diagrams (last lecture)
- challenge: stability
- challenge: comparison of currently visible to memory
  - Animation: Can It Facilitate? Tversky et al, 2002

Survey: Focus+Context

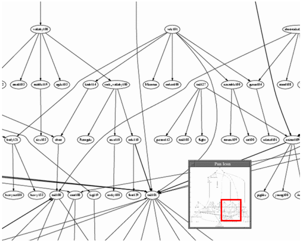
- embed focus and context in same view



A review of overview+detail, zooming, and focus+context interfaces. Andy Cockburn, Amy Karlson, and Benjamin B. Bederson. ACM Computing Surveys 41(1), 2008.

F+C vs. O+D

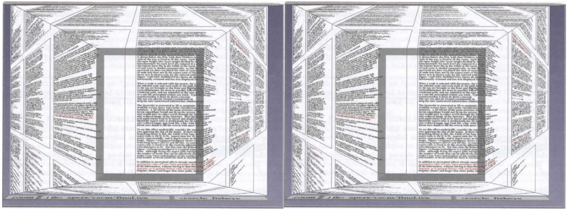
- two windows: overview + detail
  - conjecture: cognitive load to correlate

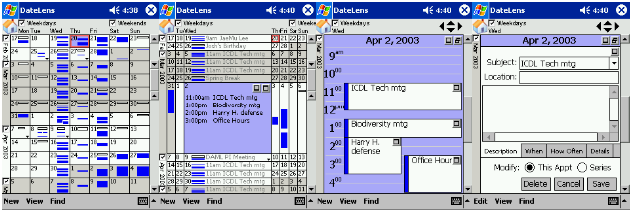


- solution
  - merge overview, detail
  - "focus+context"

Metaphor: Rubber Sheet

- stretch and squish, orthogonal order maintained
  - Document Lens, Table Lens

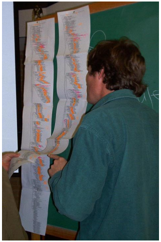


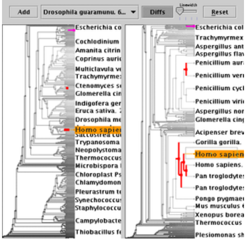


Document Lens, Robertson and Mackinlay 1993.
Table Lens, Rao and Card 1994.

Scaling Up Stretch and Squish

- TreeJuxtaposer: guaranteed visibility
  - scaling up when many more items than pixels
  - video

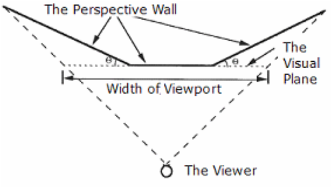


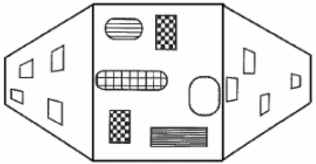


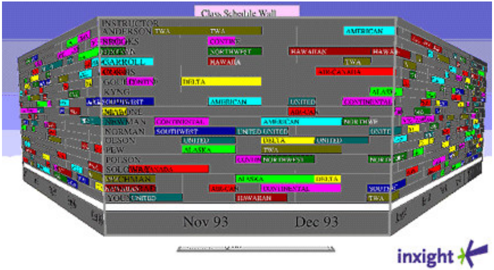
TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility. Munzner, Guimbretière, Tasiran, Zhang, and Zhou. Proc SIGGRAPH 2003, pp 453-462.

Metaphor: Move Surface Closer To Eye

- Perspective Wall



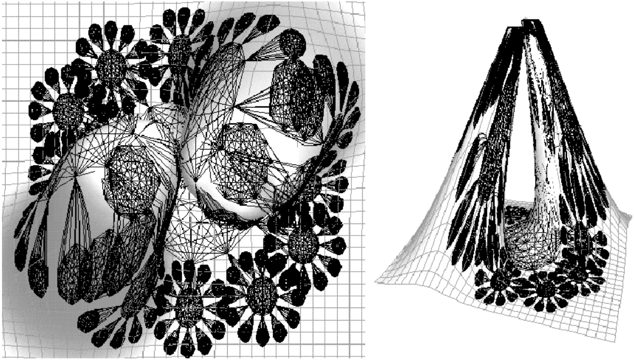




Perspective Wall, Mackinlay, Robertson and Card 1991

Pliable Surfaces

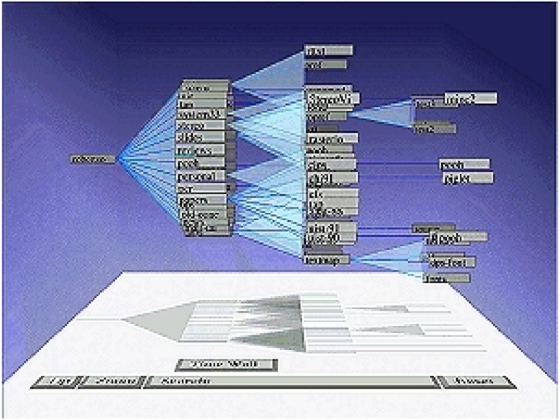
- general framework for distortion-based F+C



Graph Folding: Extending Detail and Context Viewing into a Tool for Subgraph Comparisons. Carpendale, Cowperthwaite, Fracchia, Shermer. Proc. Graph Drawing 1995.

Metaphor: 3D Perspective as F+C

- Cone Trees (early argument)
  - now 3D must be carefully justified for nonspatial data
  - now 3D not usually considered F+C



Cone Trees: Animated 3D Visualizations of Hierarchical Information. Robertson, Mackinlay, and Card. CHI 1991

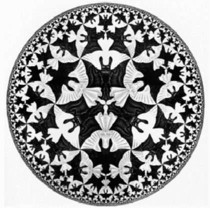
Metaphor: Fisheye

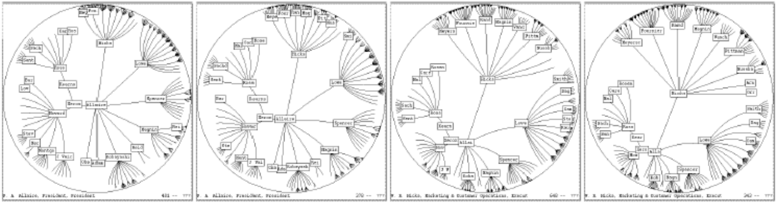
- Graphical Fisheye Views

Graphical Fisheye Views, Sarkar and Brown 1992

2D Hyperbolic Trees

- fisheye distortion effect from hyperbolic geometry
  - video: open-video.org/details.php?videoid=4567

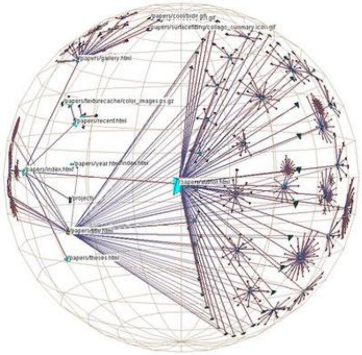




[The Hyperbolic Browser: A Focus + Context Technique for Visualizing Large Hierarchies. John Lamping and Ramana Rao, Proc SIGCHI '95.]

3D Hyperbolic Trees/Graphs

- H3
  - 3D vs 2D justification: information density at periphery

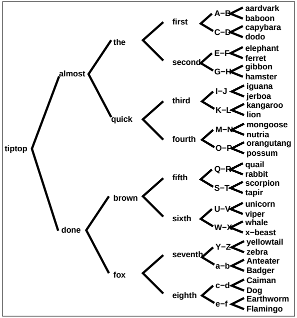


[H3: Laying Out Large Directed Graphs in 3D Hyperbolic Space. Tamara Munzner, Proc InfoVis 97.]

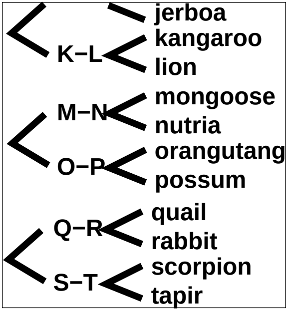
Avoiding Disorientation

- F+C problem
  - maintain user orientation when showing detail
  - hard for big datasets

global overview



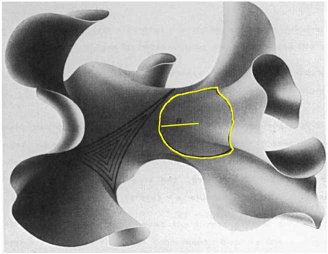
local detail



Exponential Amount Of Room

- trees require exponential amount of space
  - node count exponential in tree depth
- hyperbolic space has exponential amount of space
  - available area exponential not quadratic

2D hyperbolic plane
embedded in 3D space



[Thurston and Weeks 84]

hemisphere area

hyperbolic: exponential

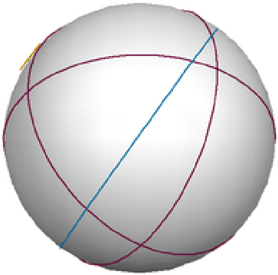
$$2\pi \sinh^2 r$$

euclidean: polynomial

$$2\pi r^2$$

Noneuclidean Geometry

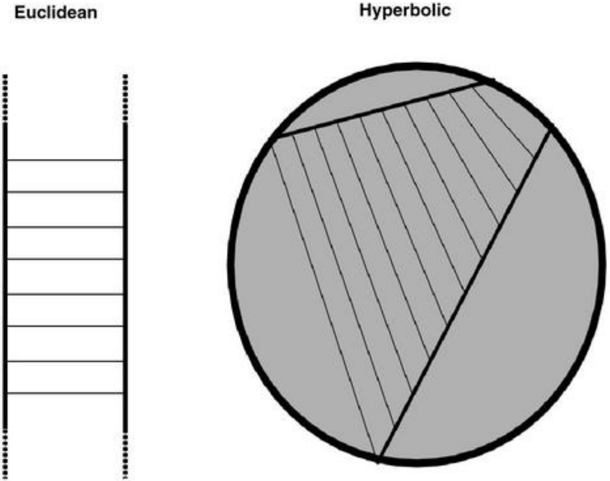
- Euclid's 5th Postulate
  - exactly 1 parallel line
- spherical
  - geodesic = great circle
  - no parallels
- hyperbolic
  - infinite parallels



(torus.math.uiuc.edu/jms/java/dragsphere

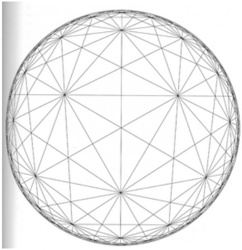
Parallel vs. Equidistant

- euclidean: inseparable
- hyperbolic: different

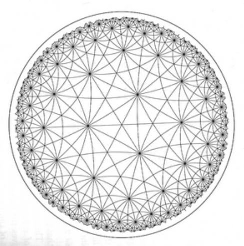


2D Hyperbolic Models

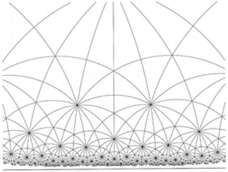
Klein/projective



Poincare/conformal

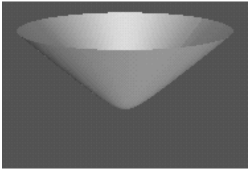


Upper Half Space



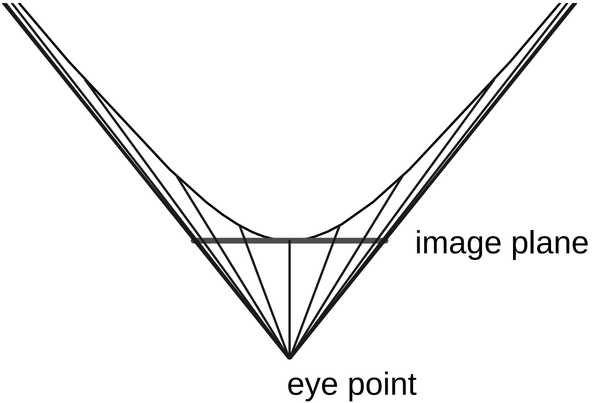
[Three Dimensional Geometry and Topology, William Thurston, Princeton University Press]

Minkowksi



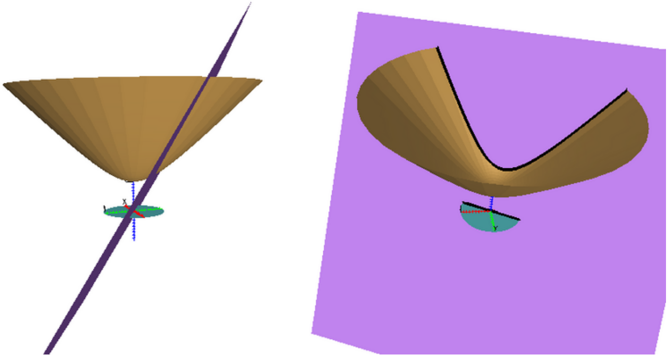
1D Hyperbolic Space: Klein Model

- hyperbola projects to line



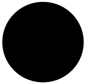
2D Hyperbolic Space: Klein Model

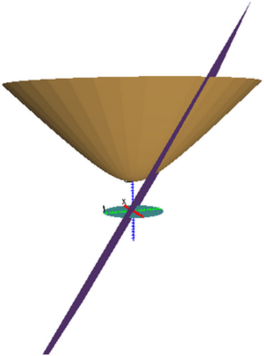
- hyperbola projects to disk

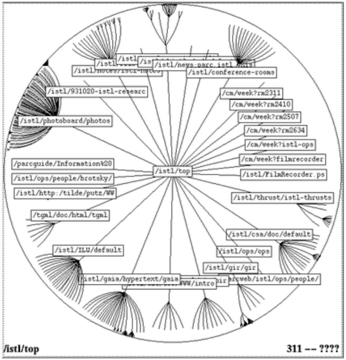


(graphics.stanford.edu/papers/munzner_thesis/html/node8.html#hyp2Dfig)

2D Hyperbolic Space: Poincare Model

- hyperboloid projects to disk 





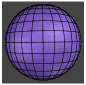
[The Hyperbolic Browser: A Focus + Context Technique for Visualizing Large Hierarchies. John Lamping and Ramana Rao, Proc SIGCHI '95.]

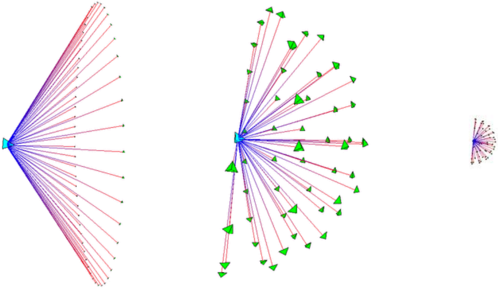
Klein vs Poincare

- Klein
  - straight lines stay straight
  - angles are distorted
- Poincare
  - angles are correct
  - straight lines curved
- graphics
  - 3D Klein: 4x4 real matrix
  - 2D Poincare: 2x2 complex matrix

- further reading
  - Real-time rendering in curved spaces, Jeff Weeks, IEEE Computer Graphics and Applications, Nov-Dec 2002.

3D Hyperbolic Space

- 3-hyperboloid projects to solid ball 
- H3 layout:
  - 3D hyperbolic cone tree with good information density
  - circumference → hemisphere

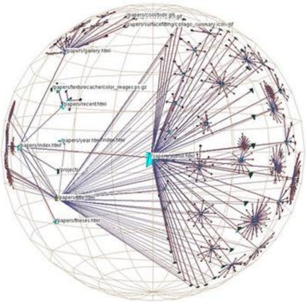


http://graphics.stanford.edu/papers/munzner_thesis/html/node8.html#conefig

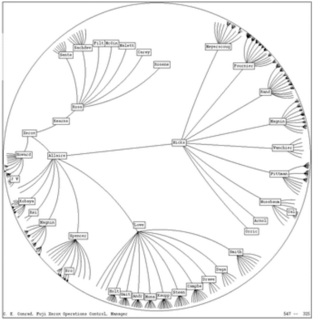
3D vs. 2D Hyperbolic Scalability

- information density: 10x better

H3



PARC Tree



	center	fringe
3D	**dozens**	**thousands**
2D	**dozens**	**hundreds**

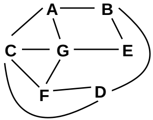
H3 Layout

- bottom-up: allocate space for nodes
- top-down: place child on parent hemisphere

Formula	Euclidean	Hyperbolic
right-angle triangle	$\tan\theta = \frac{opp}{adj}$	$\tan\theta = \frac{\tanh(opp)}{\sinh(adj)}$
right-angle triangle	$\sin\theta = \frac{opp}{hyp}$	$\sin\theta = \frac{\sinh(opp)}{\sinh(hyp)}$
circle area	πr^2	$2\pi(\cosh(r) - 1)$
hemisphere area	$2\pi r^2$	$2\pi\sinh^2(r)$
spherical cap area	$2\pi r^2(1-\cos\phi)$	$2\pi\sinh^2 r(1-\cos\phi)$

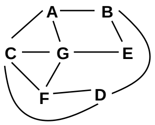
Spanning Tree Layout

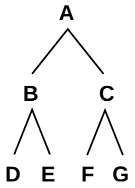
- problem
  - general graph layout problem is NP-hard



Spanning Tree Layout

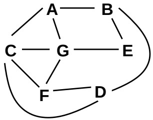
- problem
  - general graph layout problem is NP-hard
- solution
  - tractable spanning tree backbone
  - appropriate iff matches mental model
    - quasi-hierarchical
  - use domain knowledge to construct
    - select parent from incoming links
    - required as input, not automatically computed

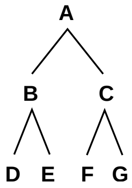


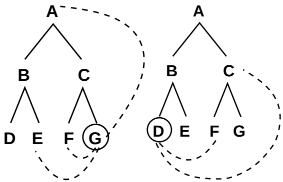


Spanning Tree Layout

- problem
  - general graph layout problem is NP-hard
- solution
  - tractable spanning tree backbone
  - appropriate iff matches mental model
    - quasi-hierarchical
  - use domain knowledge to construct
    - select parent from incoming links
    - required as input, not automatically computed
  - draw non-tree links only on demand







Degree of Interest: General F+C Model

- DOI: API(x) - D(x,y)
  - API: a priori interest
  - D: distance, semantic or spatial
  - x: data element
  - y: current focus
  - supports single or multiple foci
- infer DOI
  - interaction or explicit selection
- use of DOI
  - selective presentation or distortion

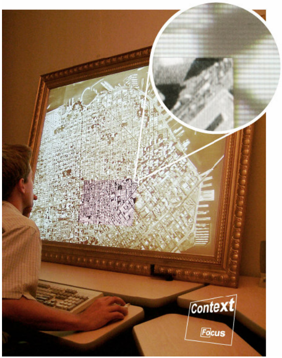
Generalized Fisheye Views, Furnas, CHI 86.

Distortion Challenges

- how to visually communicate distortion
  - gridlines, shading
- target acquisition problem
  - lens displacing items away from screen loction
- unsuitable if must make relative spatial judgements
- mixed results with empirial comparison to O+D, pan/zoom
- A Fisheye Follow-up: Further Reflection on Focus + Context. George W. Furnas. SIGCHI 2006.
  - cautions that geometric distortion was not his main point

F+C Without Distortion

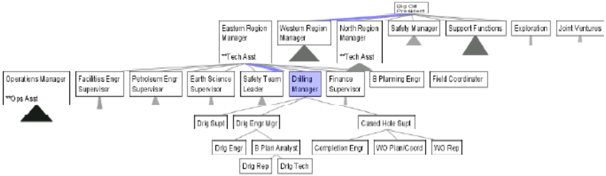
- specialized hardware
  - high-res center, low-res surround



[A review of overview+detail, zooming, and focus+context interfaces. Cockburn, Karlson, and Bederson. ACM Computing Surveys 41(1), 2008. From: Baudisch 1992.]

SpaceTree: F+C Without Distortion

- focus+context tree: filtering, not geometric distortion
  - animated transitions

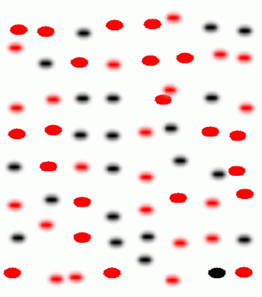


- semantic zooming

- demo

Survey: Cue-based Techniques

- idiosyncratic not standard category
  - semantic depth of field - blur
  - halos - arcs show offscreen info scent
- crosscuts other three categories (and all infovis)



[A review of overview+detail, zooming, and focus+context interfaces. Andy Cockburn, Amy Karlson, and Benjamin B. Bederson. ACM Computing Surveys 41(1), 2008. Fig 14.]

Survey: Evaluation

- complex picture of costs/benefits
  - spatial separation
    - costs: real estate, mental integration overhead
  - zooming
    - costs: cognitive load
    - anim transitions help, but don't solve
    - concurrent, unimanual over serial or bimanual
  - focus+context
    - strengths: overview, graphs
    - costs: distortion
- can combine: e.g. zooming + multiple views

Evaluation: Further Reading

- design guidelines from systematic review of 22 studies
  - A Guide to Visual Multi-Level Interface Design From Synthesis of Empirical Study Evidence. Lam/Munzner.
  - UBC CS TR-2010-11, (monograph soon).
- four-point decision tree
  - single or multi-level interface
  - create the high-level displays (overviews)
  - simultaneous or temporal display of visual levels
  - sim: embedded or separate display of visual levels
- three design guidelines
  - number of levels in display and data should match
  - high visual levels should display only task-relevant info
  - simultaneous display not temporal switching for tasks with multi-level answers