Vorlesung
Advanced Topics in HCI
(Mensch-Maschine-Interaktion 2)

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http://www.medien.informatik.uni-muenchen.de/

Chapter 2: Information Visualization

Table of Content

Techniques

- Focus & Context
- Zoom & Pan

Taxonomy for presentations and distortions

Leung & Apperley

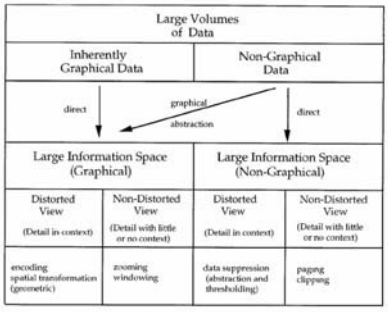


Fig. 1. A taxonomy of presentation techniques for large graphical data spaces.

Distortion-based Techniques

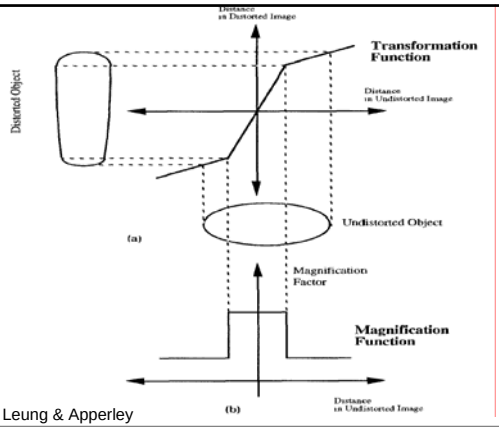
- Bifocal Display
- Polyfocal Display
- Perspective Wall
- Fisheye View
- Graphical Fisheye View

Idea of Distortion-based Techniques

- Co-existence of local details with global context at reduced magnification.
- A focus region to display detailed information.
- Demagnified view of the peripheral areas is presented around the focus area.

Distortion

- A distorted view is created by applying a transformation function to an undistorted image.
- A magnification function, provides a profile of the magnification factors for the entire area of image.



Leung & Apperley

Peripheral Region demagnification in x, y or both dimensions

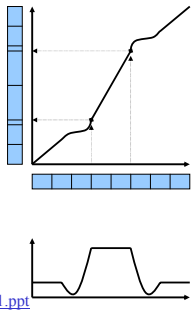
Central 'Focus' Region

no demagnification

Leung & Apperley

"Bubble"

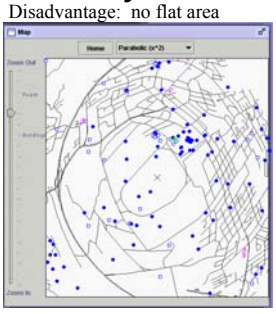
Disadvantage: local context highly de-magnified

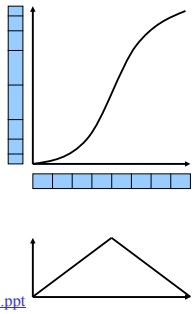


From http://people.cs.vt.edu/~north/infoviz/lecture11.ppt

"Fisheye", "wide-angle lens"

Disadvantage: no flat area

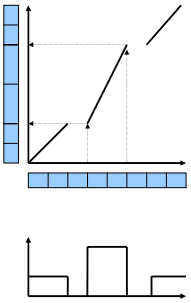




From http://people.cs.vt.edu/~north/infoviz/lecture11.ppt

Why not magnifying glass?

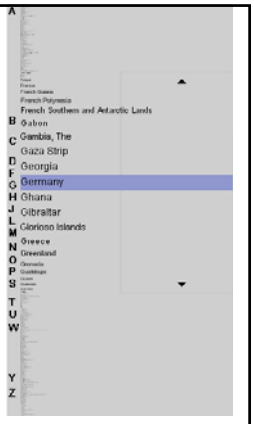
- Hides local context



From http://people.cs.vt.edu/~north/infoviz/lecture11.ppt

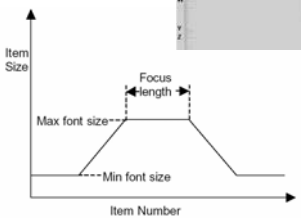
Example: Fisheye Menu

- Applies fisheye graphical visualization techniques to linear menus
- For very long menus as alternative to
  - Hierarchies
  - Scrolling
  - Arrow-bars
- Benjamin B. Bederson. Fisheye Menus. UIST'00
- Demo http://www.cs.umd.edu/hcil/fisheyemenu/fisheyemenu-demo.shtml

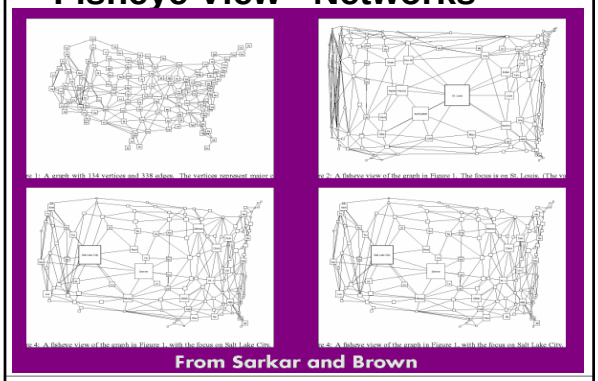


Implementation & Evaluation Fisheye Menu

- Calculating font size
- Minimal change moves the centre → hard to select
- Lock mode
- Evaluation
  - Some users like it
  - Other don't …



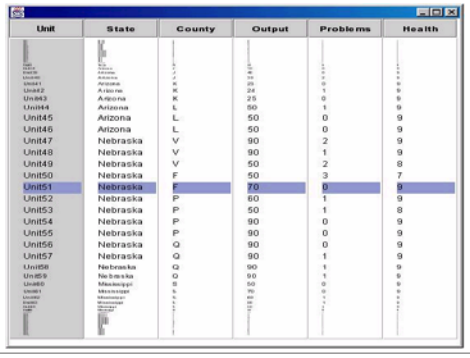
Fisheye View - Networks



From Sarkar and Brown

Fisheye View

fisheye table

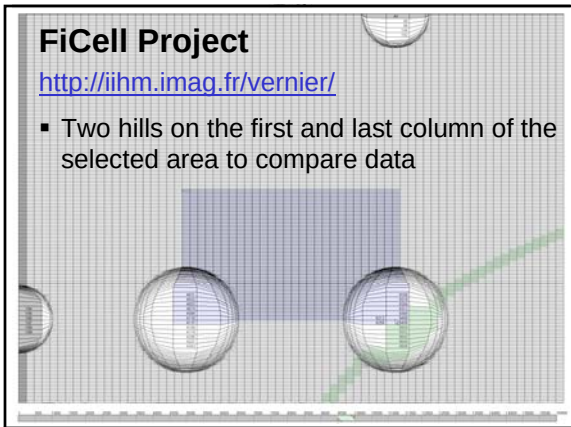


Unit	State	County	Output	Problems	Health
Unit43	Arizona	K	25	0	6
Unit44	Arizona	L	50	1	6
Unit45	Arizona	L	50	0	9
Unit46	Arizona	L	50	0	9
Unit47	Nebraska	V	90	2	9
Unit48	Nebraska	V	90	1	9
Unit49	Nebraska	V	50	2	8
Unit50	Nebraska	F	50	3	7
Unit51	Nebraska	F	70	0	9
Unit52	Nebraska	P	60	1	9
Unit53	Nebraska	P	50	1	8
Unit54	Nebraska	P	90	0	9
Unit55	Nebraska	P	90	0	9
Unit56	Nebraska	Q	90	0	9
Unit57	Nebraska	Q	90	1	9

FiCell Project

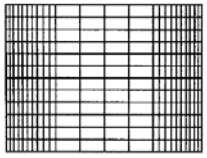
http://iihm.imag.fr/vernier/

- Two hills on the first and last column of the selected area to compare data

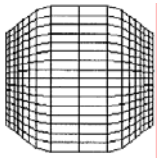


Piecewise Non-Continuous Magnification Functions

- Bifocal Display, Perspective Wall



Bifocal Display

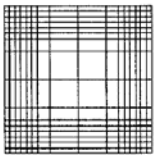


Perspective Wall

From http://www.sims.berkeley.edu/courses/is247/s02/lectures/ZoomingFocusContextDistortion.ppt

Bifocal Display

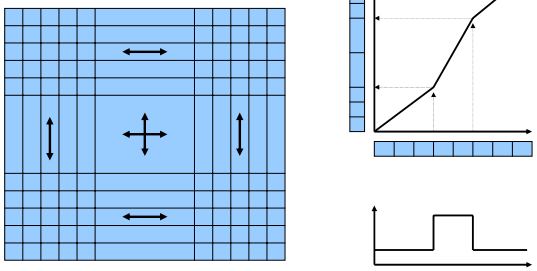
- Combination of detail view and two distorted side views
- Can be applied in 2D
  - Since the corners are distorted by the same amount in x and y, it's just scaled, not distorted



From http://www.sims.berkeley.edu/courses/is247/s02/lectures/ZoomingFocusContextDistortion.ppt

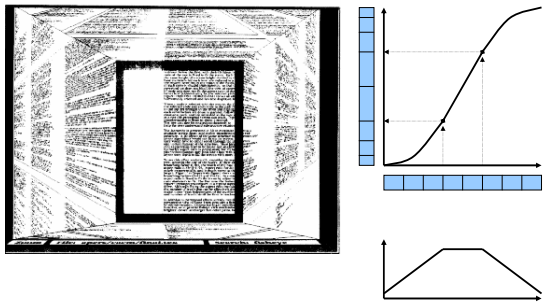
Bifocal Display

Disadvantage: 1 dimensional stretching on the 4 sides



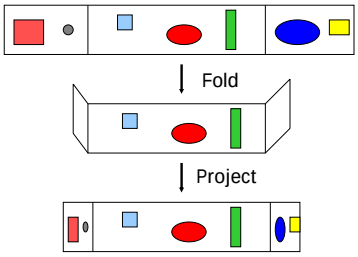
From http://people.cs.vt.edu/~north/infoviz/lecture11.ppt

Document Lens



From http://people.cs.vt.edu/~north/infoviz/lecture11.ppt

Basic idea – Perspective Wall

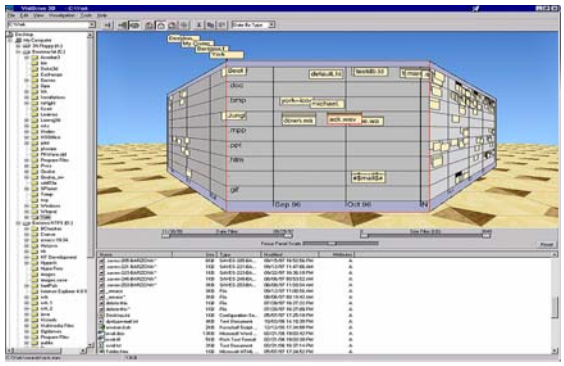


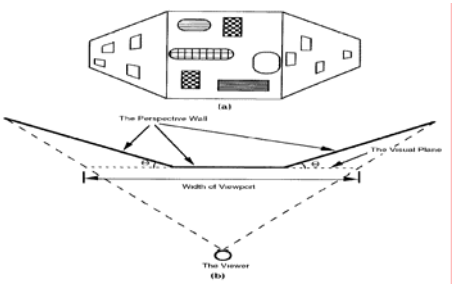
From http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/0324.fengdongdu.ppt

Perspective Wall

- A conceptual descendent of the Bifocal display.
- Smoothly integrated detailed and contextual views.
- Side panels are demagnified directly proportional to their distance from the viewer.

From http://www.sims.berkeley.edu/courses/is247/s02/lectures/ZoomingFocusContextDistortion.ppt





The view is dependent on the length of the wall, the width of the view port, the angle Θ, the size of the central region.

From http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/0324.fengdongdu.ppt

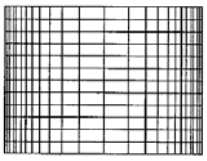
Perspective Wall

- Similar to Bifocal, except demagnifies at increasing rate, while Bifocal is constant
- Visualizes linear information such as timeline
- Adds 3D but wastes real estate on screen (which is contrary to prime objectives of distortion techniques)

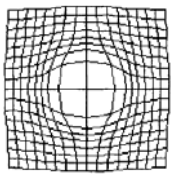
From http://www.sims.berkeley.edu/courses/is247/s02/lectures/ZoomingFocusContextDistortion.ppt

Continuous Magnification Functions

- Fisheye View, Polyfocal Display
  - Can distort boundaries because applied radially rather than x y



1D Fisheye

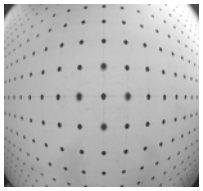


2D Polyfocal

From http://www.sims.berkeley.edu/courses/is247/s02/lectures/ZoomingFocusContextDistortion.ppt

Fisheye View

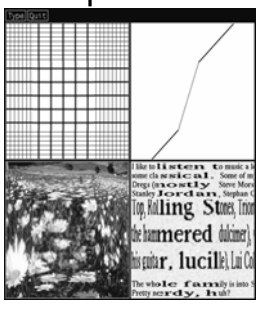
- Thresholding
  - Information elements have numbers based on relevance and distance from point of focus
  - Value then determines what information is to presented or suppressed



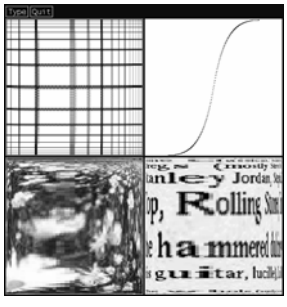
Polar Fisheye View
Image from Shishir Shaw
University of Texas, Austin
www.adires.com/~castleman/proj_02.html

From http://www.sims.berkeley.edu/courses/is247/s02/lectures/ZoomingFocusContextDistortion.ppt

Comparisons



Bifocal View

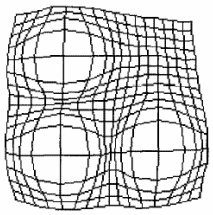


Polyfocal View

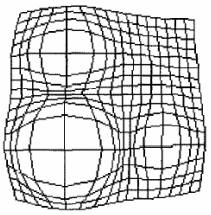
From http://www.sims.berkeley.edu/courses/is247/s02/lectures/ZoomingFocusContextDistortion.ppt

Multifocal Polyfocal Projection

Focal points where there is interest in the visualization, e.g. maps



(e)



(f)

From http://www.sims.berkeley.edu/courses/is247/s02/lectures/ZoomingFocusContextDistortion.ppt

Multifocal Polyfocal Projection

- Multiple peaks in the display
- No restriction on the numbers of peaks in the magnification function.
- Need to consider the computation time and the comprehensibility of the distorted image.

From http://www.sims.berkeley.edu/courses/is247/s02/lectures/ZoomingFocusContextDistortion.ppt

Fisheye View

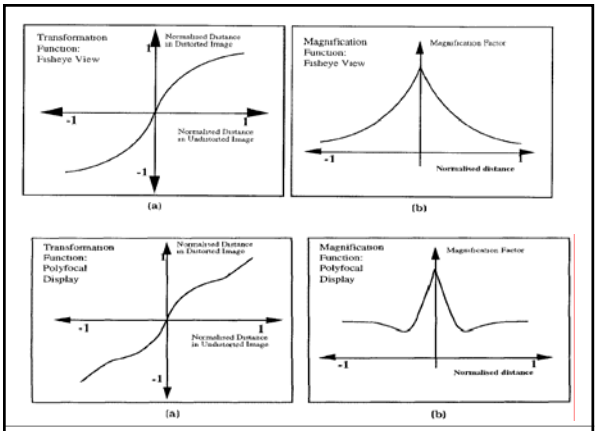
- Originally proposed by Furnas (1986), but many variations of applications.
- Basic idea: more relevant information presented in great detail; the less relevant information presented as an abstraction.
- Relevance is computed on basis of the importance of information elements and their distance to the focus.

From http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/0324.fengdongdu.ppt

(Continued)

- Degree of interest (DOI) function:
  - DOI(a|.=b) = API(a) – D(a,b)
    - DOI(a|.=b): DOI of a, given the current focus is b.
    - API(a): static global apriori importance measure.
    - D(a,b): distance between a and b.

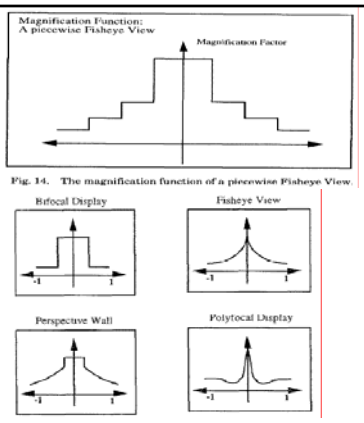
From http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/0324.fengdongdu.ppt



Taxonomy of Distortion-based Techniques

- Magnification
  - Piecewise continuous magnification function
    - Bifocal display: constant magnifications
    - Perspective wall: varying magnifications
  - Continuous magnification function
    - Polyfocal display
    - Fisheye view
  - Continuous magnification function can be simulated by piecewise functions.

From http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/0324.fengdongdu.ppt

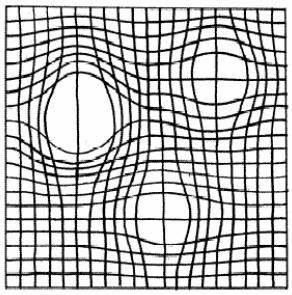


Unified Theory

- Treat the displayed information as it was printed on a stretchable rubber sheet with rigid frame.
- Any stretching in one part of the sheet results in an equivalent amount of shrinkage in other areas.
- The consequence of the stretching and the shrinking of the sheet is an overall distorted view.

From http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/0324.fengdongdu.ppt

Stretchable Rubber Sheet



Implementation Issues

- Distortion-based techniques have widely different complexities, depending on the transformation function.
- Tradeoff needs to be made to choose computational power and the system memory.
- Distortion with continuous magnification functions are hard to apply the cutting and pasting technique.

From http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/0324.fengdongdu.ppt

Distortion can also be used for Input

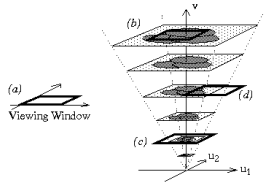
- Edward Lank
  Fluid Sketching on a Pocket PC (Ubicomp 2004 Workshop)
  http://tlaloc.sfsu.edu/~lank/research/appearing/FocusMotion.pdf
- Edward Lank, Son Phan
  Focus+Context sketching on a pocket PC
  CHI '04 extended abstracts on Human factors in computing systems

Panning and Zooming

- Panning
  - Smooth movement of camera across scene (or scene moves and camera stays still)
- Zooming
  - Increasing or decreasing the magnification of the objects in a scene
- Useful for changing focal point

Space-Scale Diagrams
(Furnas & Bederson 95)

- User has a fixed-sized viewing window
- Moving it through 3D space yields all possible sequences of pan & zoom



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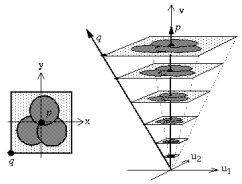
Space-Scale Diagrams
(Furnas & Bederson 95)

- A point is transformed to a ray
- Circular regions become cones



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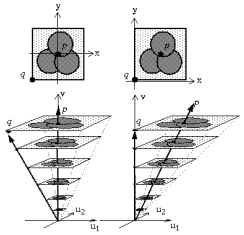
Space-Scale Diagrams
(Furnas & Bederson 95)

- If you move the origin of the 2D plane, the properties of the original 2D picture do not change
- Therefore, the absolute angles between the rays should not be assigned any meaning



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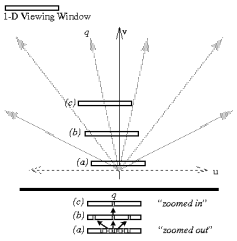
Space-Scale Diagrams
(Furnas & Bederson 95)

- We can think of this in terms of 1D too
- When zoomed out, you can see wider set of points



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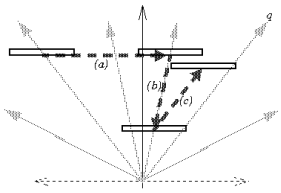
Space-Scale Diagrams
(Furnas & Bederson 95)

- Pure pan (a)
- Pure zoom (b)
- Pan and zoom keeping q in same position in the viewing window (c)



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Semantic Zooming

- Geometric (standard) zooming:
  - The view depends on the physical properties of what is being viewed
- Semantic Zooming:
  - When zooming away, instead of seeing a scaled-down version of an object, see a different representation
  - The representation shown depends on the meaning to be imparted.

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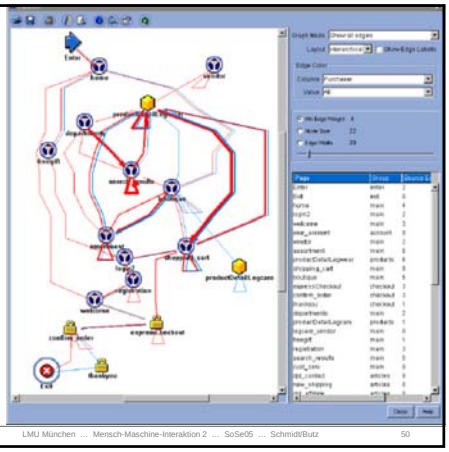
Further examples

Click stream Visualization

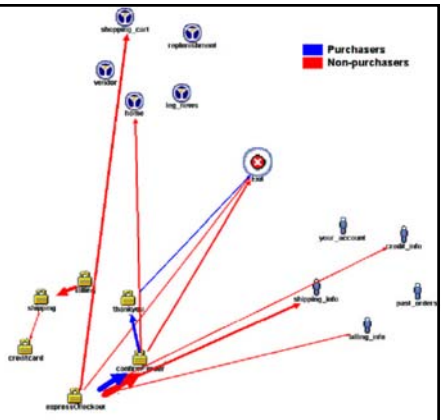
- Jeffrey Brainerd Barry Becker
  Case Study: E-Commerce Clickstream Visualization
  Proceedings of the IEEE Symposium on Information Visualization 2001 (INFOVIS'01)
- http://www.sims.berkeley.edu/courses/is247/s02/readings/brainerd.pdf

Click stream Visualization



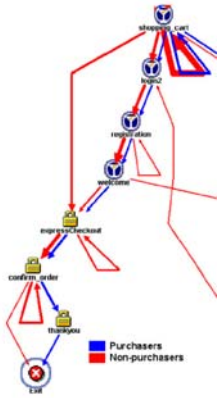
- Brainerd et al.

Click stream Visualization



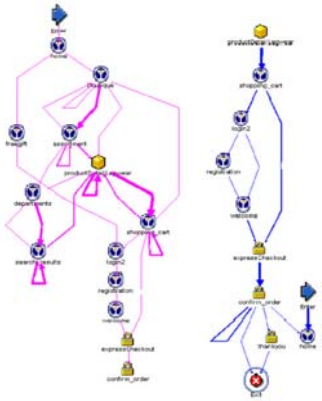
- Brainerd et al.

Click stream Visualization



- Brainerd et al.

Click stream Visualization

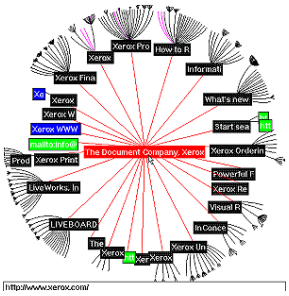


- Brainerd et al.

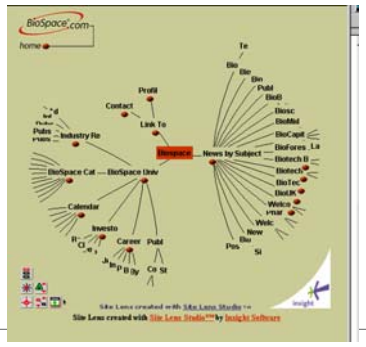
Hyperbolic Browser

- Focus + Context Technique
  - detailed view blended with a global view
- First lay out the hierarchy on Poincare' mapping of the hyperbolic plane
- Then map this plane to a disk
- Use animation to navigate along this representation of the plane
- Start with the tree's root at the center

Hyperbolic Tree Browser
(Lamping et al. 95)



Inxight's Hyperbolic Browser



Hyperbolic Tree Views

- Nice demos on the web now
  - www.inxight.com
  - www.thebrain.com
    - This is a variation on it that might be more interesting
    - Decides dynamically which subsets of the data to show

Thebrain.com

Hyperbolic Browser

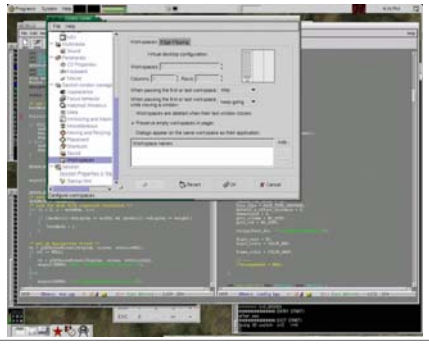
- In the hyperbolic plane, the circumference and area of a circle grow exponentially with its radius
- Allocate each node a wedge of the hyperbolic plane
- The node recursively places all its children within an arc of that wedge
  - at an equal distance from itself
  - far enough out so the children are separated by at least a minimum distance
- Parallel lines diverge in hyperbolic geometry
  - each child's wedge will span about the same angle as its parent's
  - but not children's wedges will overlap

Determining Layout

- User selects focus
  - As user drags mouse, display changes
- For each object: size, position, and amount of detail depend on:
  - distortion factor
  - object's "normal" size and position
  - distance of object from focus (POI)
  - pre-assigned importance value
  - other user-controlled parameters (optional)

3D Desktop - http://desk3d.sourceforge.net/

switching virtual desktops in 3D



3D Desktop - http://desk3d.sourceforge.net/

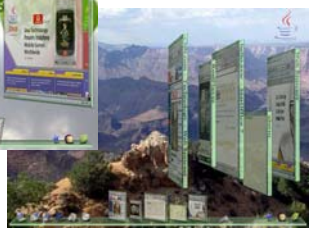
switching virtual desktops in 3D

3D Desktop - http://desk3d.sourceforge.net/

switching virtual desktops in 3D

Sun: Project Looking Glass functional 3D-Desktop

Video ~ 6min



https://lg3d.dev.java.net/

Visualization on Mobile Devices

- Some common challenges
  - Small screen
  - Limited processing power
  - Limited interaction
  - Limited bandwidth to data source

Rectangular Fish Eye View

saving bandwidth in transmission

- Rauschenbach, U.: *"The Rectangular Fish Eye View as an Efficient Method for the Transmission and Display of Large Images"*, in: Proceedings of IEEE ICIP'99, Kobe, Japan, Oct. 25-28, 1999. http://wwwicg.informatik.uni-rostock.de/Projekte/MoVi/Publications/ICIP99/

Rectangular Fish Eye View

saving bandwidth in transmission

Figure 3: Rectangular fish eye view example

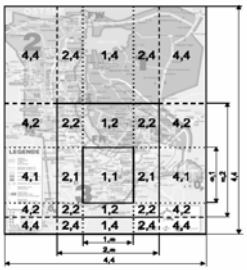


Figure 4: Generating RoI grid

- Rauschenbach, U.; and Schumann, H.: *"Flexible Embedded Image Communication using Levels of Detail and Regions of Interest", in: Proceedings of IMC '98 - Rostock, Germany - November 24-25, 1998.*

Providing context for map navigation

- Baudisch, P. and Rosenholtz, R.
  Halo: A Technique for Visualizing Off-Screen Locations.
  In *Proceedings of CHI 2003*, Fort Lauderdale, FL, April 2003,pp. 481-488.

Providing context for map navigation

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  Halo: A Technique for Visualizing Off-Screen Locations.
  In *Proceedings of CHI 2003*, Fort Lauderdale, FL, April 2003,pp. 481-488.

Providing context for map navigation

Video ~ 2min

- Baudisch, P. and Rosenholtz, R.
  Halo: A Technique for Visualizing Off-Screen Locations.
  In *Proceedings of CHI 2003*, Fort Lauderdale, FL, April 2003,pp. 481-488.

References

- A Review and Taxonomy of Distortion-Oriented Presentation Techniques, Leung & Apperley, 1994
- Barlow et al. "A Comparison of 2-D Visualizations of Hierarchies" INFOVIS'01 http://www.sims.berkeley.edu/courses/is247/s02/readings/barlow.pdf
- Martin Wattenberg. Arc Diagrams: Visualizing Structure in Strings IBM Watson Research Center, Technical report 2002-11 http://domino.research.ibm.com/cambridge/research.nsf/0/e2a83c4986332d4785256ca7006cb621?OpenDocument
- Thread Arcs http://www.research.ibm.com/remail/threadarcs.html
- Focus+Context Taken Literally, Robert Kosara, Silvia Miksch, Helwig Hauser, 2000
- Marti Hearst, http://bailando.sims.berkeley.edu/talks/chi03-tutorial.ppt
- Storey, http://www.cs.uvic.ca/~mstorey/teaching/infovis/course_notes/introduction.pdf
- Shneiderman, http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/readings/shneiderman96eyes.pdf

References

- Marti Hearst
  - http://bailando.sims.berkeley.edu/infovis.html
  - http://bailando.sims.berkeley.edu/talks/chi03-tutorial.ppt
  - SIMS 247, Information Visualization and Presentation Oct 2000
- Storey
  - http://www.csr.uvic.ca/~mstorey/
  - http://www.cs.uvic.ca/~mstorey/teaching/infovis/course_notes/introduction.pdf
- Shneiderman
  - http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/readings/shneiderman96eyes.pdf

Readings

- “A Review and Taxonomy of Distortion-Oriented Presentation Techniques,” Leung & Apperley, 1994
- “Information Visualization Using 3D Interactive Animation,” Robertson, Card, & Mackinlay, 1993
- “Pad++: A Zooming Graphical Interface for Exploring Alternate Interface Physics,” Bederson & Hollan, 1994
- “Data Mountain: Using Spatial Memory for Document Management,” Robertson, et al, 1998
- “Fisheye Menus,” Bederson, 2000
- “Quantum Treemaps & Bubblemaps for a Zoomable Image Browser,” Bederson, 2001
- SPACE-SCALE DIAGRAMS: UNDERSTANDING MULTISCALE INTERFACES, George W. Furnas, Benjamin B. Bederson