

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

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## Chapter 2: Information Visualization

### Table of Content

- Information & representation
- What is information visualization
- Perception basics
- Standard techniques
- Principles and Taxonomy
- Options for visualization & Examples

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## Techniques

- Focus & Context
- Zoom & Pan

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## Taxonomy for presentations and distortions

Leung & Apperley

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

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## Distortion-based Techniques

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

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## 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.

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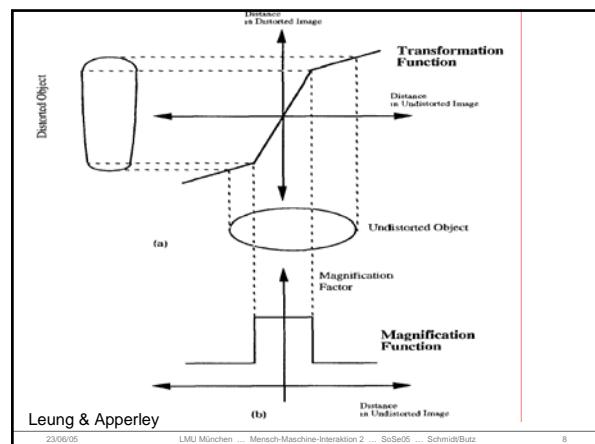
## Distortion

- 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.

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Peripheral Region demagnification in x, y or both dimensions

**Central 'Focus' Region**  
no demagnification

Leung & Apperley

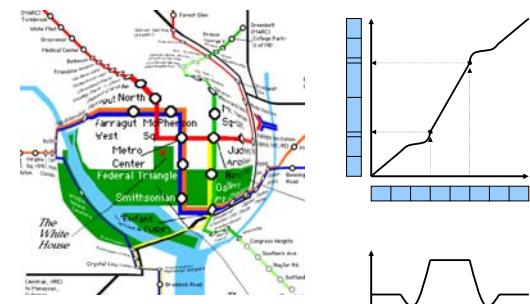
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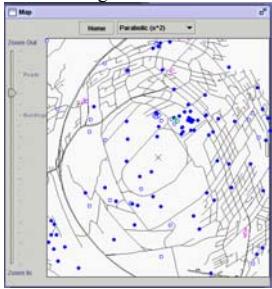
## “Bubble”

Disadvantage: local context highly de-magnified



## “Fisheye”, “wide-angle lens”

Disadvantage: no flat area



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

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## Why not magnifying glass?

- Hides local context

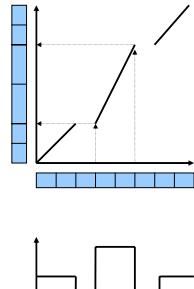
Now is the time for all good people to come to the aid of their country.

Now is the time for all good people to come to the aid of their country.  
**peo**

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

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## 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>

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## 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 ...

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## Fisheye View - Networks

Fig.1: A graph with 334 vertices and 338 edges. The vertices represent major cities in the USA.  
Fig.2: A fisheye view of the graph in Figure 1. The focus is on St. Louis. (The 12 nearest neighbors are shown.)  
Fig.3: A fisheye view of the graph in Figure 1, with the focus on Chicago.  
Fig.4: A fisheye view of the graph in Figure 1, with the focus on Salt Lake City.

**From Sarkar and Brown**

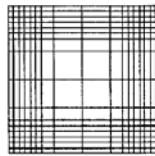
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## Fisheye View fisheyetable

Unit	State	County	Output	Problems	Health
Unit1	P	P	70	0	9
Unit2	Nebraska	P	60	1	9
Unit3	Nebraska	P	60	1	9
Unit4	Nebraska	P	90	0	9
Unit5	Nebraska	P	90	0	9
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## Bifocal Display

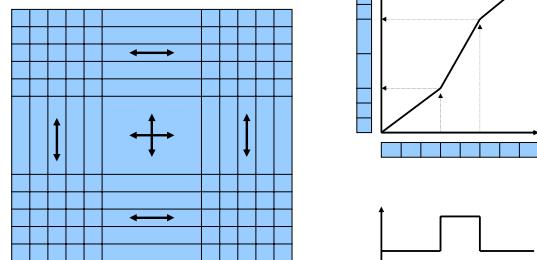
- Combination of detail view and two distorted side views
- Can be applied in 2D
  - Since the corners are distorted by the same amount in x and y, it's just scaled, not distorted



From <http://www.sims.berkeley.edu/courses/is247/s02/lectures/ZoomingFocusContextDistortion.ppt>  
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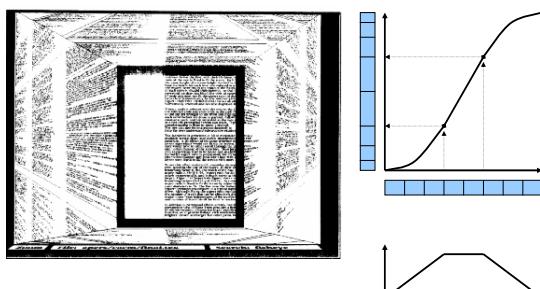
## Bifocal Display

Disadvantage: 1 dimensional stretching on the 4 sides



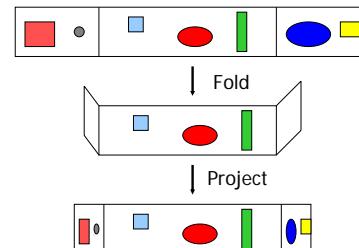
From <http://people.cs.vt.edu/~north/infoviz/lecture11.ppt>  
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## Document Lens



From <http://people.cs.vt.edu/~north/infoviz/lecture11.ppt>  
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## Basic idea – Perspective Wall

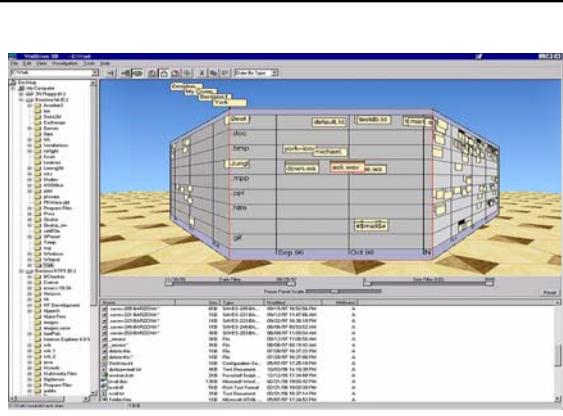


From <http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/0324.fengdongdu.ppt>  
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## Perspective Wall

- 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>  
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From <http://www.sims.berkeley.edu/courses/is247/s02/lectures/ZoomingFocusContextDistortion.ppt>  
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The view is dependent on the length of the wall, the width of the view port, the angle  $\Theta$ , the size of the central region.

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

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## 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>

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## Continuous Magnification Functions

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

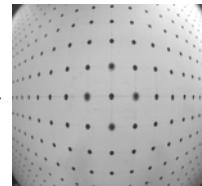
**1D Fisheye**      **2D Polyfocal**

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

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## Fisheye View

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



**Polar Fisheye View**  
Image from Shishir Shah  
University of Texas, Austin  
[www.adries.com/~castleman/proj\\_02.html](http://www.adries.com/~castleman/proj_02.html)

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

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## Comparisons

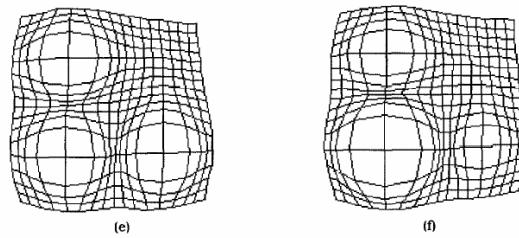
**Bifocal View**      **Polyfocal View**

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

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## Multifocal Polyfocal Projection

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



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

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## 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>  
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## Fisheye View

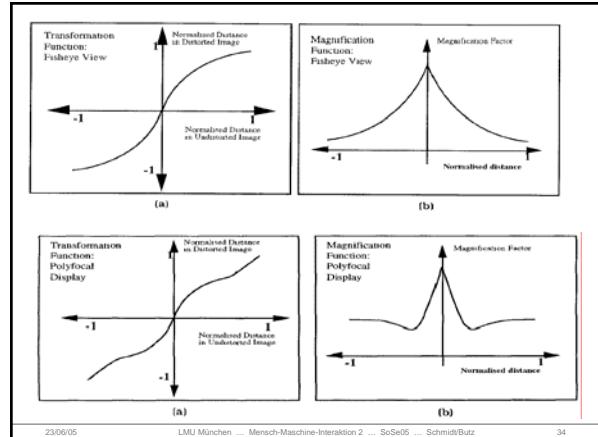
- Originally proposed by Furnas (1986), but many variations of applications.
- **Basic idea:** more relevant information presented in great detail; the less relevant information presented as an abstraction.
- Relevance is computed on basis of the importance of information elements and their distance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

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

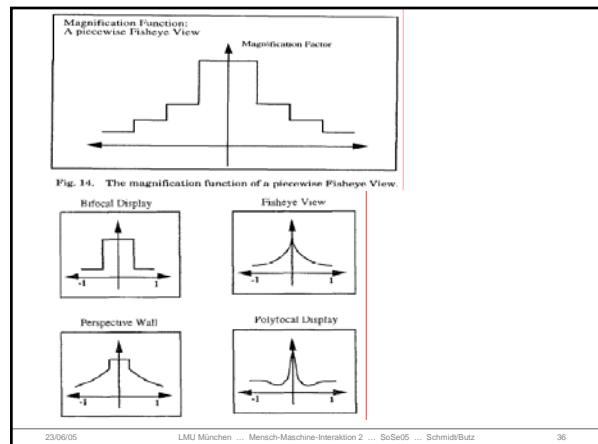
From <http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/0324.fengdongdu.ppt>  
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## Taxonomy of Distortion-based Techniques

- 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>  
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## 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.

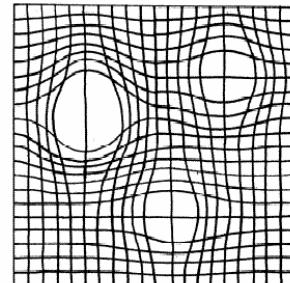
From <http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/0324.fengdongdu.ppt>

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## Stretchable Rubber Sheet



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## 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>

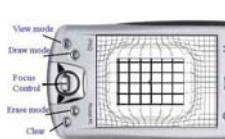
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## Distortion can also be used for Input

- 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



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## 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

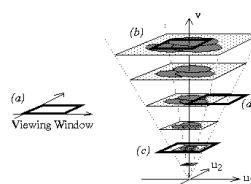
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## Space-Scale Diagrams (Furnas & Bederson 95)

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



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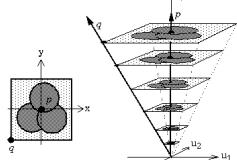
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## Space-Scale Diagrams (Furnas & Bederson 95)

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



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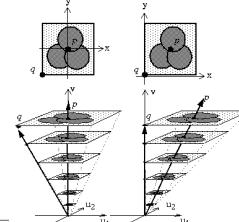
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## Space-Scale Diagrams

(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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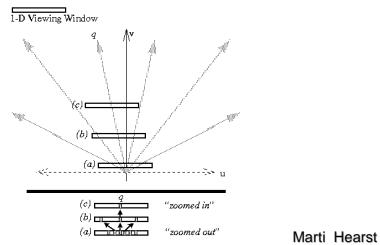
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Schmidt/Butz

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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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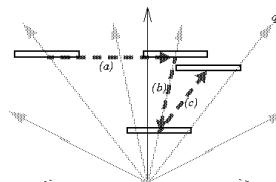
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## Space-Scale Diagrams (Furnas & Bederson 95)

- 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

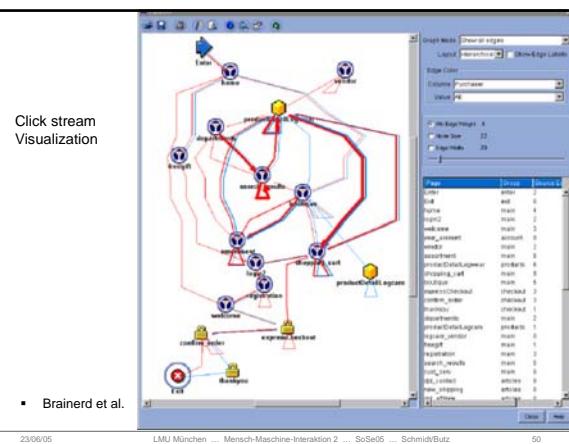
## Click stream Visualization

- 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>

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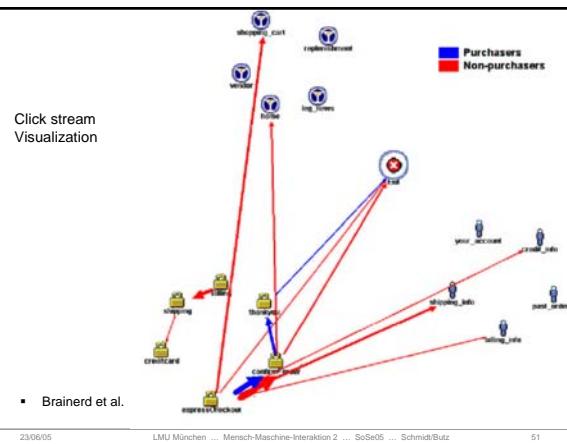
49



▪ Brainerd et al.

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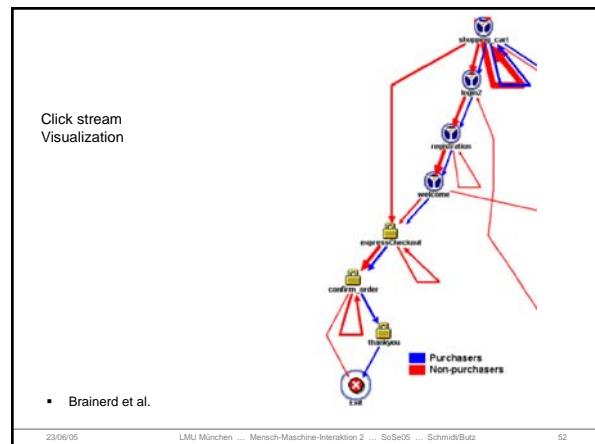
50



▪ Brainerd et al.

LMU München ... Mensch-Maschine-Interaktion 2 ... SoSe05 ... Schmid/Butz

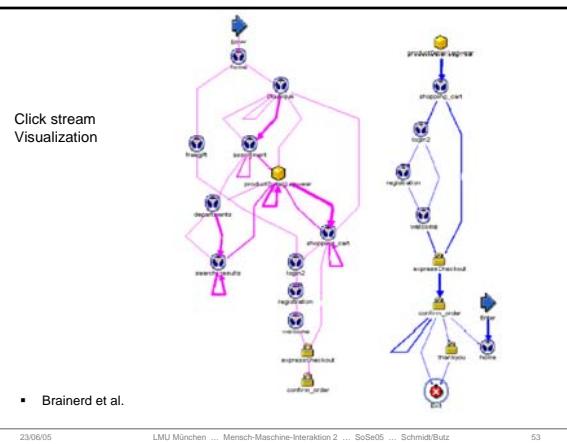
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▪ Brainerd et al.

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▪ Brainerd et al.

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## Hyperbolic Browser

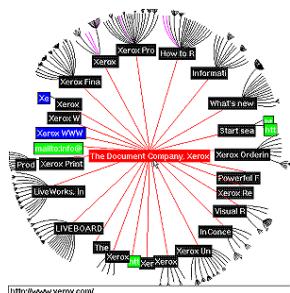
- Focus + Context Technique
  - detailed view blended with a global view
- First lay out the hierarchy on Poincaré' mapping of the hyperbolic plane
- Then map this plane to a disk
- Use animation to navigate along this representation of the plane
- Start with the tree's root at the center

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## Hyperbolic Tree Browser (Lamping et al. 95)

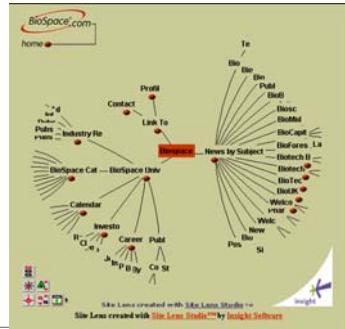


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## Inxight's Hyperbolic Browser



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## Hyperbolic Tree Views

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

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## Thebrain.com



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## 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

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## Determining Layout

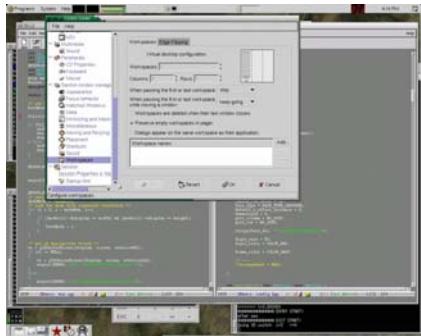
- User selects focus
  - As user drags mouse, display changes
- For each object: size, position, and amount of detail depend on:
  - distortion factor
  - object's "normal" size and position
  - distance of object from focus (POI)
  - pre-assigned importance value
  - other user-controlled parameters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

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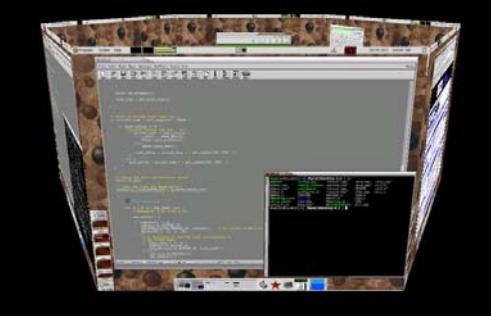
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### 3D Desktop - <http://desk3d.sourceforge.net/> switching virtual desktops in 3D



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### 3D Desktop - <http://desk3d.sourceforge.net/> switching virtual desktops in 3D



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### 3D Desktop - <http://desk3d.sourceforge.net/> switching virtual desktops in 3D



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### Sun: Project Looking Glass functional 3D-Desktop



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

Video ~ 6min

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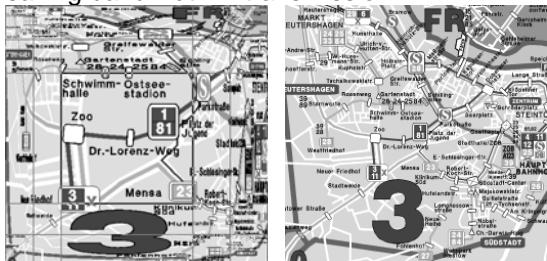
### Visualization on Mobile Devices

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



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### 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/>

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## Rectangular Fish Eye View saving bandwidth in transmission



Figure 3: Rectangular fish eye view example

- 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 24-26, 1998.

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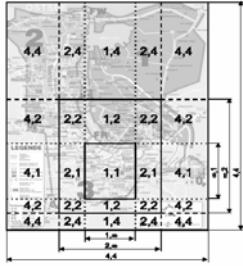


Figure 4: Generating ROI grid

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## 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.

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## 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.

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## 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.

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## References

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- Barlow et al. "A Comparison of 2-D Visualizations of Hierarchies" INFOVIS'01 <http://www.sims.berkeley.edu/courses/s247b/02/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/e2a3c4986332d4785256ca7006cb6217?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](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>

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  - <http://bailando.sims.berkeley.edu/infovis.html>
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  - <http://www.cs.uvic.ca/~mstorey/>
  - [http://www.cs.uvic.ca/~mstorey/teaching/infovis/course\\_notes/introduction.pdf](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>

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## 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 & Hollán, 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