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

Ludwig-Maximilians-Universität München

LFE Medieninformatik

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SS2006

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

Focus + Context

- Basic Idea:
  - Show selected regions of interest in greater detail (*focus*)
  - Preserve global view at reduced detail (*context*)
  - NO occlusion - All information is visible simultaneously

- Techniques
  - Fisheye views
  - Fisheye lens
  - Continuously variable zoom
  - Nonlinear magnification
  - Hyperbolic views
  - Distortion viewing
  - Rubber sheet views

Focus + Context

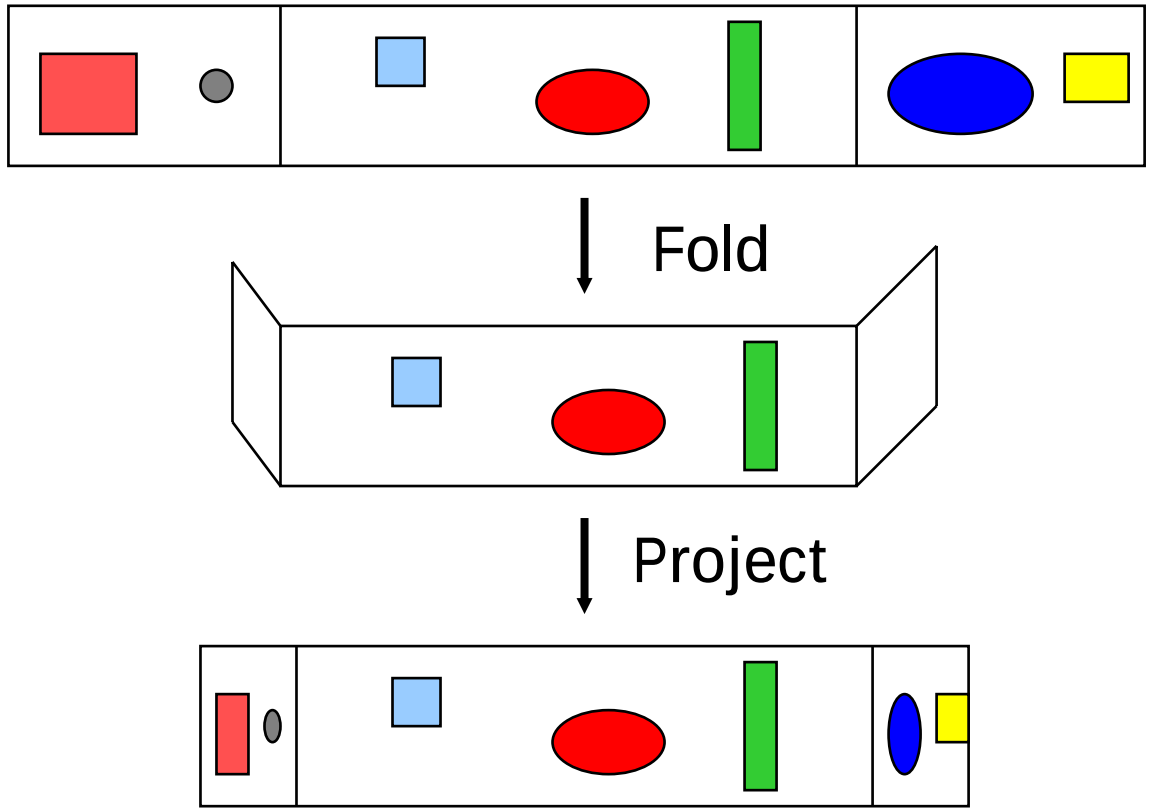
- Often combined with distortion
  - E.g. fisheye
  - Data not in focus is suppressed and distorted
  - Data of interest is larger and clearer

- “Allows dynamic interactive positioning of the local detail without severely compromising spatial relationships.”
  - *Leung & Apperley*
- “One challenge in navigating through any large dataspace is maintaining a sense of relationship between what you are looking at and where it is with respect to the rest of the data.”
  - *Bederson & Hollan*

Distorted vs. Non-distorted

- Non-distorted
  - Display only a selection at a time
  - Scrolling
  - Paging access
  - hierarchical structure
  - Structure-specific presentation
- Distorted
  - See next week

Basic idea – Perspective Wall

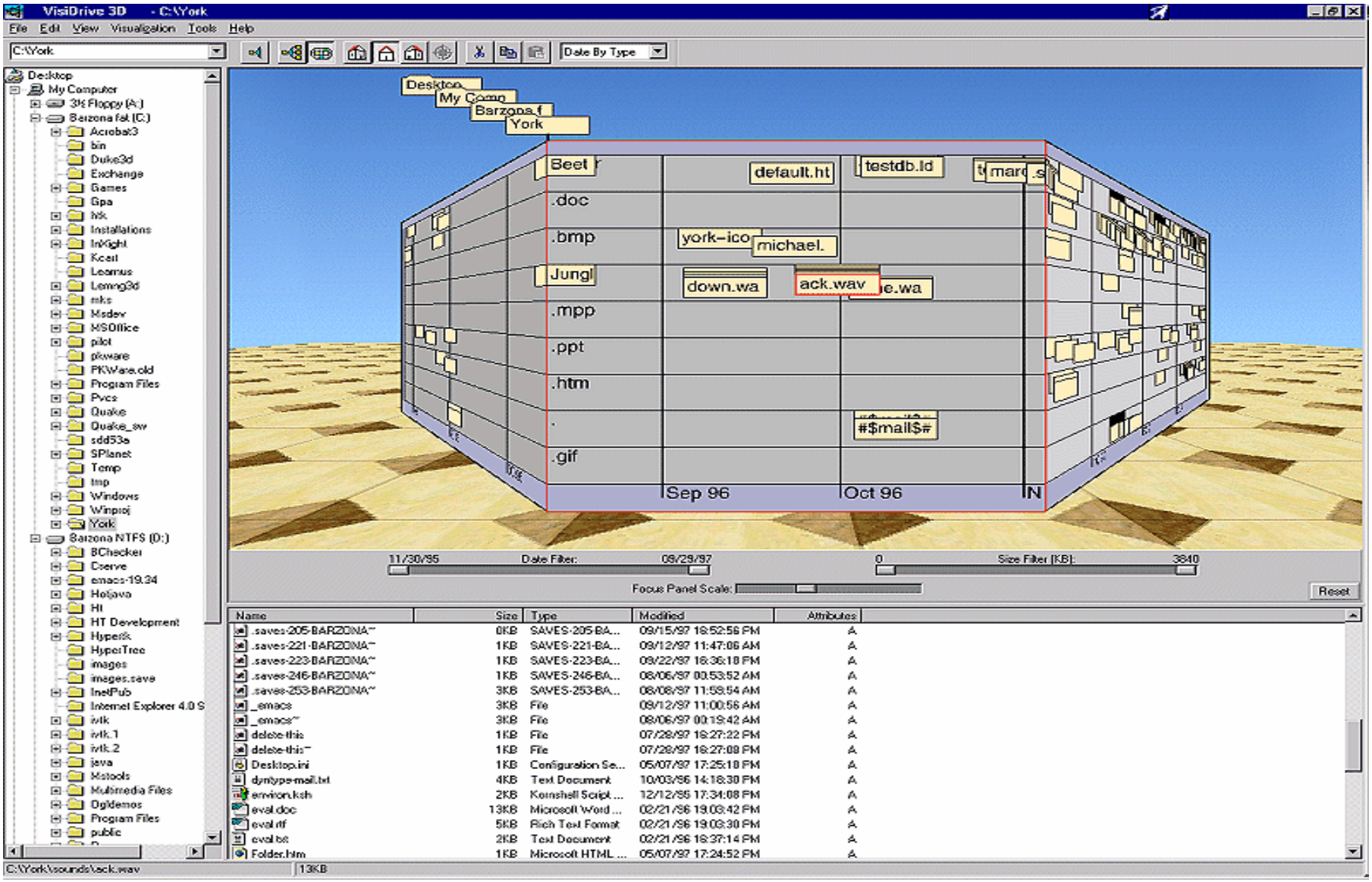


From http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/0324.fengdongdu.ppt

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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Learnus
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HT Development
Hypertk
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2KB
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eval.doc
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Microsoft Word ...
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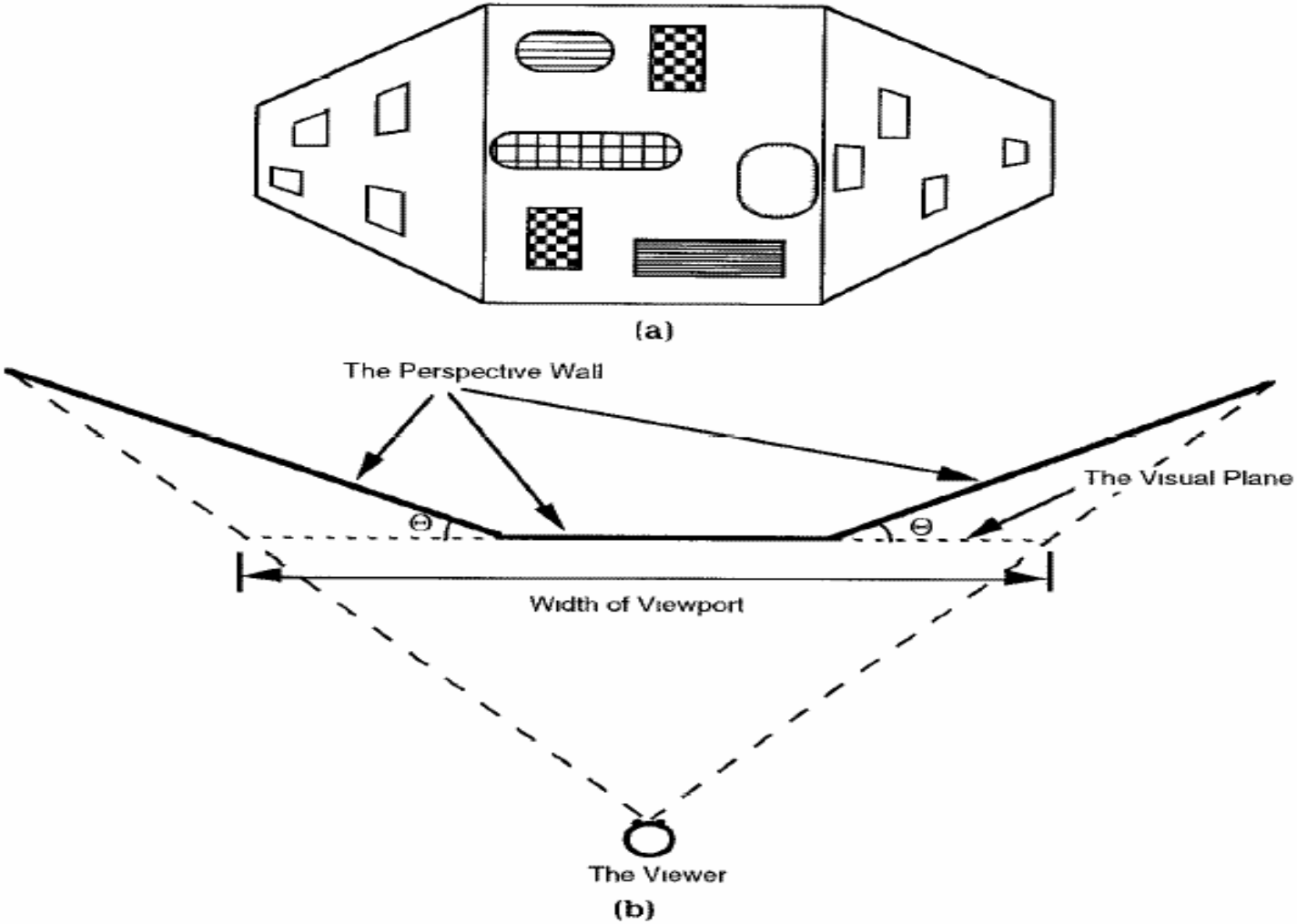


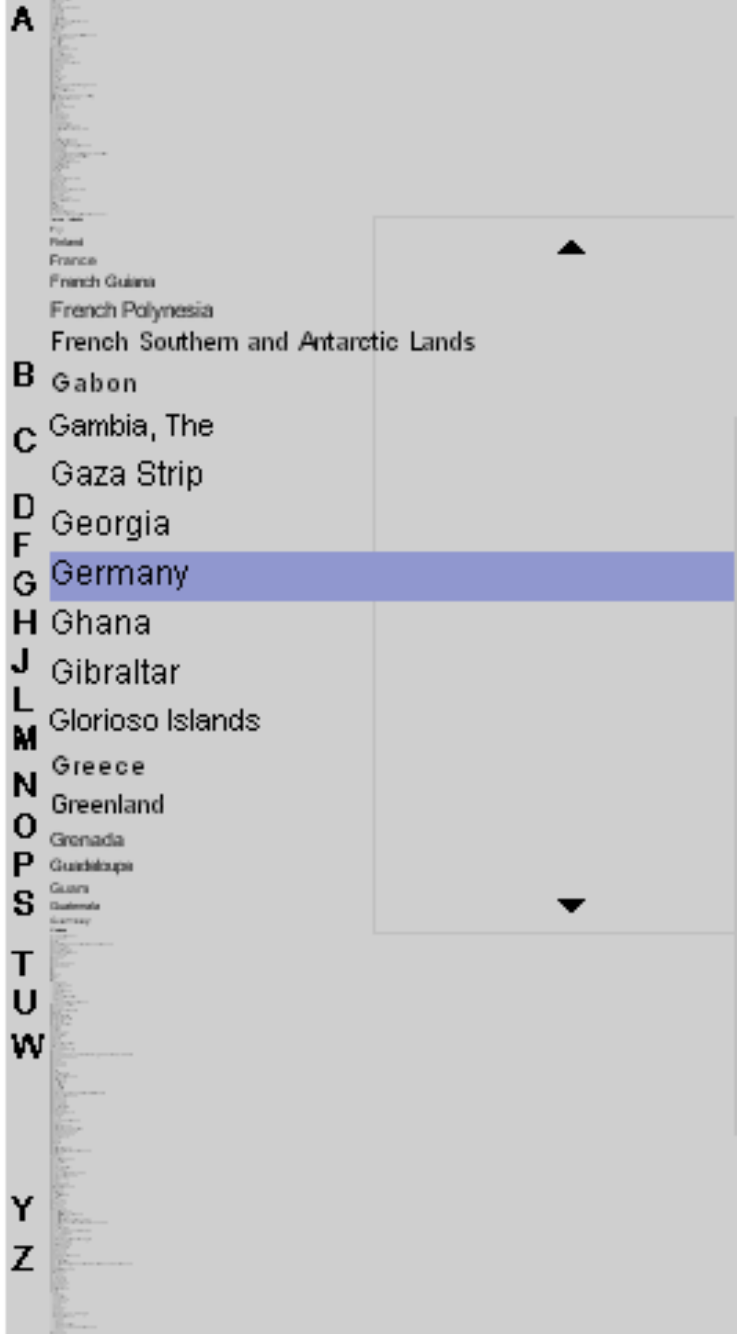
The view is dependent on the length of the wall, the width of the view port, the angle Θ, the size of the central region.

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

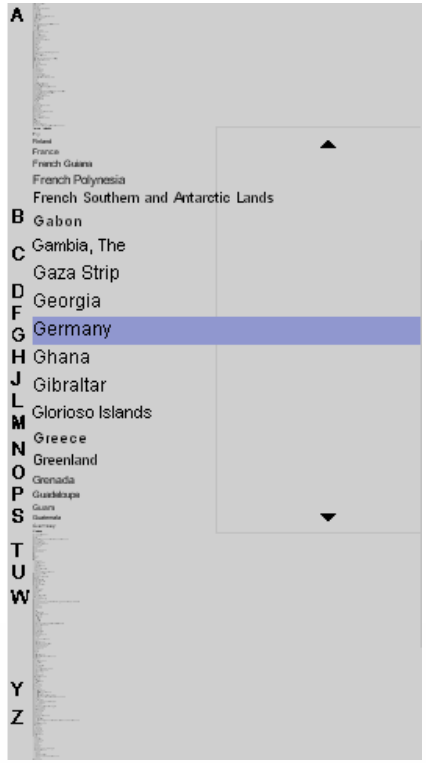
Example: Fisheye Menu

- 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

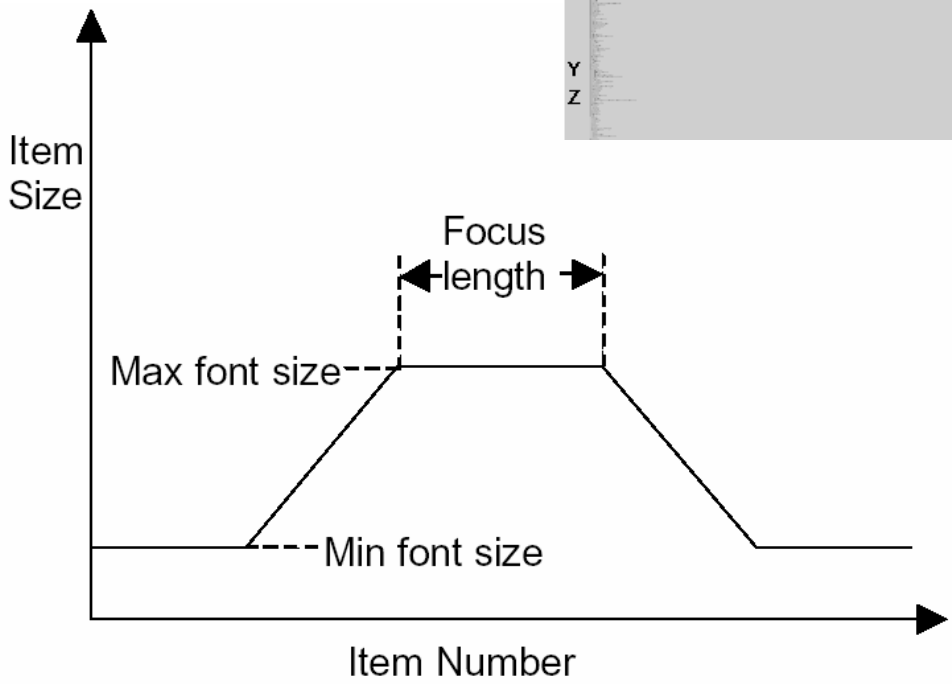


Implementation & Evaluation
Fisheye Menu



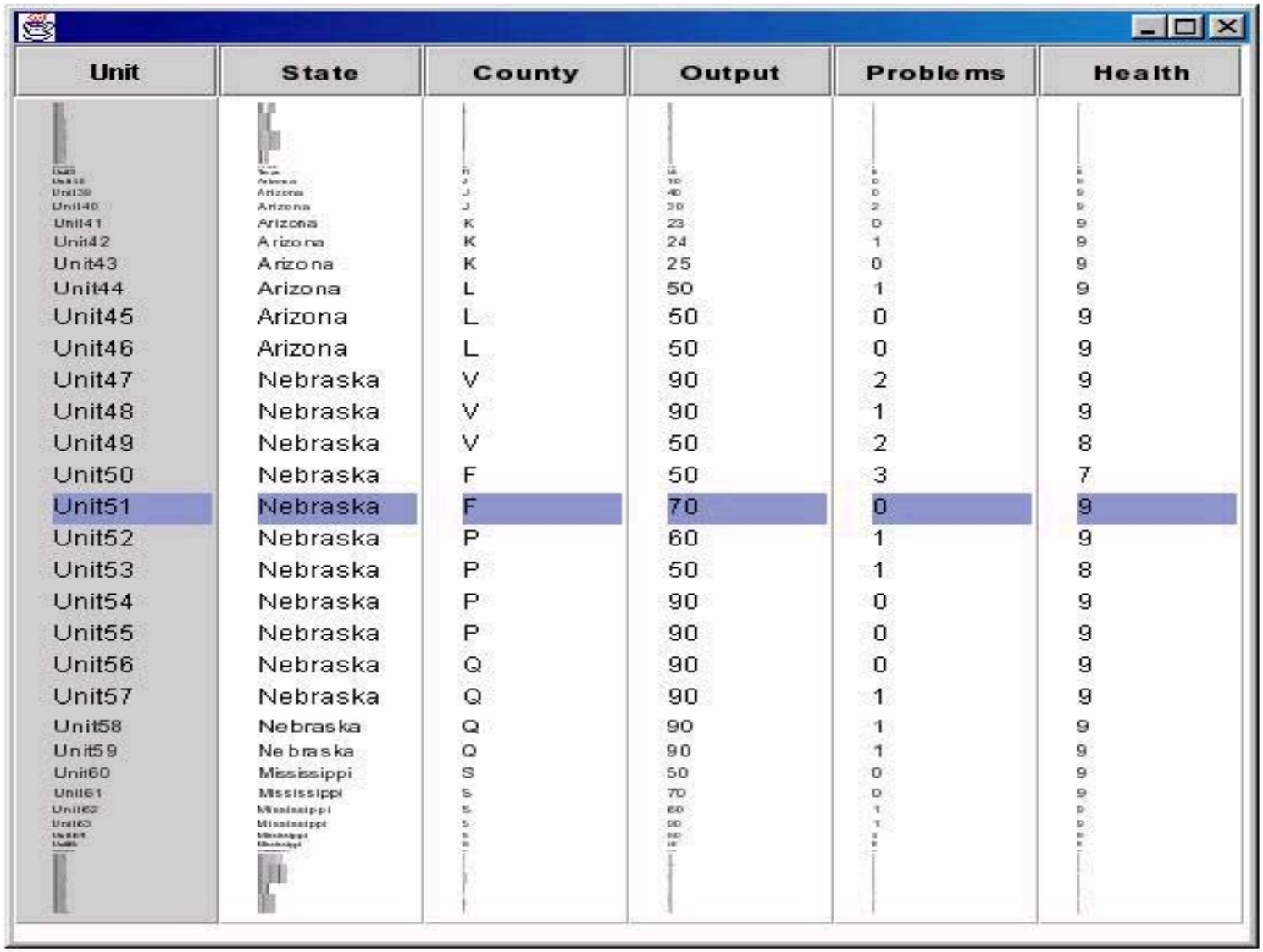
- Calculating font size
- Minimal change moves the centre → hard to select
- Lock mode

- Evaluation
  - Some users like it
  - Others don't …



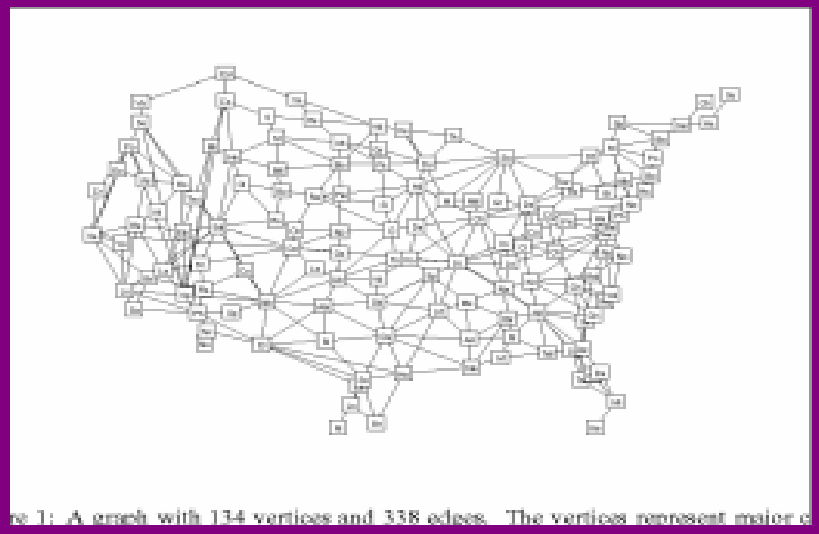
Fisheye View

fisheye table

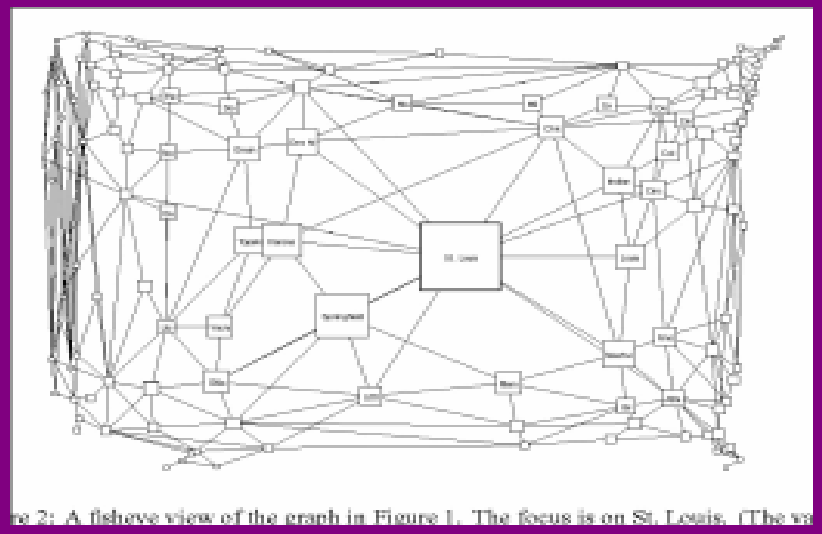


Unit	State	County	Output	Problems	Health
Unit41	Arizona	K	23	0	9
Unit42	Arizona	K	24	1	9
Unit43	Arizona	K	25	0	9
Unit44	Arizona	L	50	1	9
Unit45	Arizona	L	50	0	9
Unit46	Arizona	L	50	0	9
Unit47	Nebraska	V	90	2	9
Unit48	Nebraska	V	90	1	9
Unit49	Nebraska	V	50	2	8
Unit50	Nebraska	F	50	3	7
Unit51	Nebraska	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
Unit58	Nebraska	Q	90	1	9
Unit59	Nebraska	Q	90	1	9
Unit60	Mississippi	S	50	0	9
Unit61	Mississippi	S	70	0	9

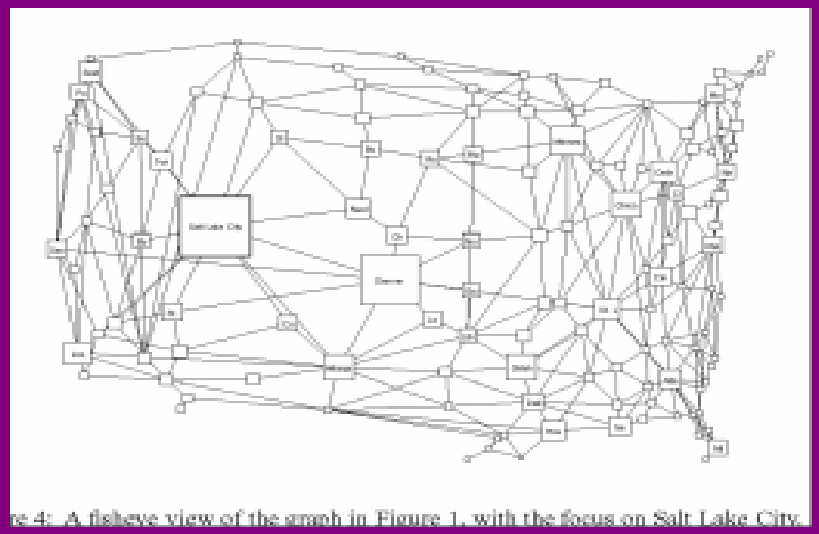
Fisheye View - Networks



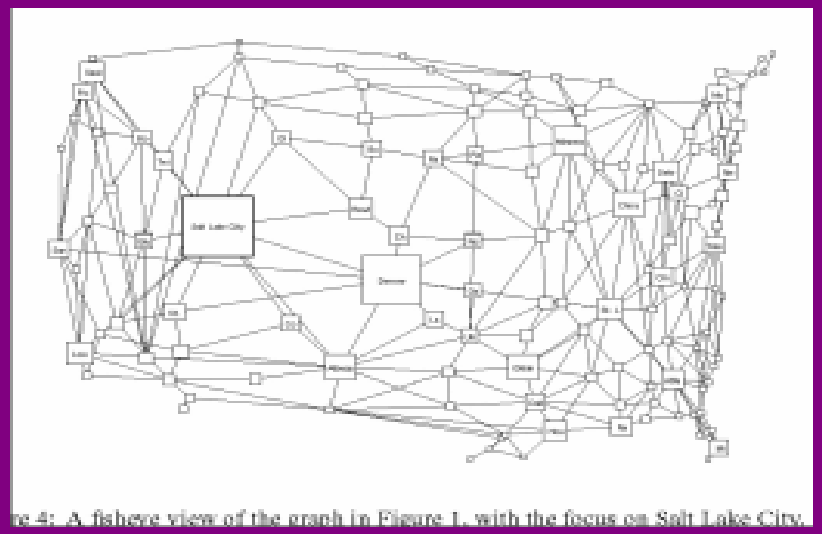
e 1: A graph with 134 vertices and 338 edges. The vertices represent major c



re 2: A fisheye view of the graph in Figure 1. The focus is on St. Louis. (The vi



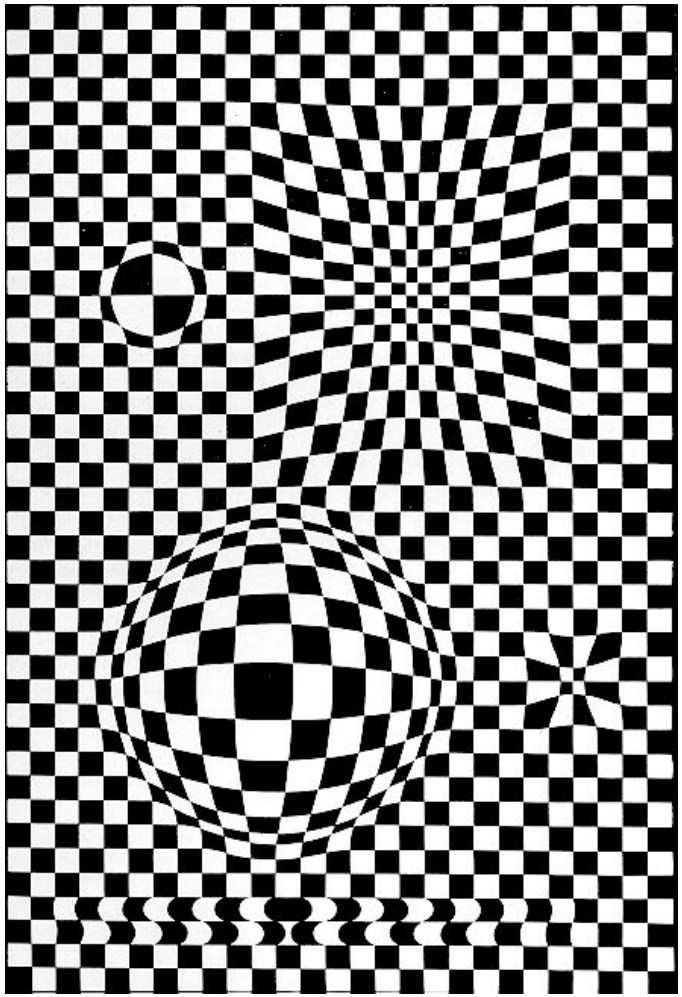
re 4: A fisheye view of the graph in Figure 1, with the focus on Salt Lake City.

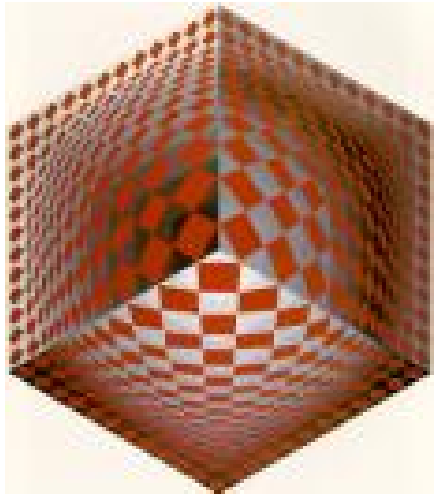


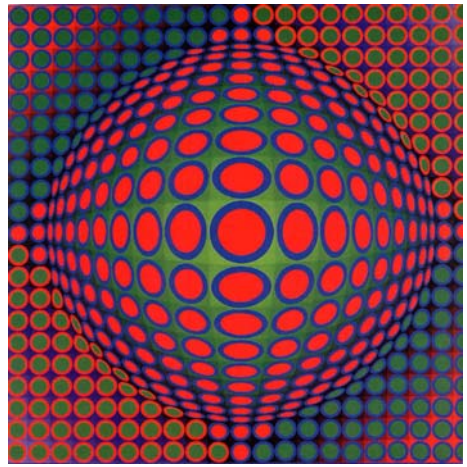
re 4: A fisheye view of the graph in Figure 1, with the focus on Salt Lake City.

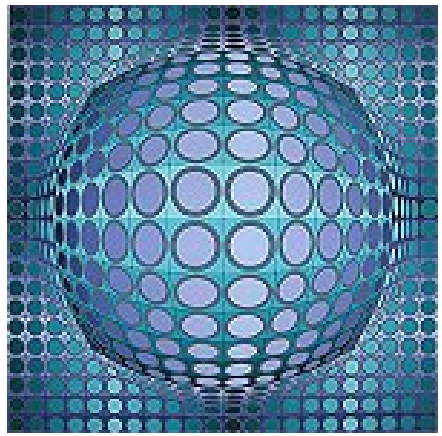
From Sarkar and Brown

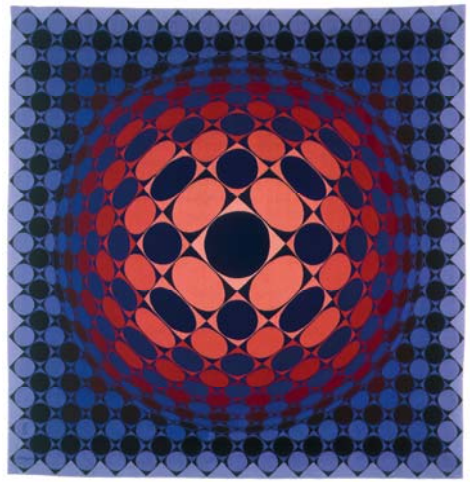
Victor Vasarely (1906-1997, http://www.vasarely.org/)





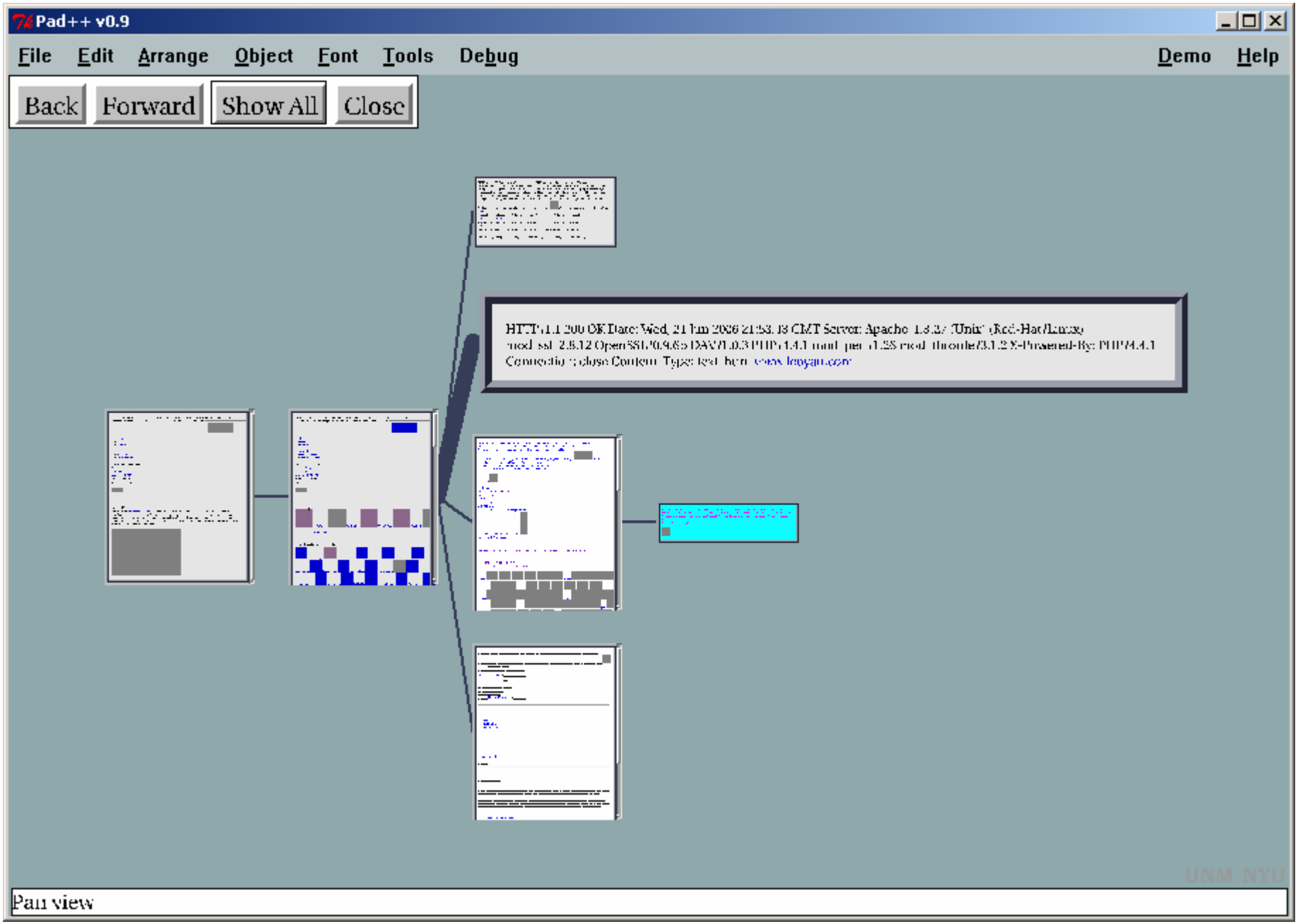






Panning and Zooming

- 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


Pad++ v0.9
File
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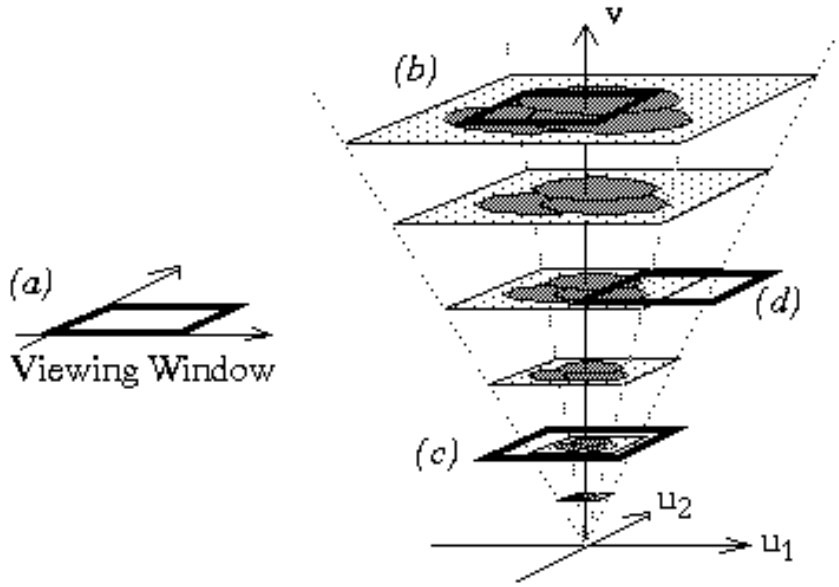
Back
Forward
Show All
Close
Pan view

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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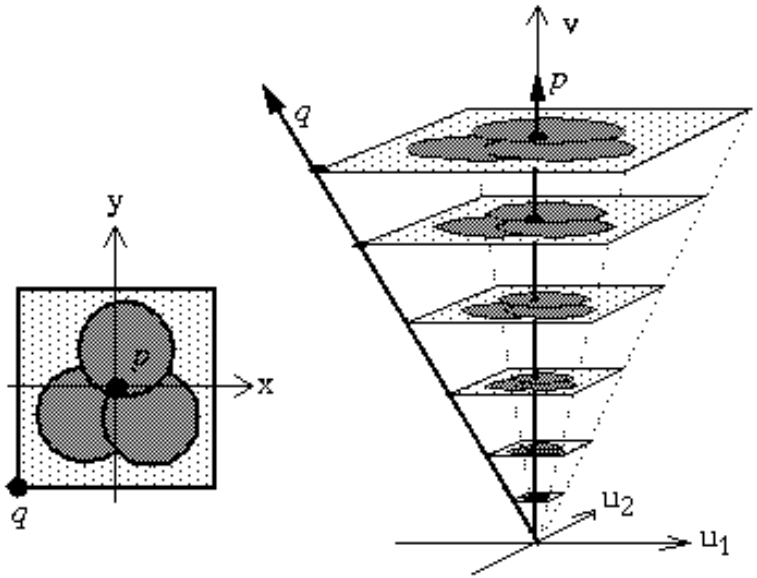
Space-Scale Diagrams
(Furnas & Bederson 95)

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



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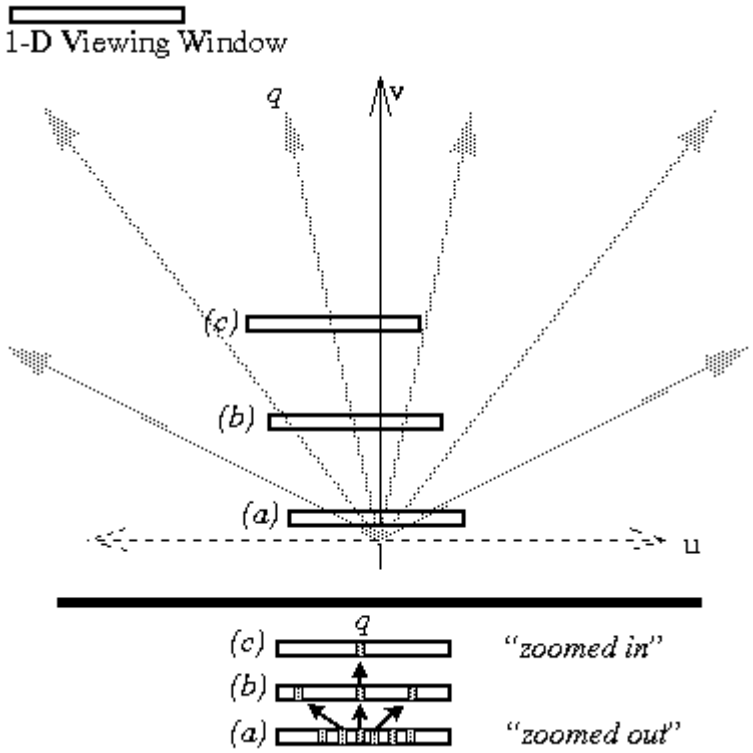
Space-Scale Diagrams
(Furnas & Bederson 95)

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



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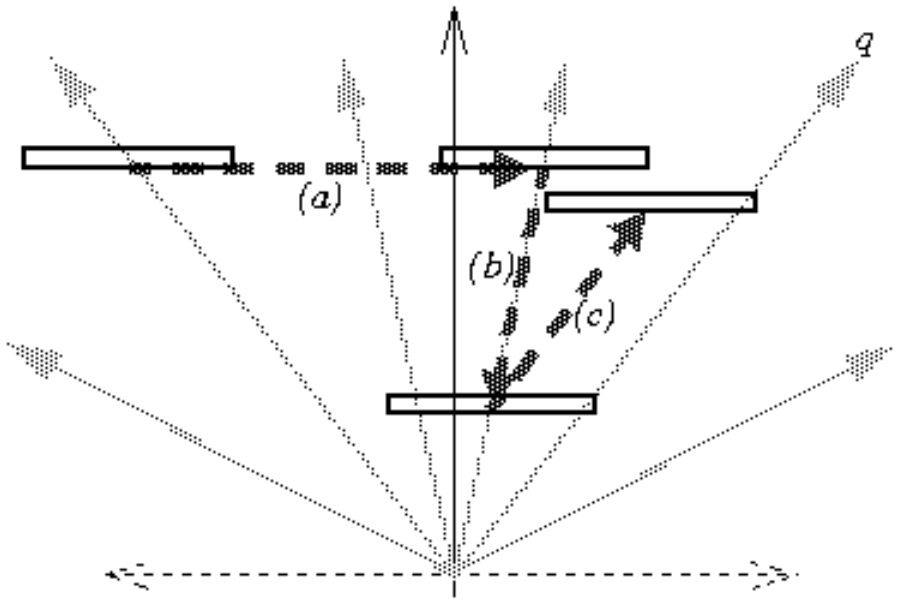
Space-Scale Diagrams
(Furnas & Bederson 95)

- 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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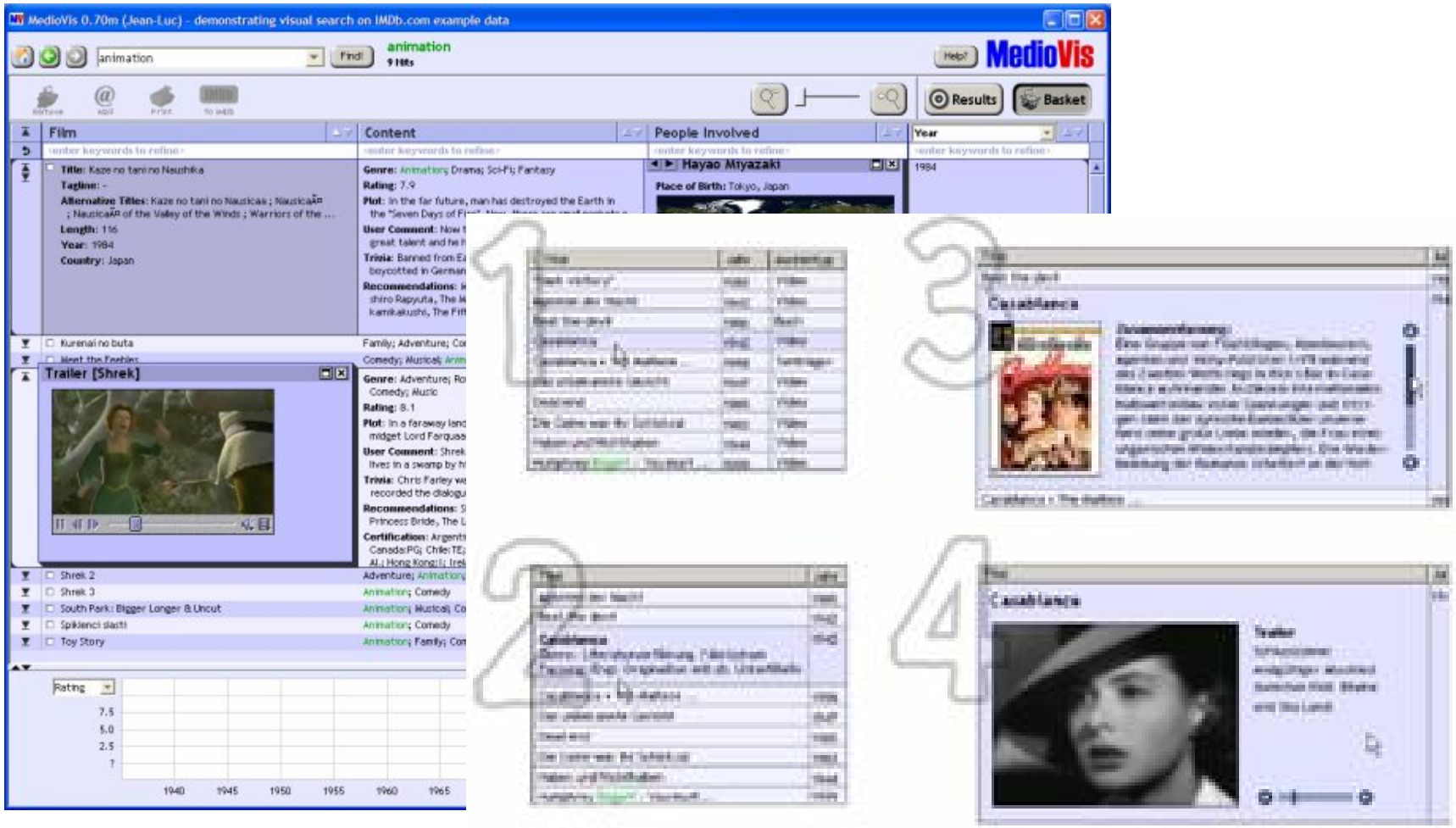
Semantic Zoom in MedioVis

http://hci.uni-konstanz.de/research/projects/mediovis



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

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.

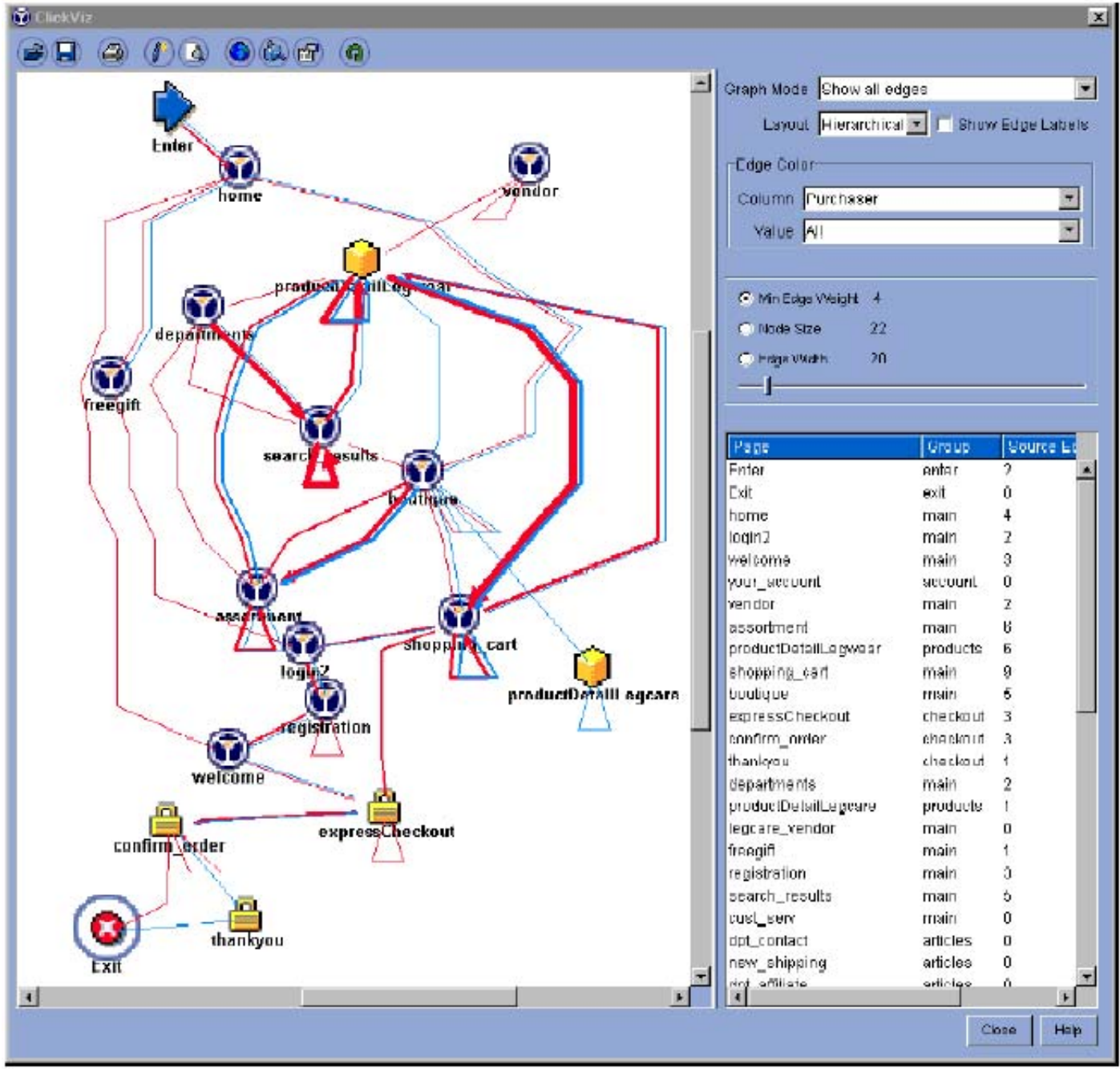
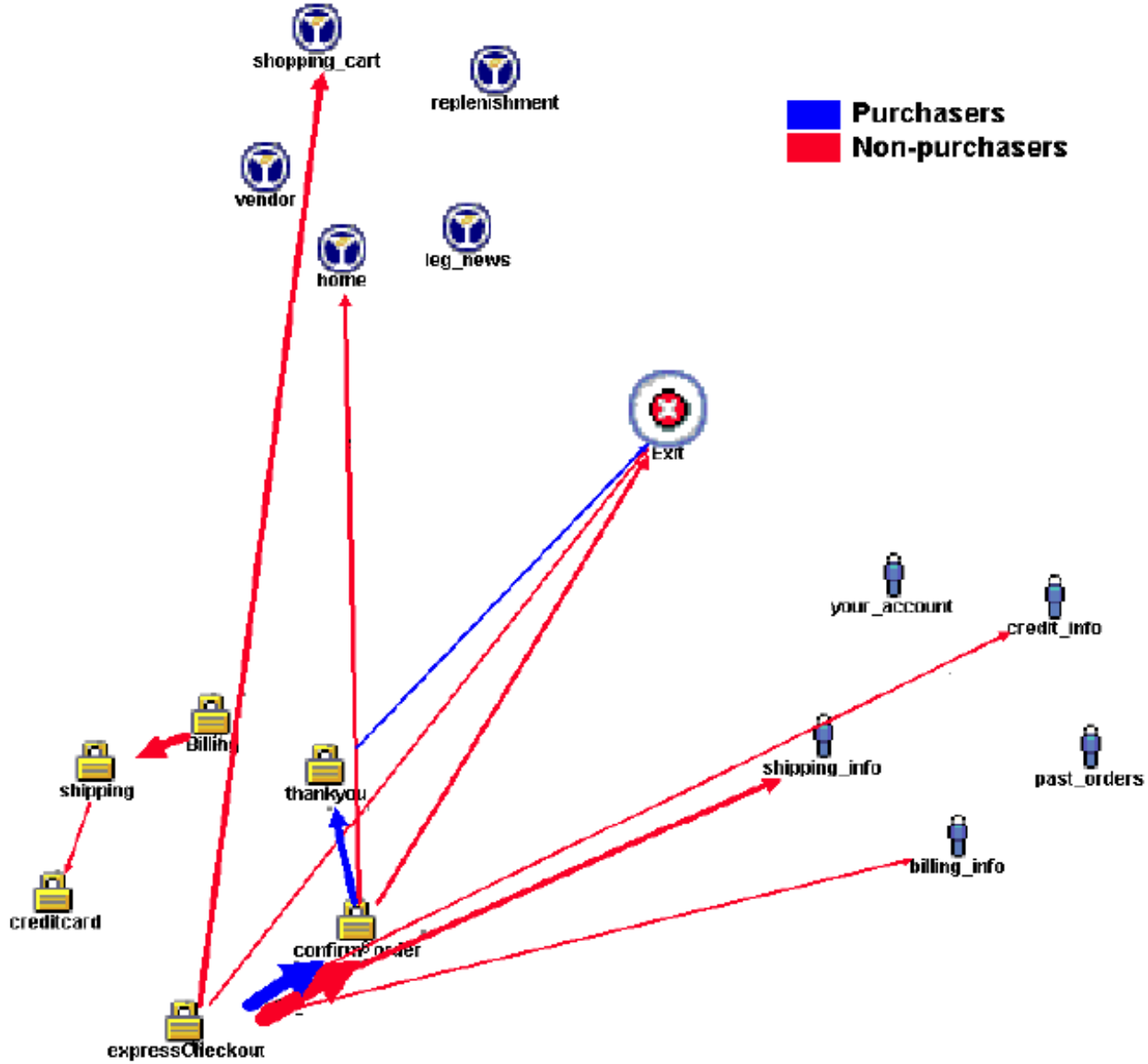


Figure 1: Main ClickViz window showing hierarchical layout

Click stream Visualization



- Brainerd et al.

Figure 2. Circular layout. All the checkout pages are grouped (lower left). Red edges that emanate from the checkout pages to other parts of the site represent non-purchasers who are abandoning the checkout process.

Click stream
Visualization

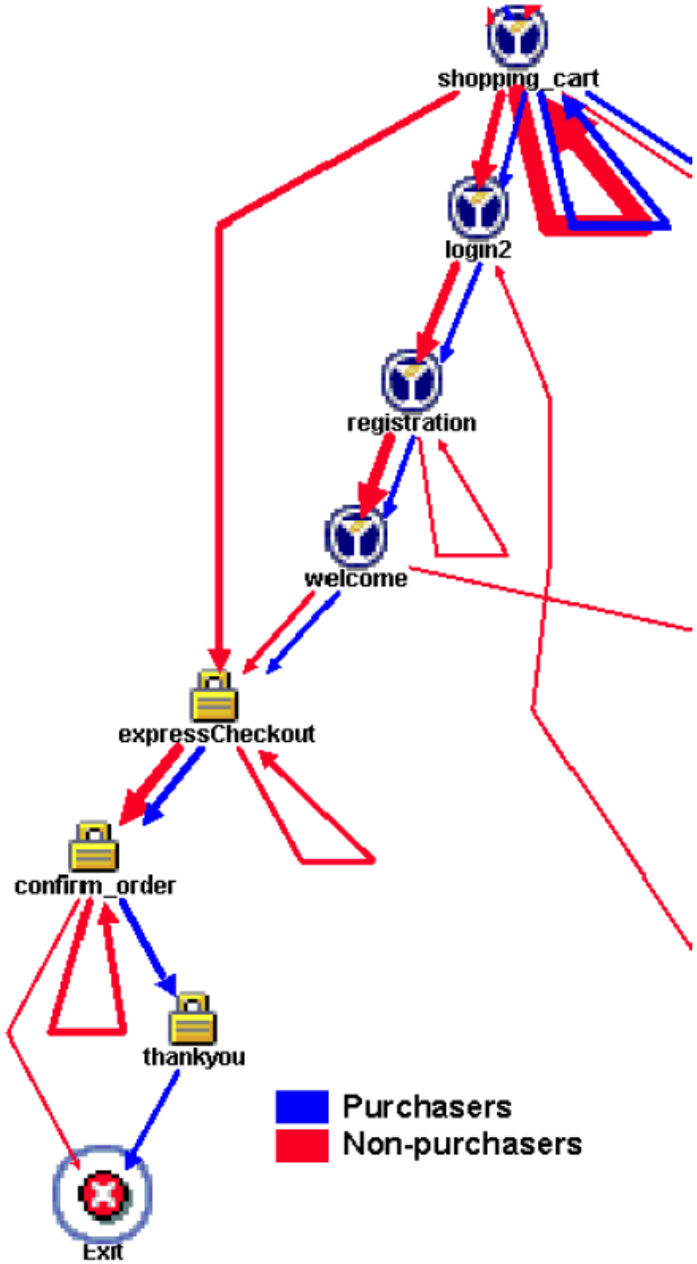


Figure 4. Checkout process. Purchasers take a direct route through the checkout process, whereas non-purchasers show a more haphazard route, including self-edges and early abandonment, possibly indicating a confusing checkout process.

- Brainerd et al.

Click stream
Visualization

- Brainerd et al.

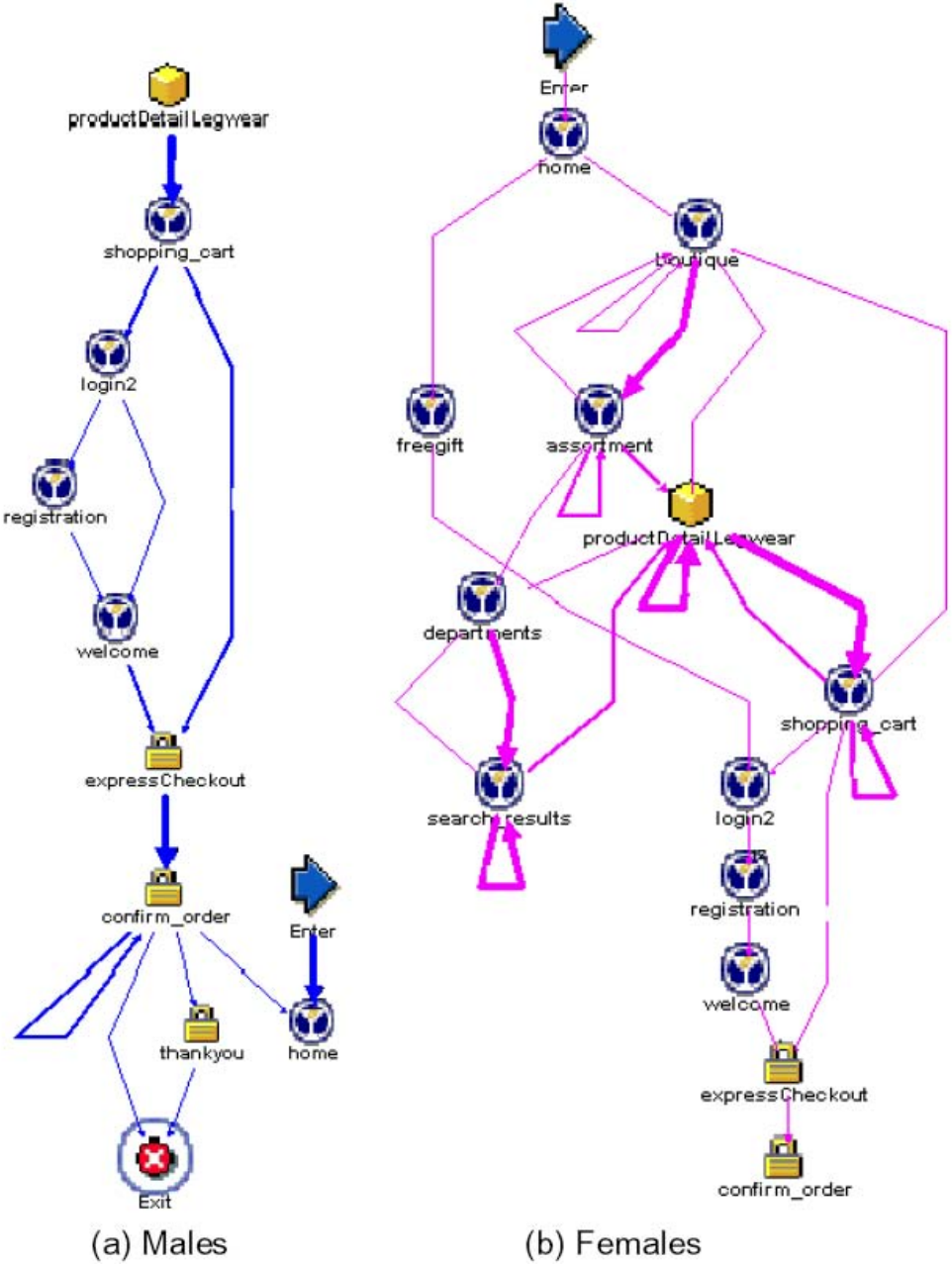
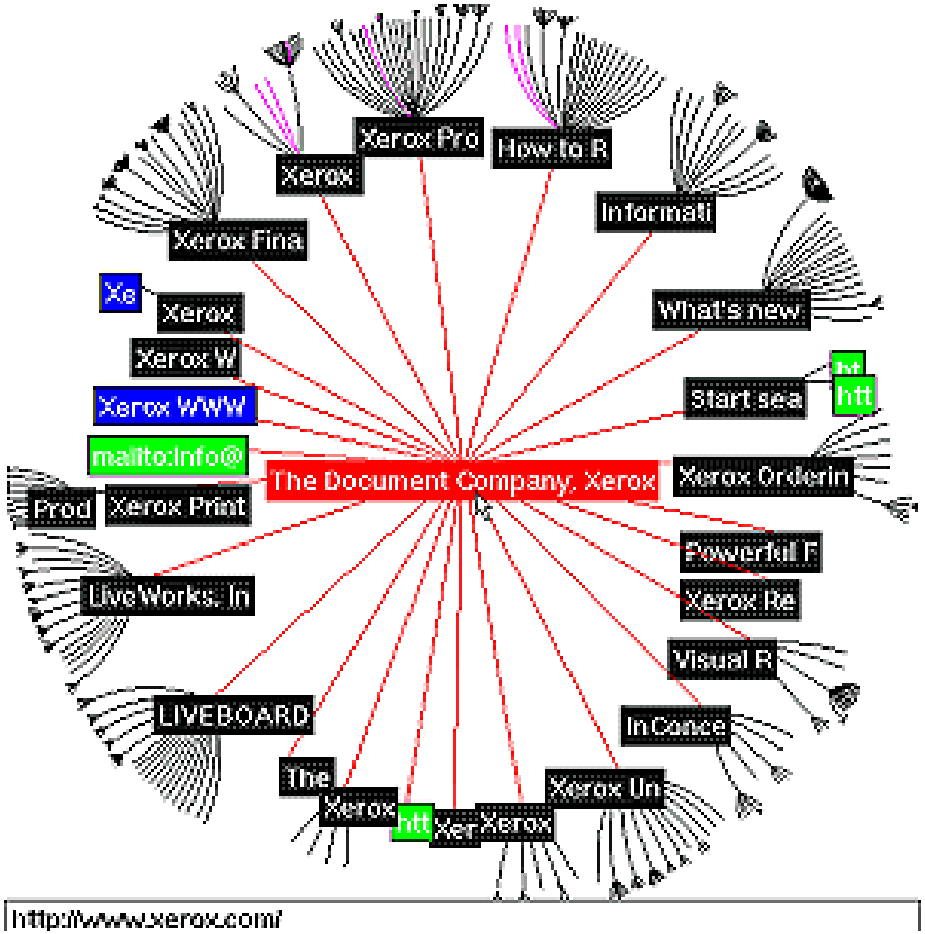
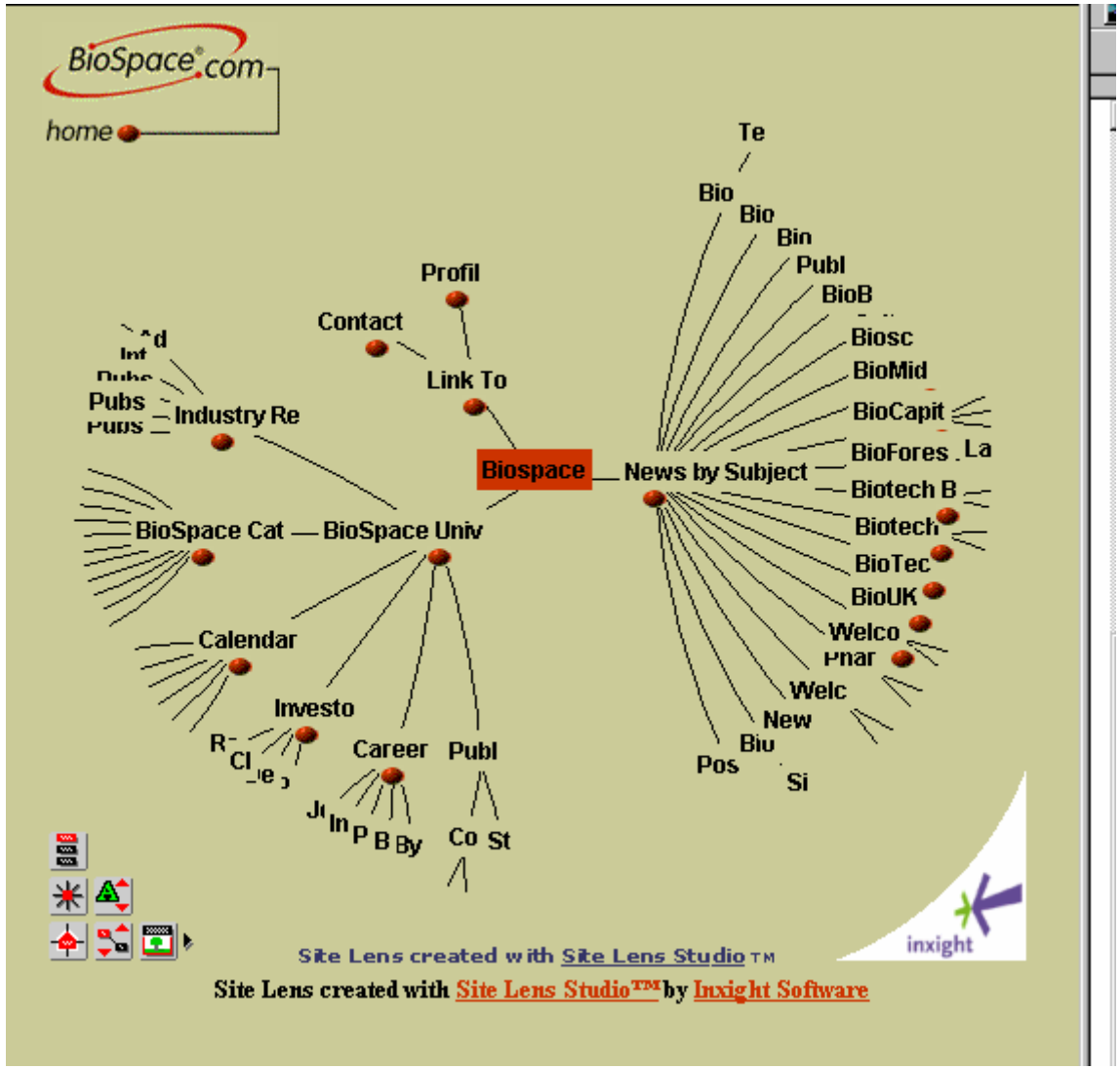


Figure 3. Gender Differences: Males tend to navigate in specific, direct patterns, whereas women's navigation patterns include much more browsing, utilizing much more of the site.

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

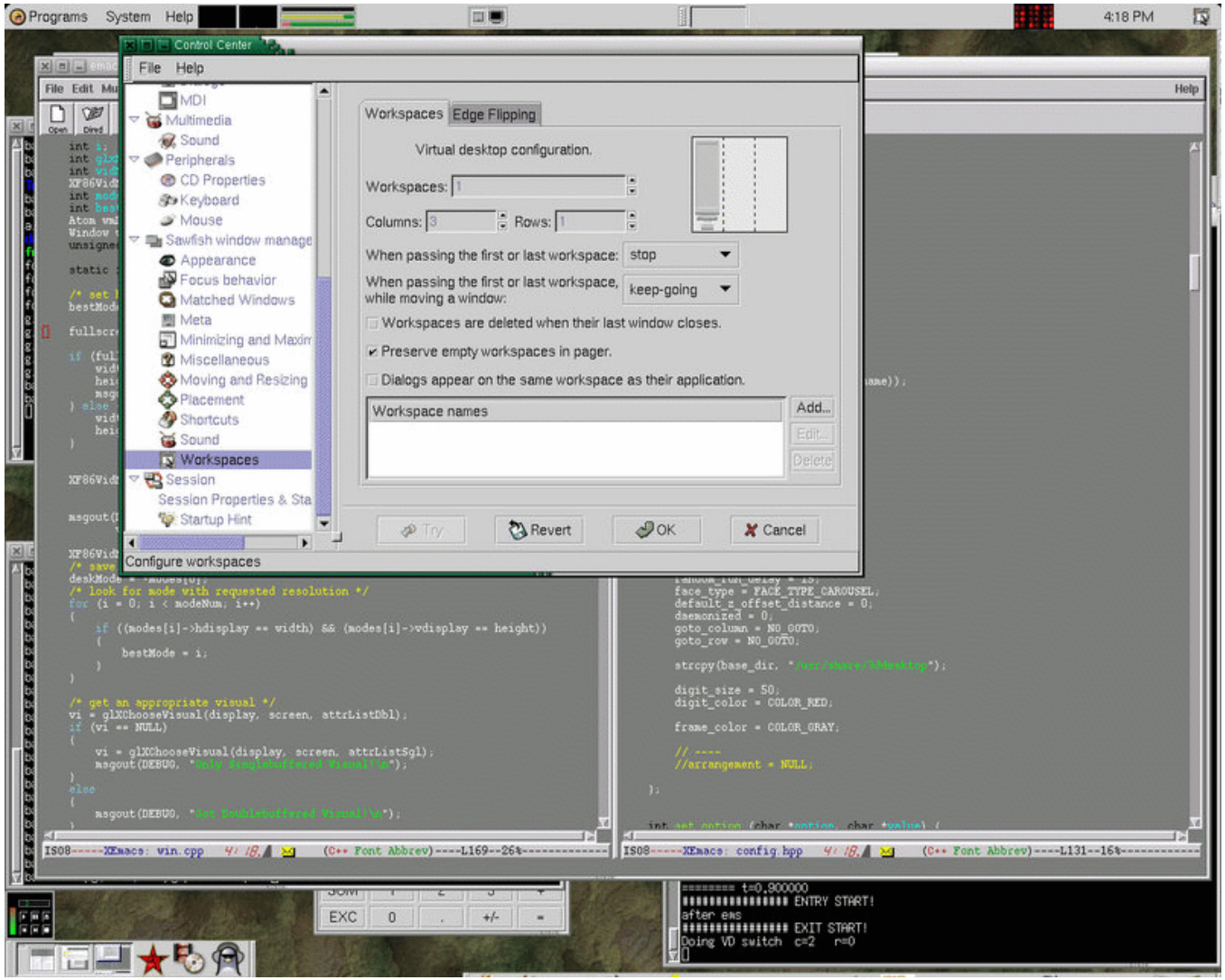
Thebrain.com

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)

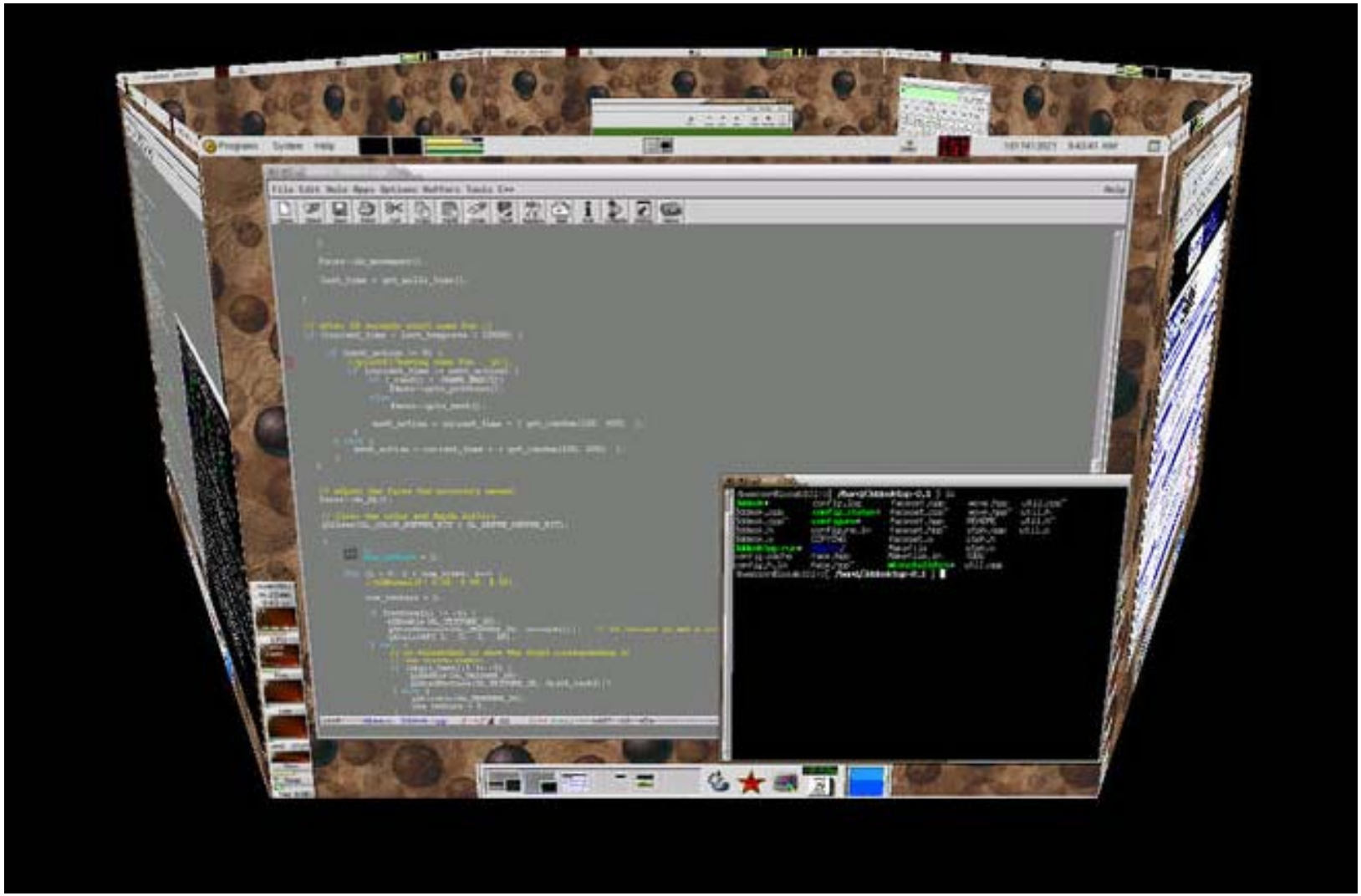
3D Desktop - http://desk3d.sourceforge.net/

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/

BumpTop [Agrawala & Balakrishnan, CHI 2006]

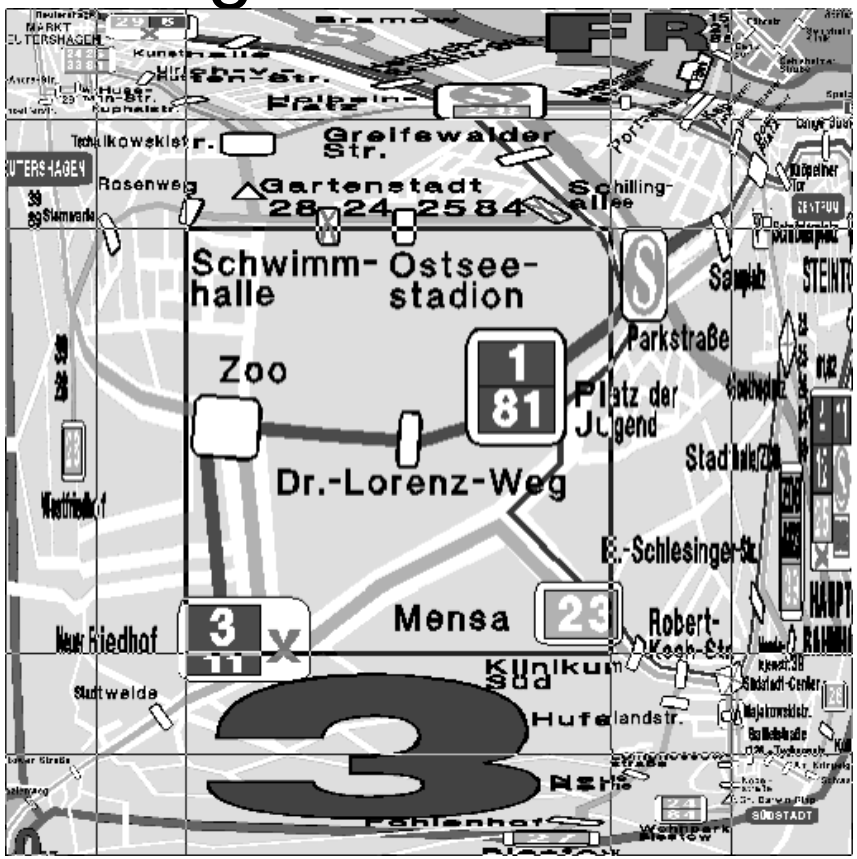
http://honeybrown.ca/Pubs/BumpTop.html

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

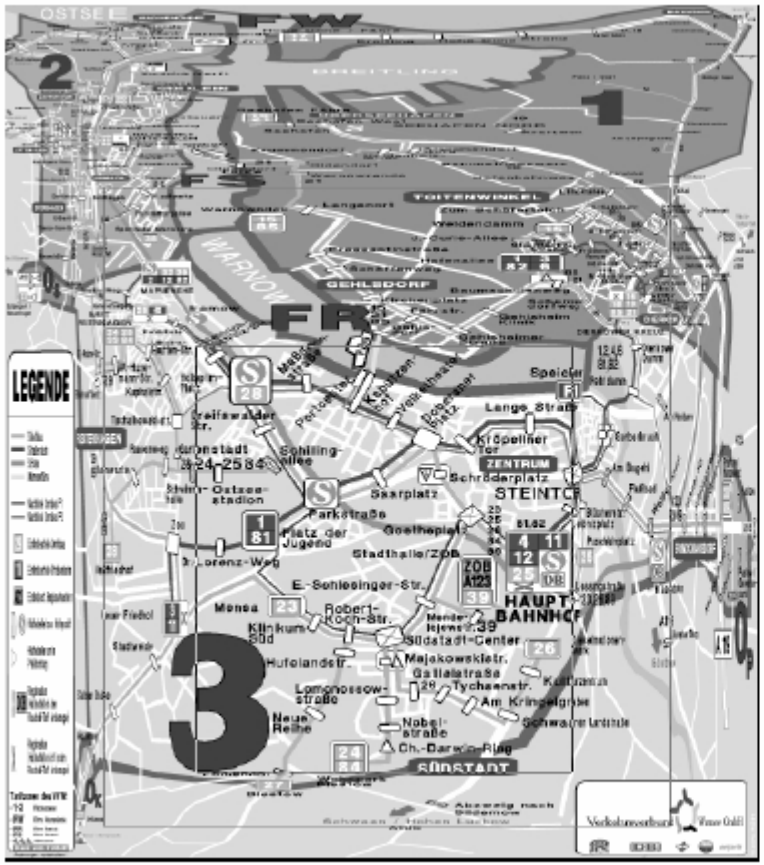


Figure 3: Rectangular fish eye view example

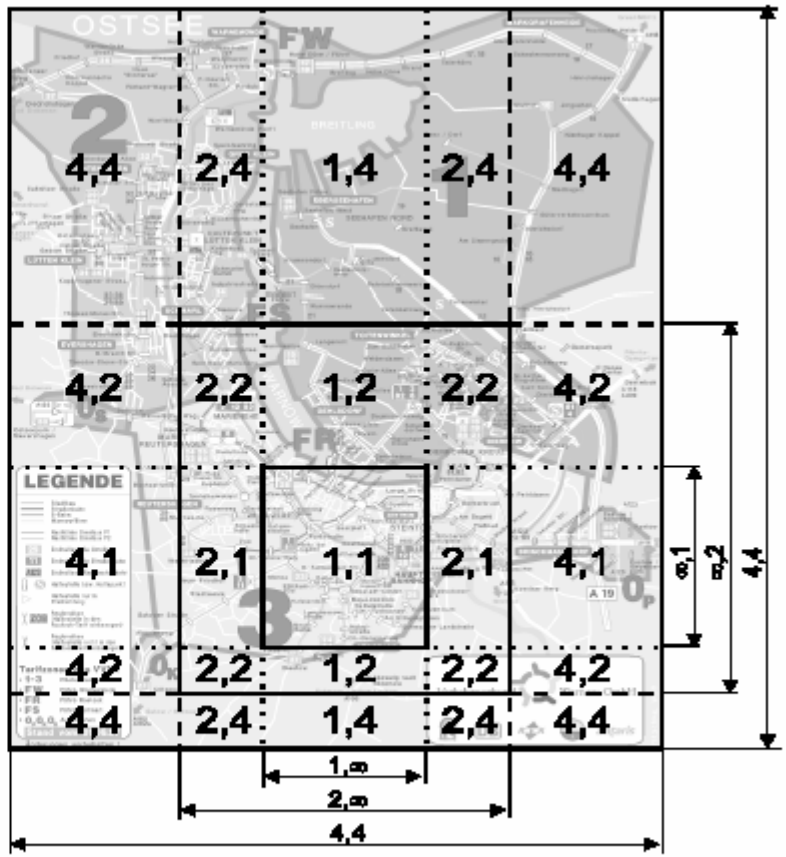


Figure 4: Generating RoI grid

- 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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  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.

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

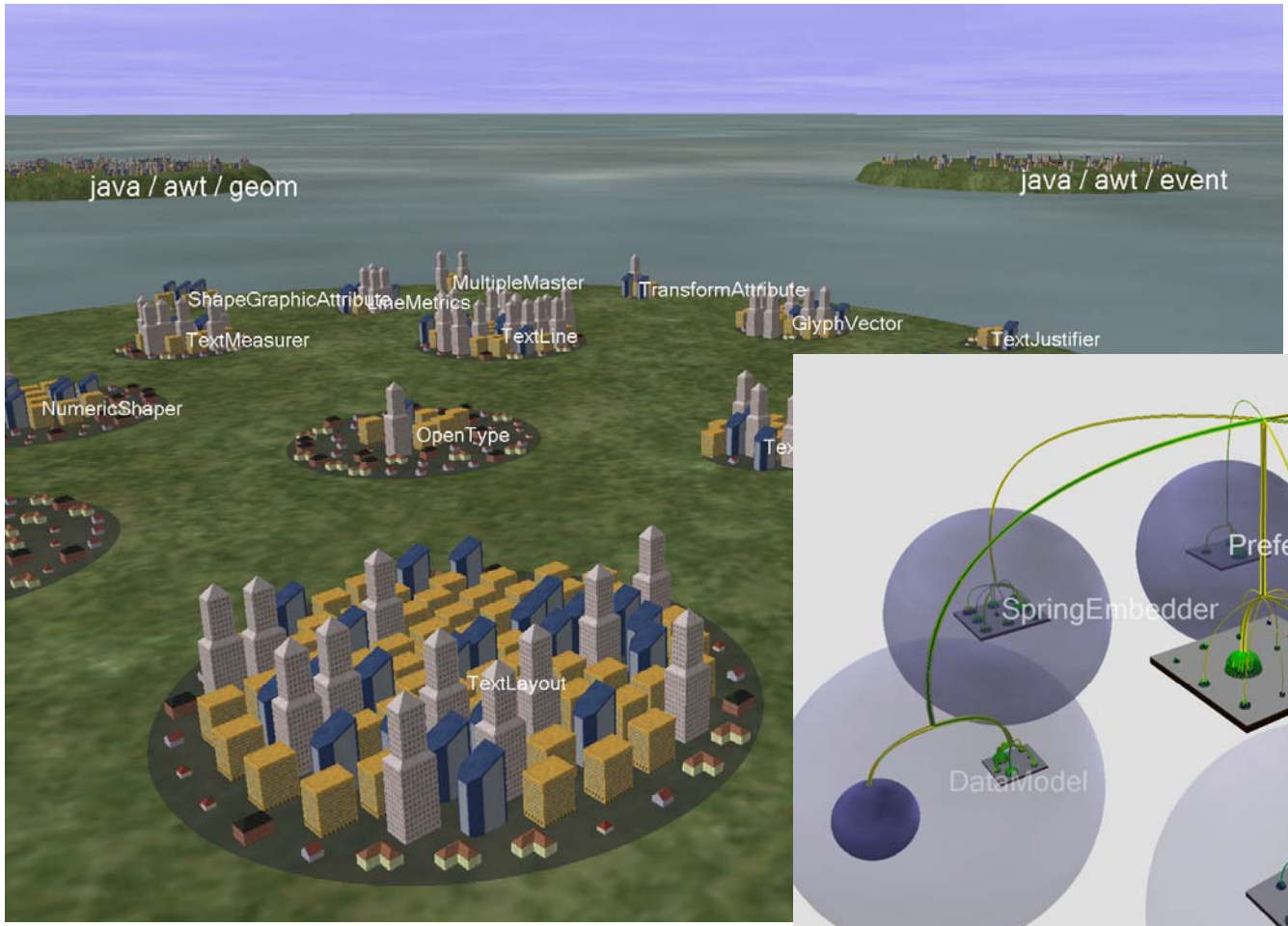
CodeProfile (Brad Paley, http://www.textarc.org/OtherWork.html)

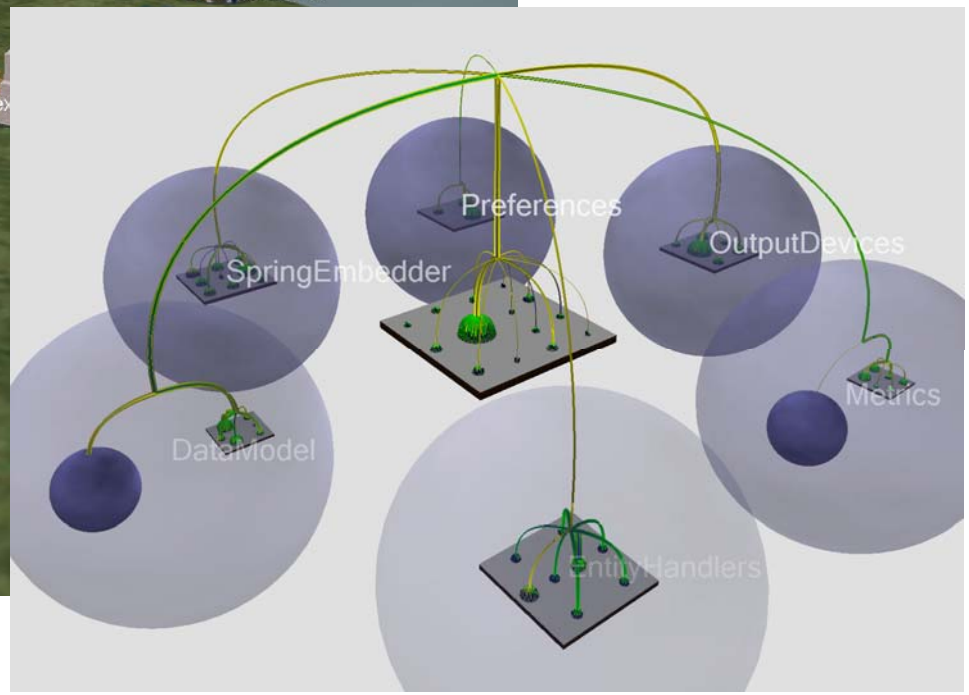
- Example for artistic software visualization
- Java code showing ist own execution

Live demo

SW-visualization (Oliver Deussen)

http://graphics.uni-konstanz.de/research/softwarevisualization.html





SW-visualization with Voronoi treemaps (Michael Balzer)

http://graphics.uni-konstanz.de/members/balzer.html

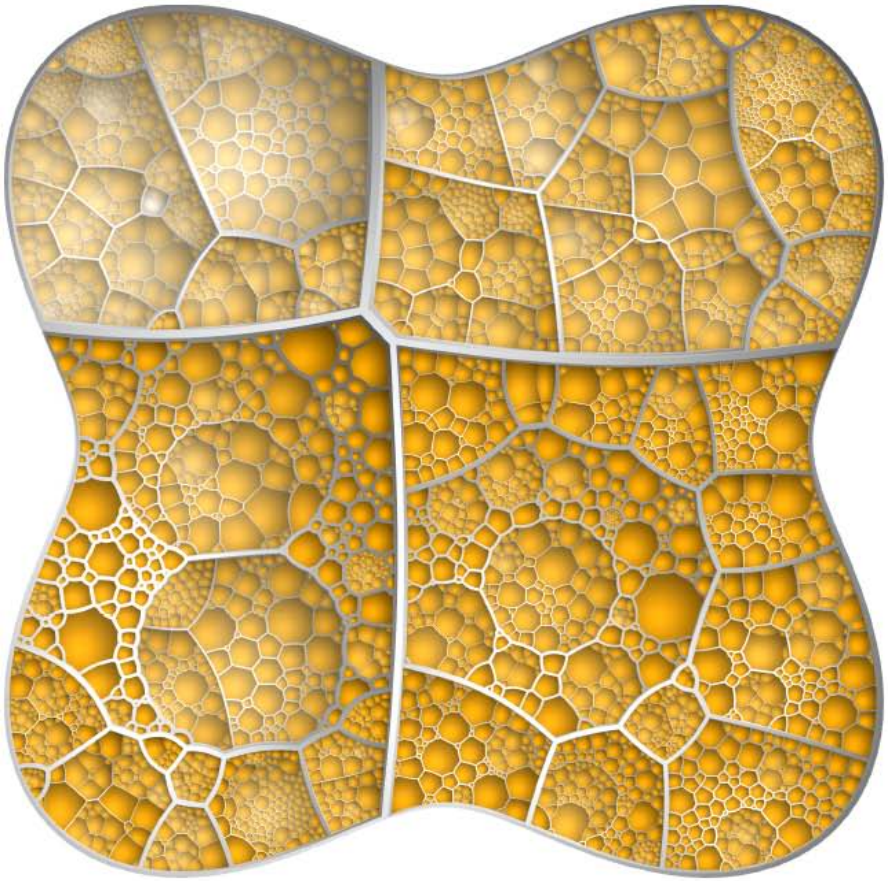


Figure 10: Enhanced AW Voronoi Treemap layout of 4075 nodes at 10 hierarchy levels (a brighter color indicates a lower hierarchy level)

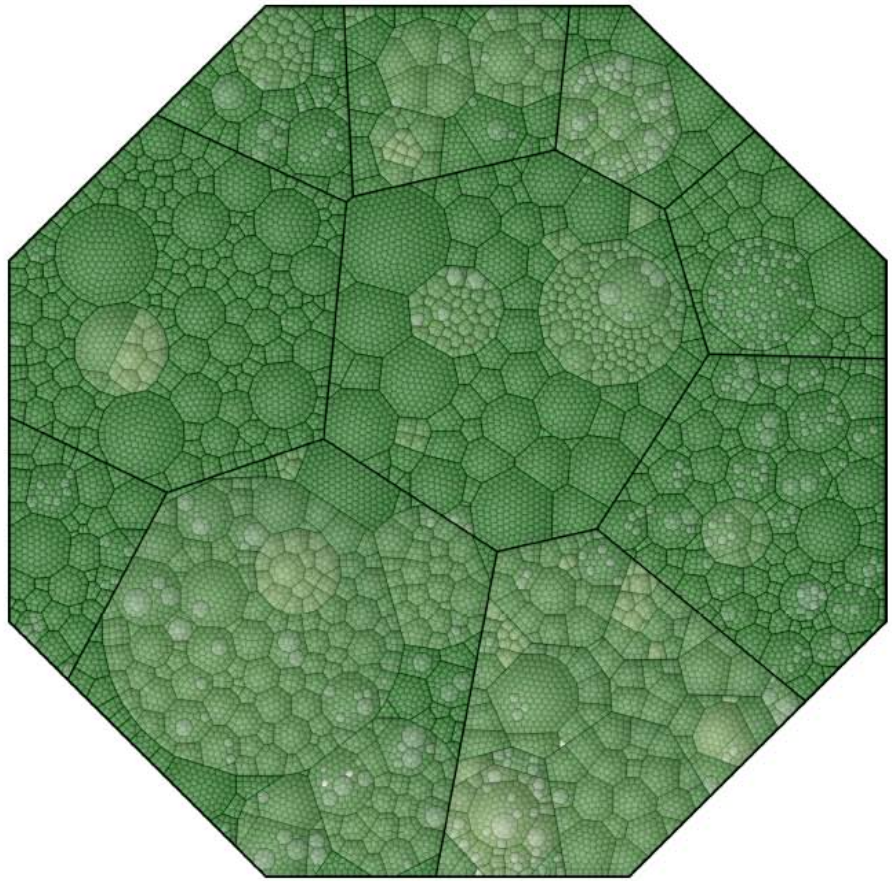
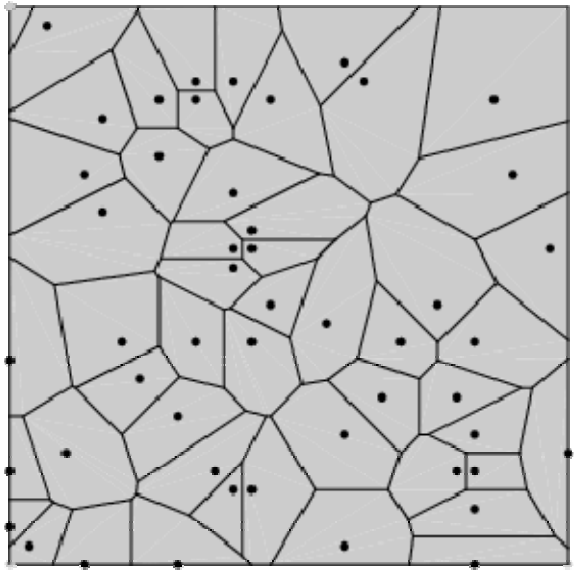


Figure 11: Enhanced PW Voronoi Treemap layout of 16288 nodes at 7 hierarchy levels (a brighter color indicates a lower hierarchy level)

Hmmmm… Voronoi??



The partitioning of a plane with points into convex polygons such that each polygon contains exactly one generating point and every point in a given polygon is closer to its generating point than to any other. A Voronoi diagram is sometimes also known as a Dirichlet tessellation. The cells are called Dirichlet regions, Thiessen polytopes, or Voronoi polygons.

http://mathworld.wolfram.com/VoronoiDiagram.html

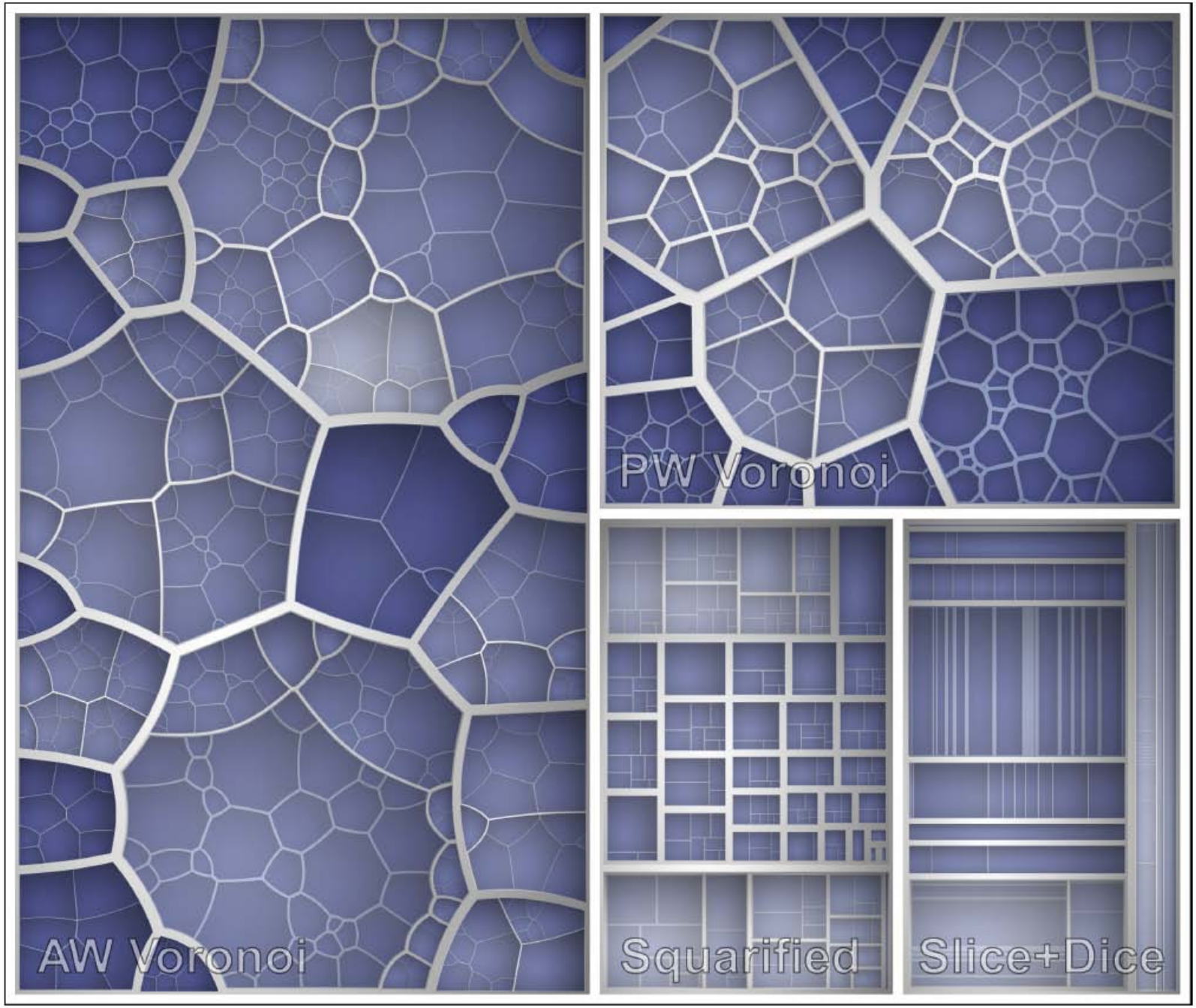


Figure 12: Comparison of four Treemap layout algorithms—at first, the top hierarchy level was subdivided with the Squarified Treemap algorithm, then for each of the four subareas according to its label a different layout algorithm was used (a brighter color indicates a lower hierarchy level)

Special lecture on 7.7.

- Bill Buxton, Abigail Sellen, Shahram Iszadi from Microsoft Research, Cambridge
- Fri, 7.7. 12-14h, room 112, Theresienstr.

- UI design Gurus!

- Reporting on their current work

User Study: Perci Prototyp

Probanden für die Evaluation des Perci (PERvasive ServiCe Interaction) Prototypen gesucht!

Thema: Physical Mobile Interactions with the Real World

- Dauer: ca. 20 Minuten
- Ort: Amalienstr., Gang 1. Stock bzw. Raum 101
- Zeiten: ½ stündlich ab 14 Uhr

DANKE!

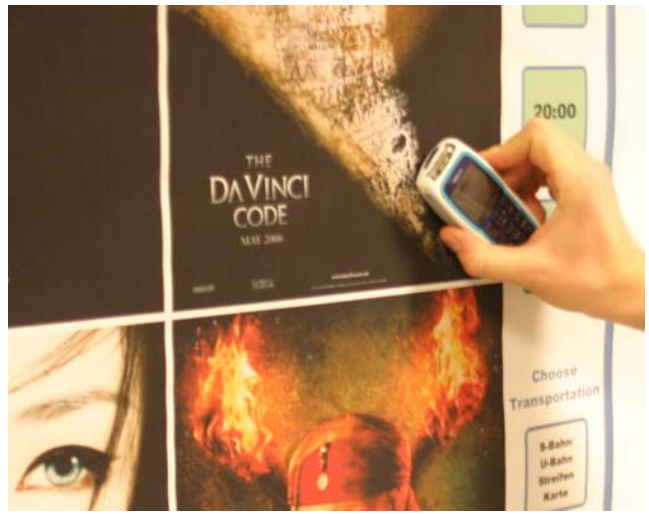


Photo-Workshop: neuer Termin!

- Kein Schein, freiwilliges Angebot
- Dauer: 1 Woche: 9.-13.Oktober
- Morgens ca.1/2 - 1 Stunde Vorbespr.
  - Technische Grundlagen (Optik, Kamera)
  - Bildgestaltung durch
    - Bildaufbau & Perspektive
    - Zeit, Blende
    - Licht, Inszenierung

- Tagsüber praktisches Photographieren
  - Voraussichtlich Architektur + Natur
  - Benötigt: eigene Kamera + Stativ
- Abends Bildbesprechungen am Rechner
- https://wiki.medien.ifi.lmu.de/view/Main/PhotoWorkshopSoSe06

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

Ludwig-Maximilians-Universität München

LFE Medieninformatik

Albrecht Schmidt & Andreas Butz

SS2006

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

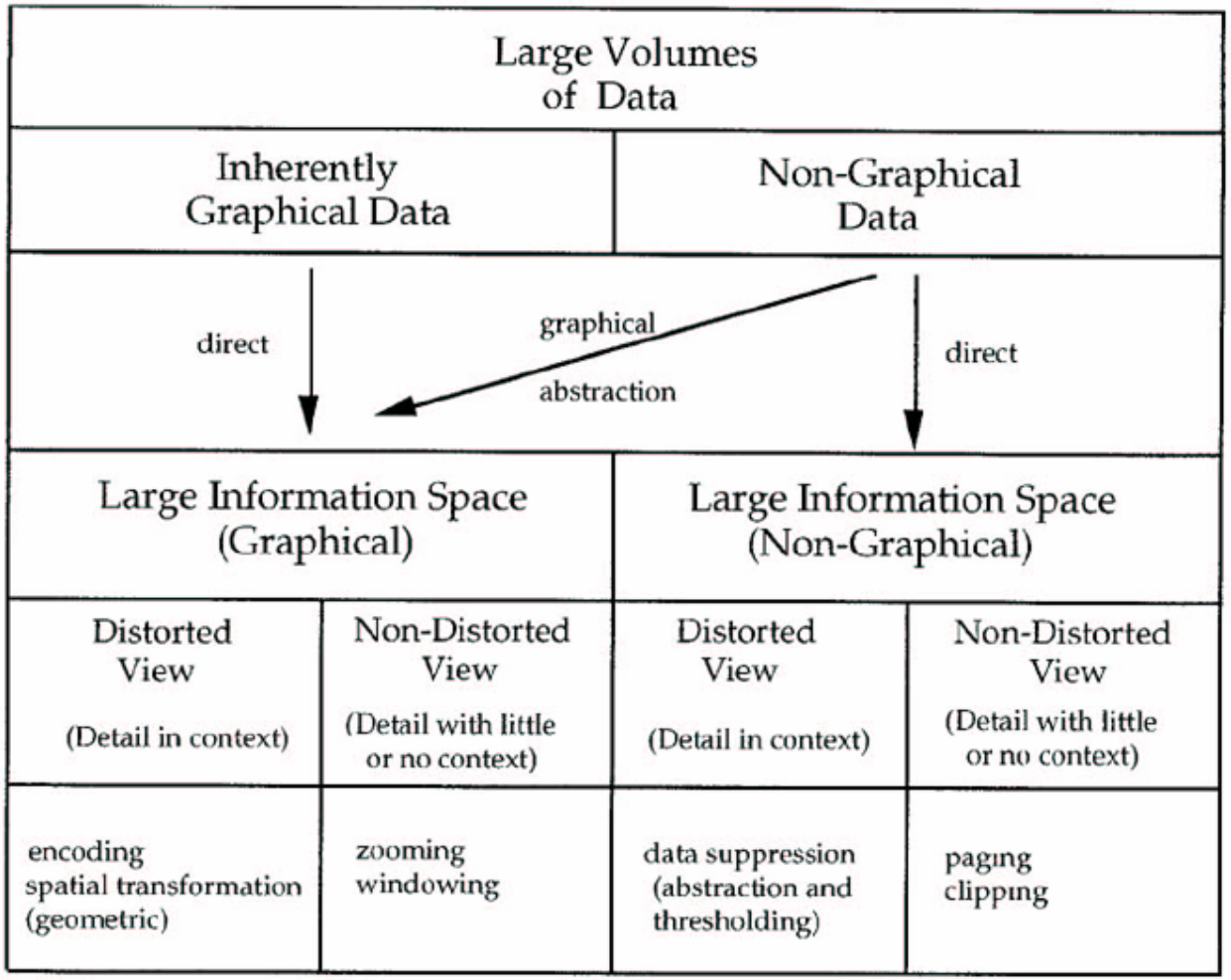
Additional Material on Distortion

Leung & Apperley: Distortion

Unified theory of distortion techniques

- "…stretchable rubber sheet mounted on a rigid frame"
- Stretching = Magnification
- Stretching one part must equal shrinkage in other areas

Taxonomy for presentations and distortions



Leung & Apperley

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

Distortions

- Method
  - Post-Process: Modify results after primary graphical mapping
  - In-Process: Distortion during the primary graphical mapping
- Types
  - Focus+context – change display size relative to focus
  - Highlighting – change display type relative to focus

Distortion-based Techniques

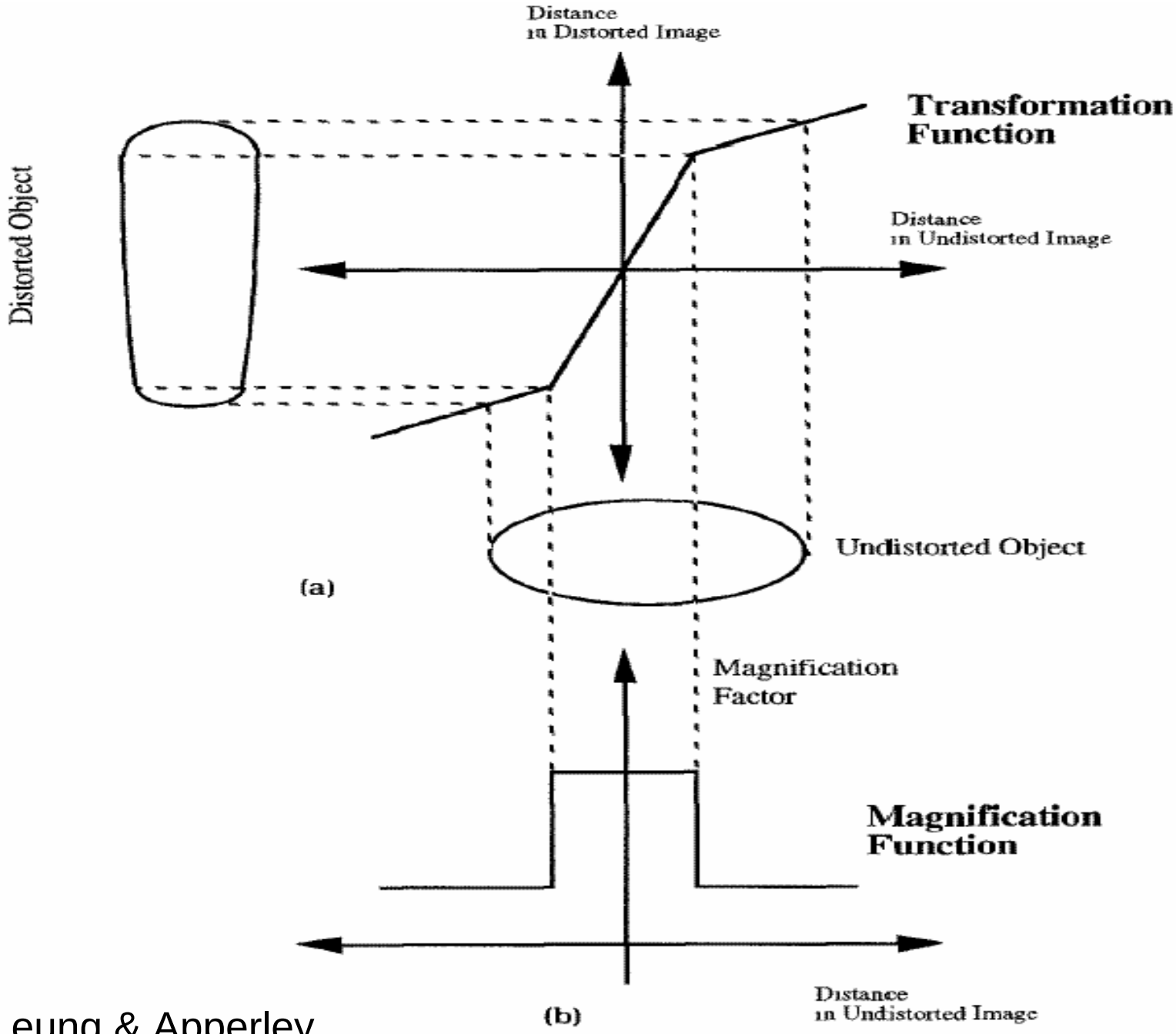
- Bifocal Display
- Polyfocal Display
- Perspective Wall
- Fisheye View
- Graphical Fisheye View

Idea of Distortion-based Techniques

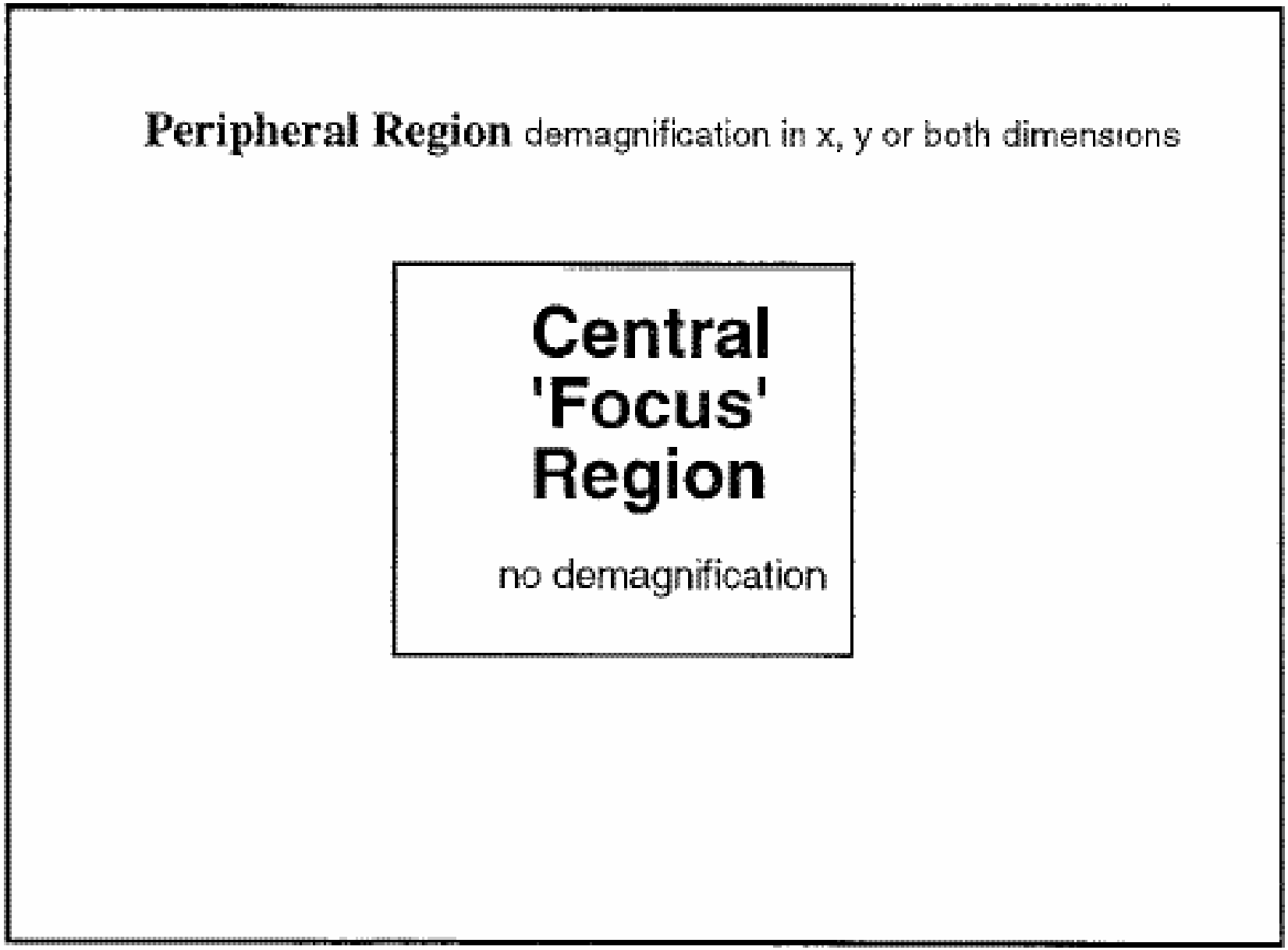
- Co-existence of local details with global context at reduced magnification.
- A focus region to display detailed information.
- Demagnified view of the peripheral areas is presented around the focus area.

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.

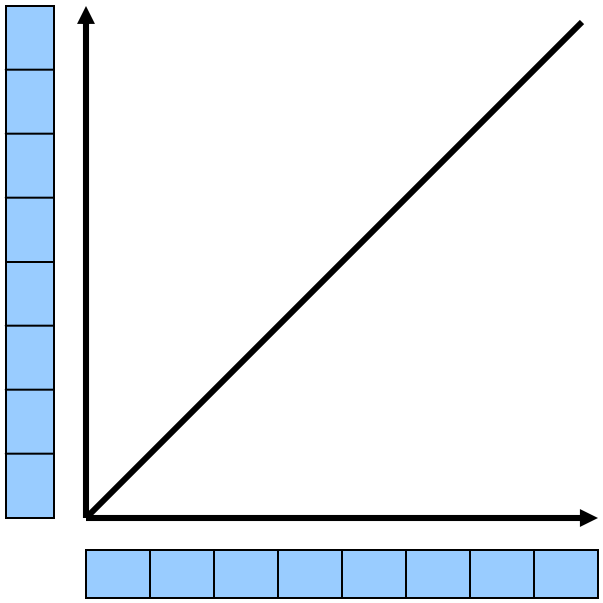


Leung & Apperley

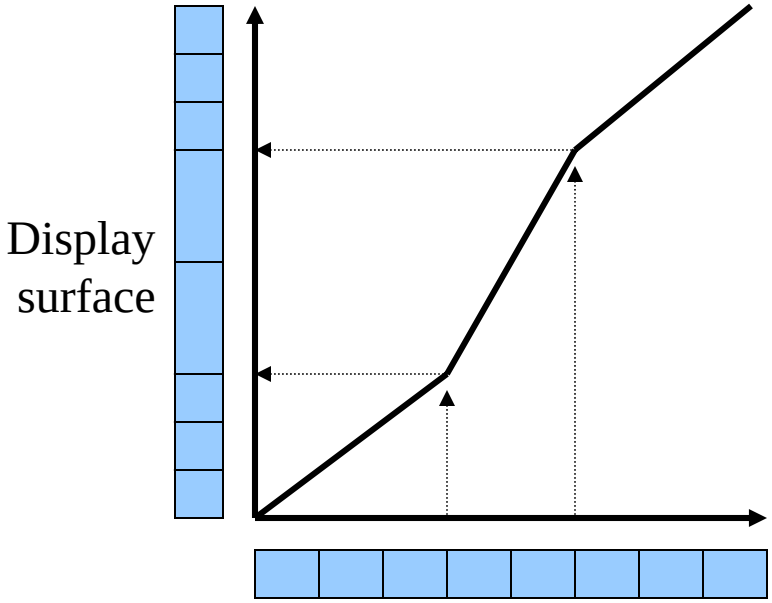


Leung & Apperley

Visual Transfer Functions



Identity function =
normal flat overview

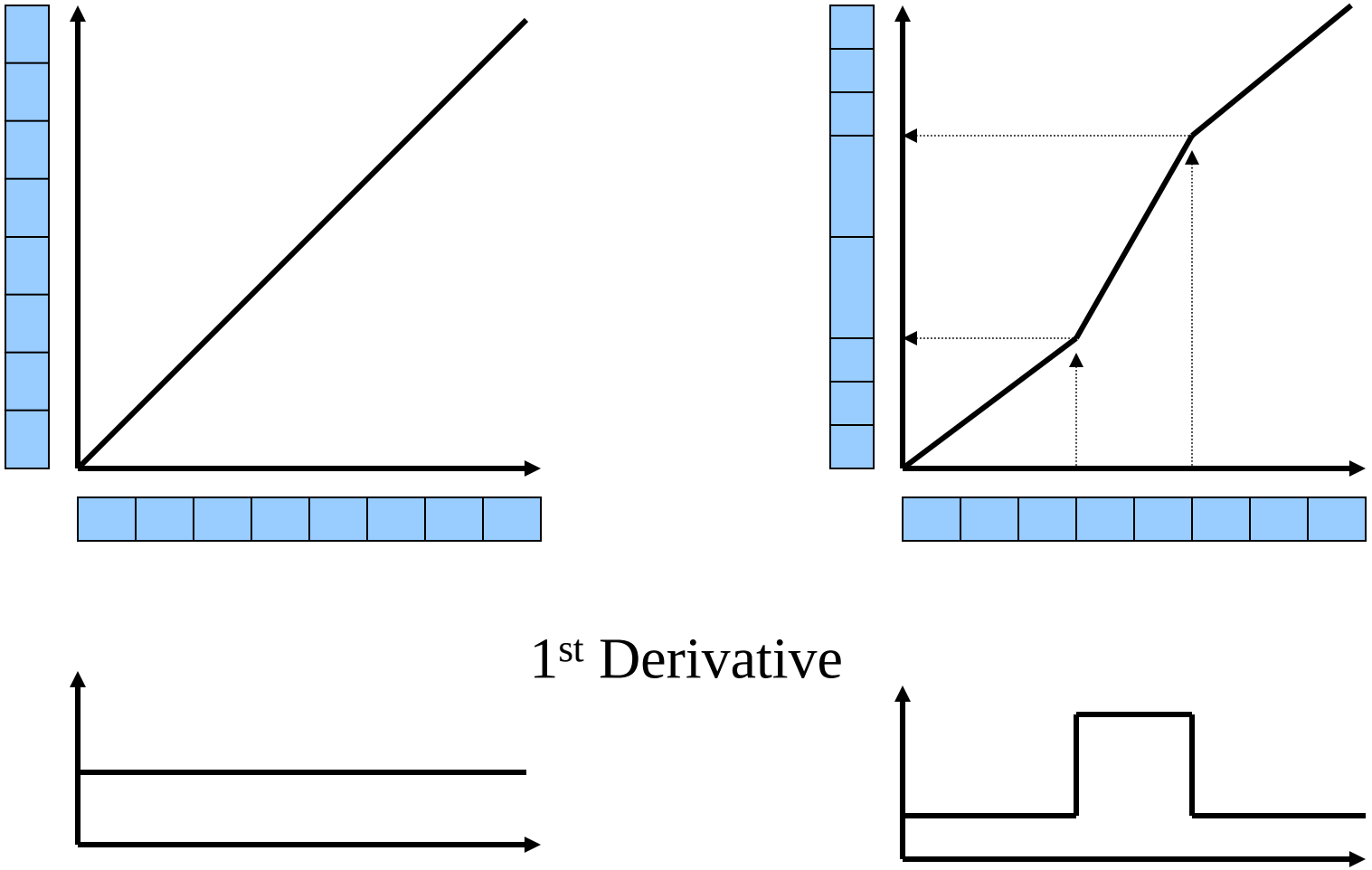


Information surface

Bifocal

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

Magnification Functions



1st Derivative

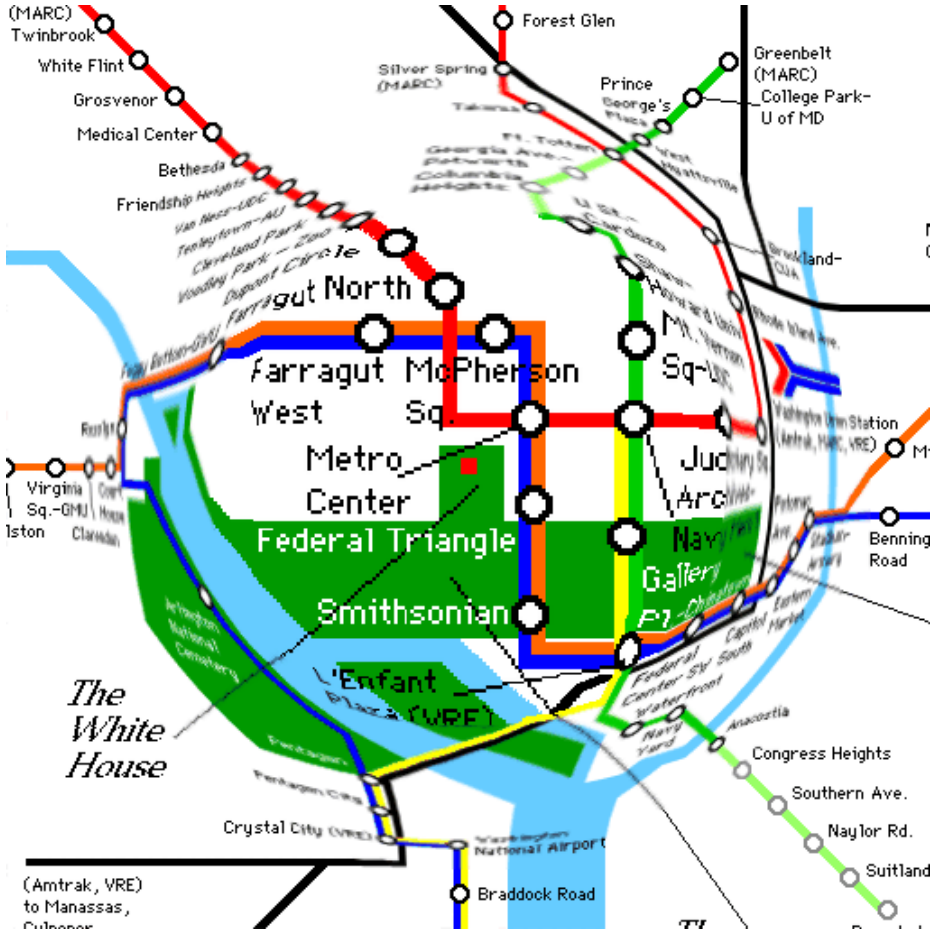
From http://people.cs.vt.edu/~north/infoviz/lecture11.ppt

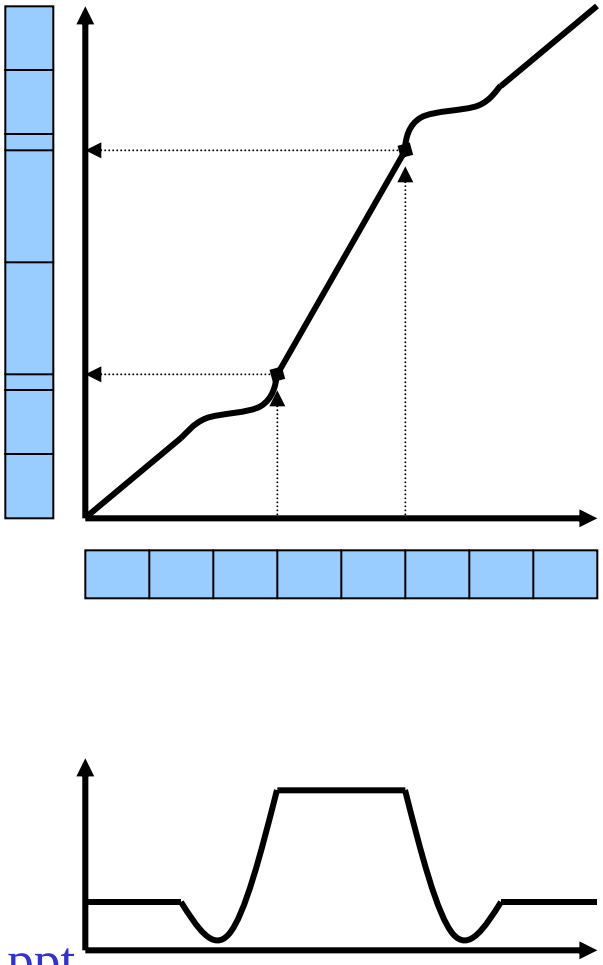
References

- Leung, Y., and Apperley, M. *A Review and Taxonomy of Distortion-Oriented Presentation Techniques ACM Transactions on Computer-Human Interaction*, 1994 1, 2, 126-160.
- B.-B. Bederson and J. D. Hollan. Pad++: *A zooming graphical interface for exploring alternate interface physics*. In Proc. ACM UIST'94, pages 17--26. ACM, ACM Press, 1994.

“Bubble”

Disadvantage: local context highly de-magnified

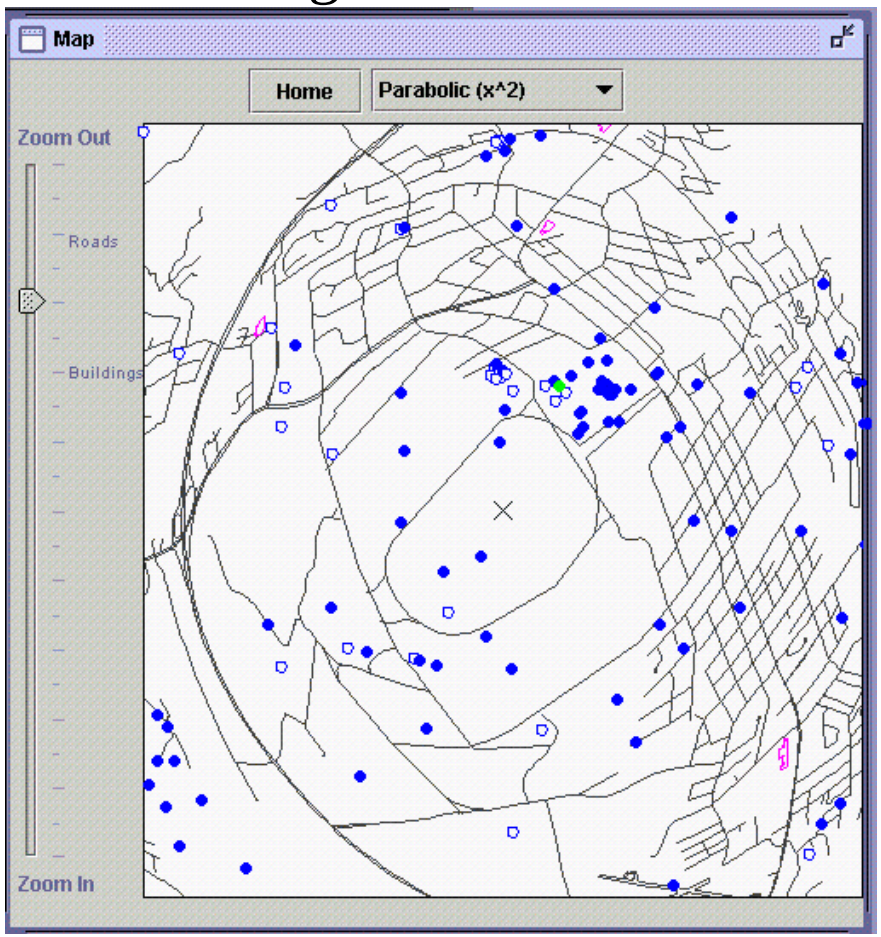


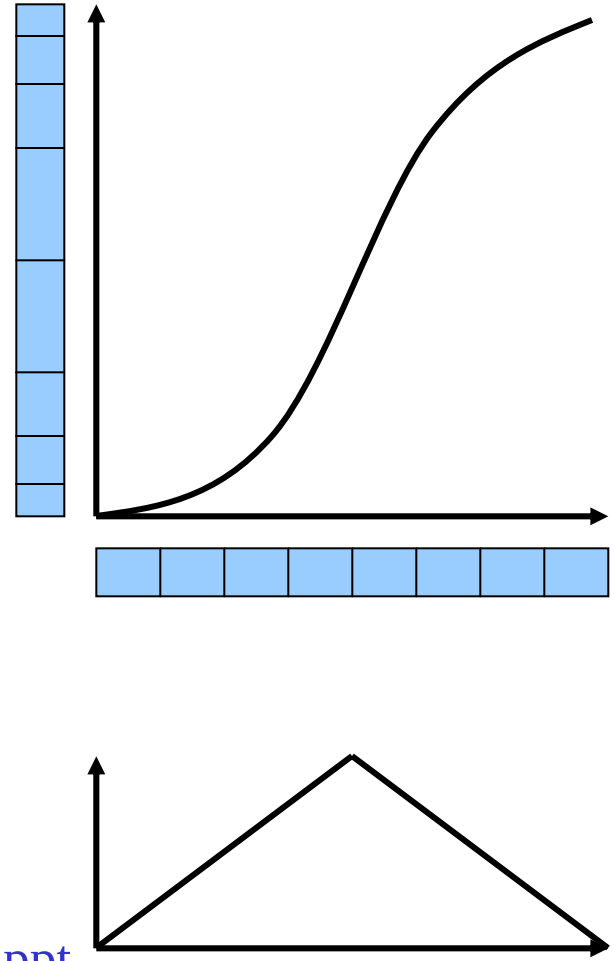


From http://people.cs.vt.edu/~north/infoviz/lecture11.ppt

“Fisheye”, “wide-angle lens”

Disadvantage: no flat area

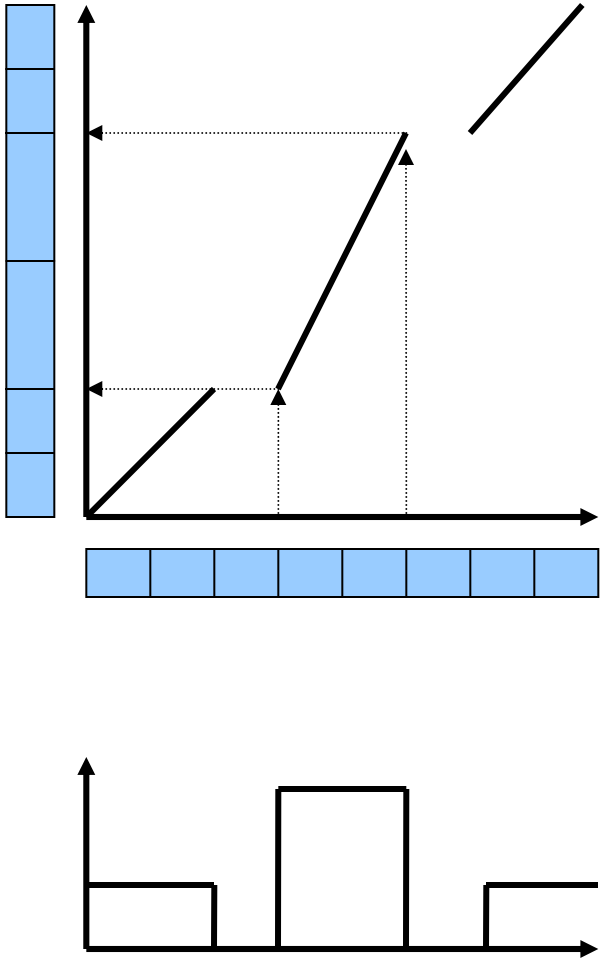




From http://people.cs.vt.edu/~north/infoviz/lecture11.ppt

Why not magnifying glass?

- Hides local context

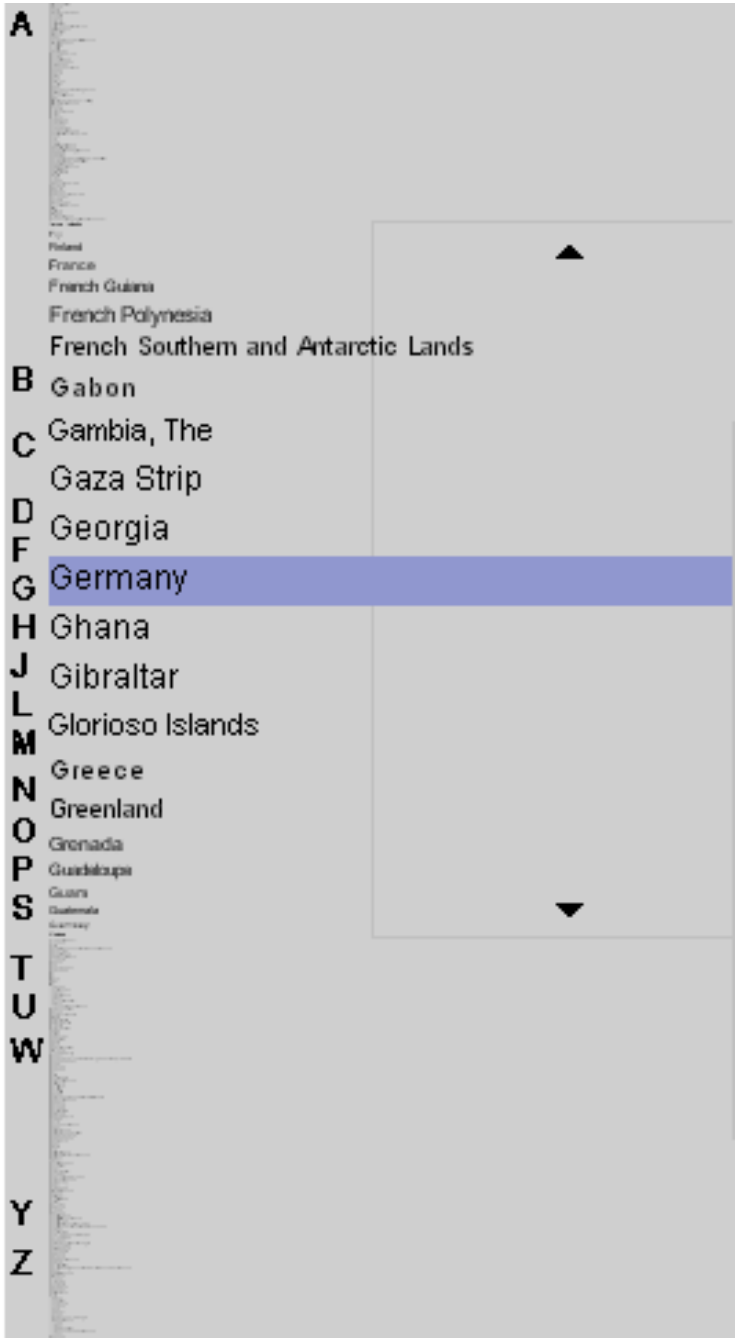


From http://people.cs.vt.edu/~north/infoviz/lecture11.ppt

Example: Fisheye Menu

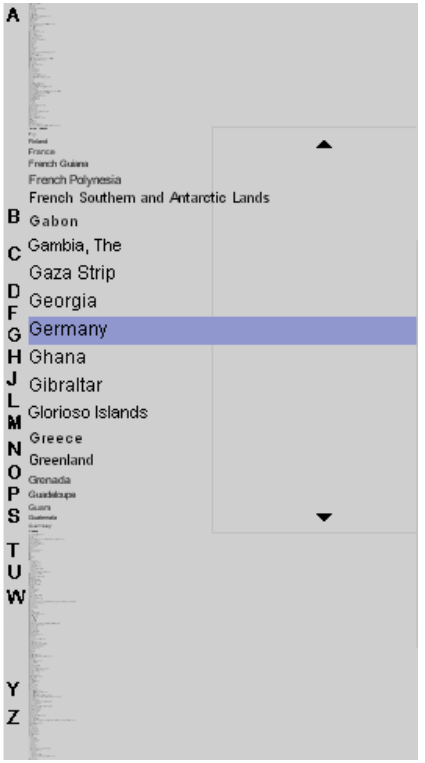
- Applies fisheye graphical visualization techniques to linear menus
- For very long menus as alternative to
  - Hierarchies
  - Scrolling
  - Arrow-bars

- Benjamin B. Bederson. Fisheye Menus. UIST'00
- Demo http://www.cs.umd.edu/hcil/fisheyemenu/fisheyemenu-demo.shtml

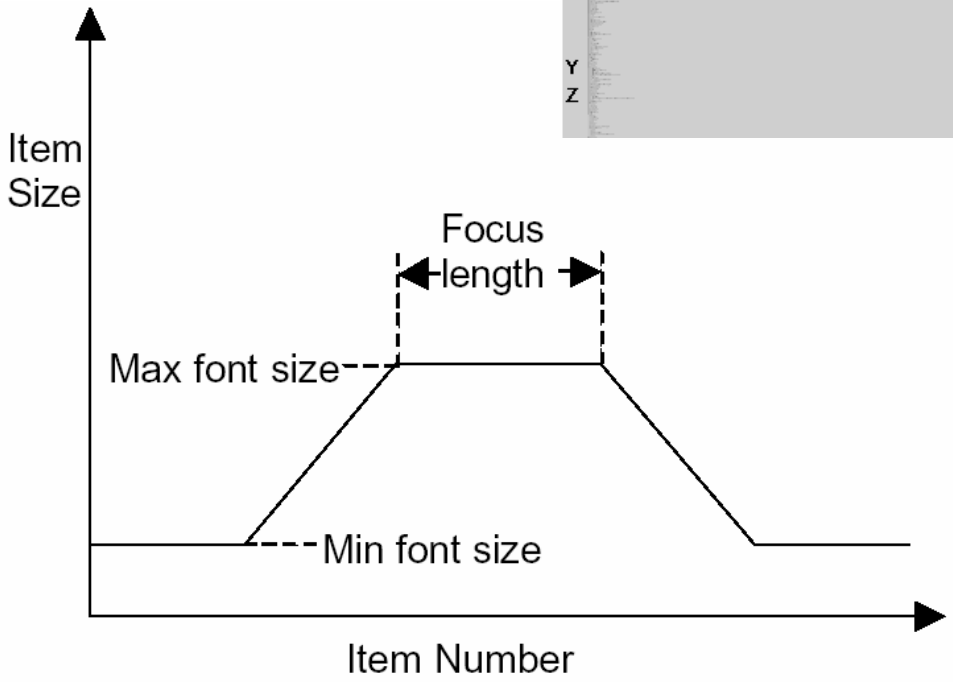


Implementation & Evaluation
Fisheye Menu

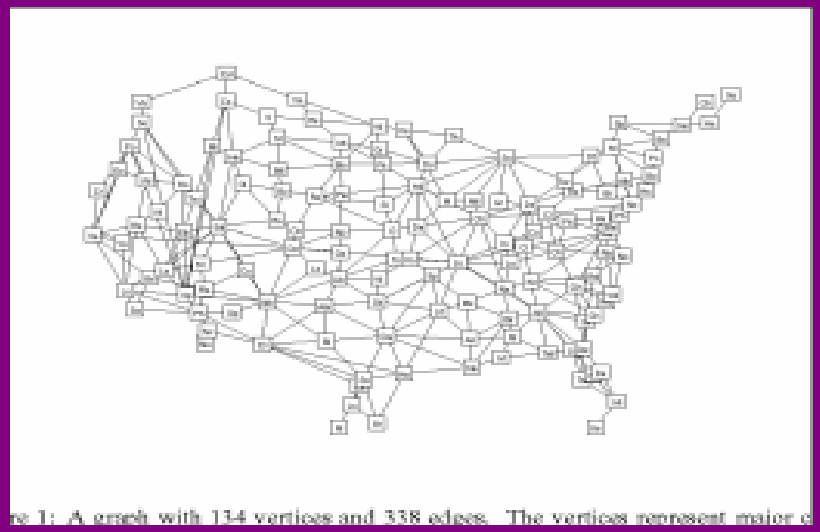
- Calculating font size
- Minimal change moves the centre → hard to select
- Lock mode



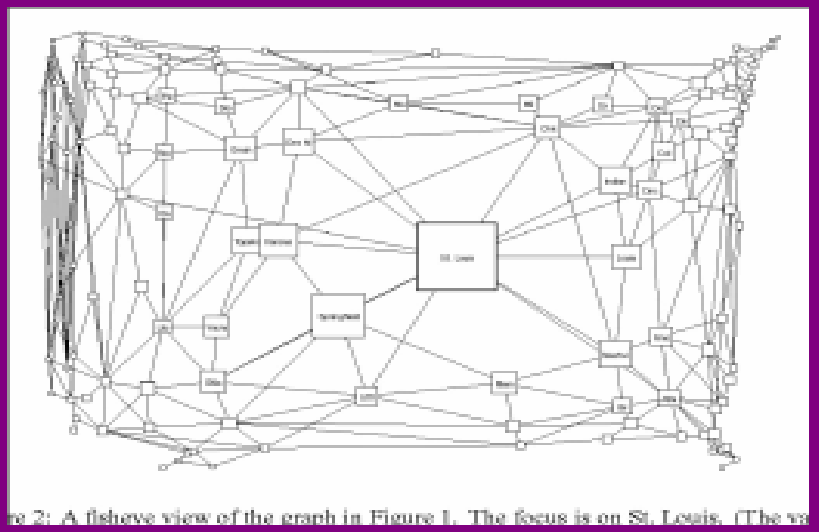
- Evaluation
  - Some users like it
  - Other don't …



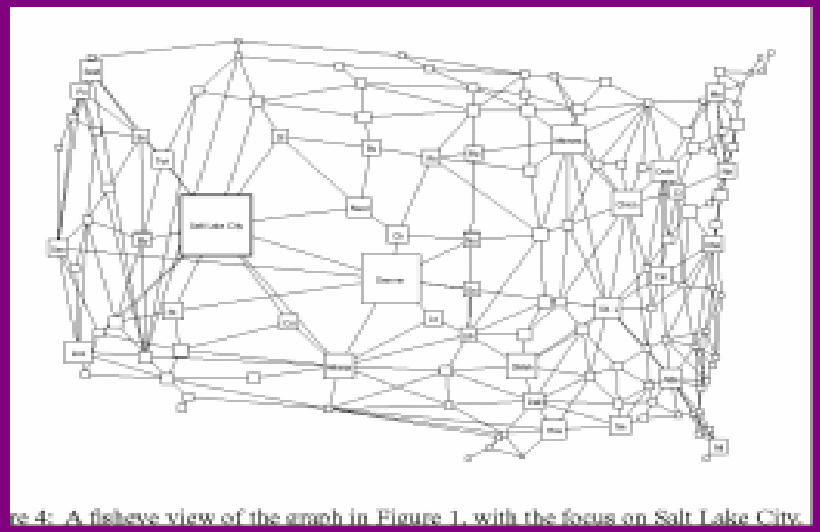
Fisheye View - Networks



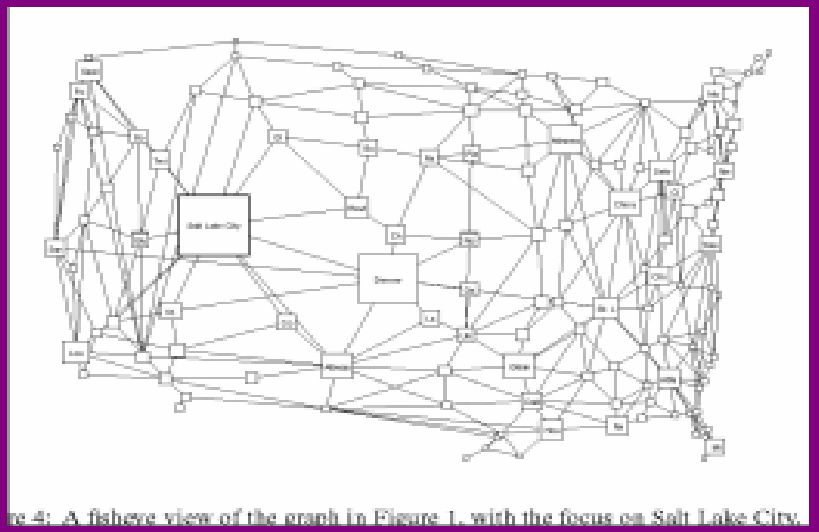
re 1: A graph with 134 vertices and 338 edges. The vertices represent major c



re 2: A fisheye view of the graph in Figure 1. The focus is on St. Louis. (The ve



re 4: A fisheye view of the graph in Figure 1, with the focus on Salt Lake City.

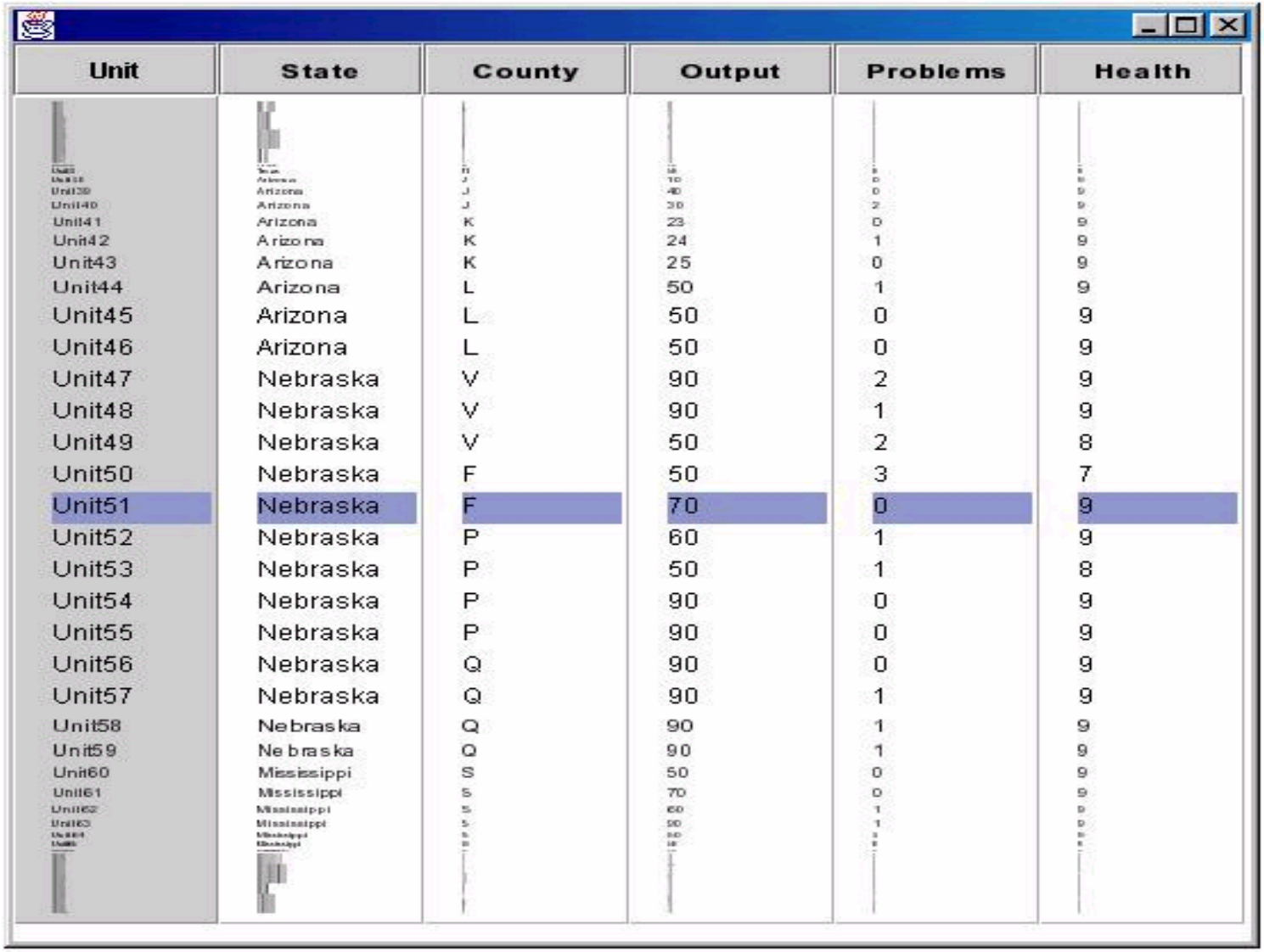


re 4: A fisheye view of the graph in Figure 1, with the focus on Salt Lake City.

From Sarkar and Brown

Fisheye View

fisheye table

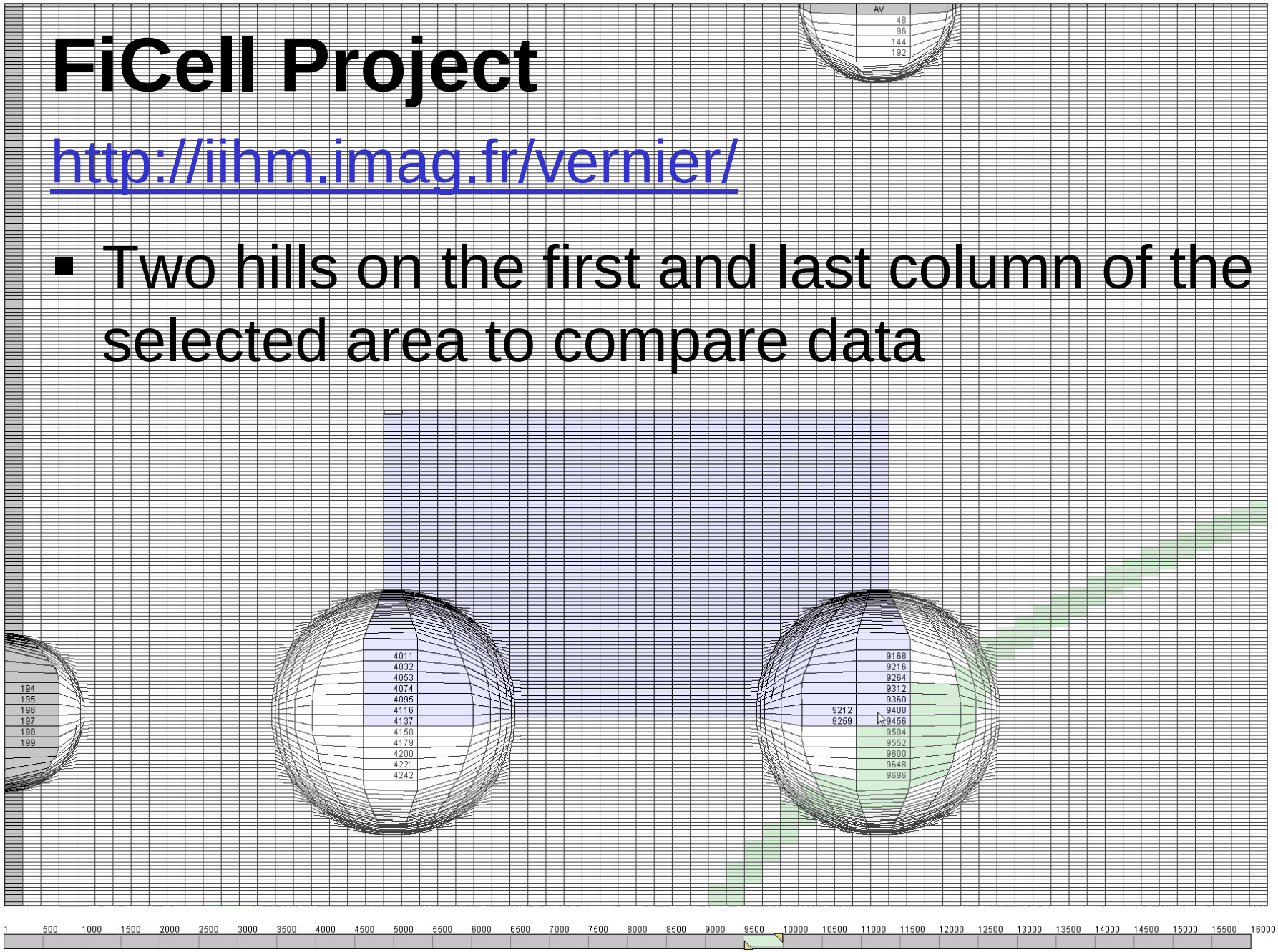


Unit	State	County	Output	Problems	Health
Unit41	Arizona	K	23	0	9
Unit42	Arizona	K	24	1	9
Unit43	Arizona	K	25	0	9
Unit44	Arizona	L	50	1	9
Unit45	Arizona	L	50	0	9
Unit46	Arizona	L	50	0	9
Unit47	Nebraska	V	90	2	9
Unit48	Nebraska	V	90	1	9
Unit49	Nebraska	V	50	2	8
Unit50	Nebraska	F	50	3	7
Unit51	Nebraska	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
Unit58	Nebraska	Q	90	1	9
Unit59	Nebraska	Q	90	1	9
Unit60	Mississippi	S	50	0	9
Unit61	Mississippi	S	70	0	9

FiCell Project

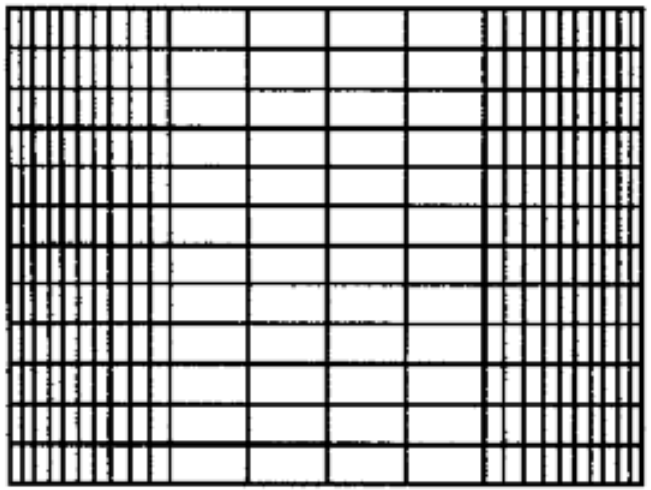
http://iihm.imag.fr/vernier/

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

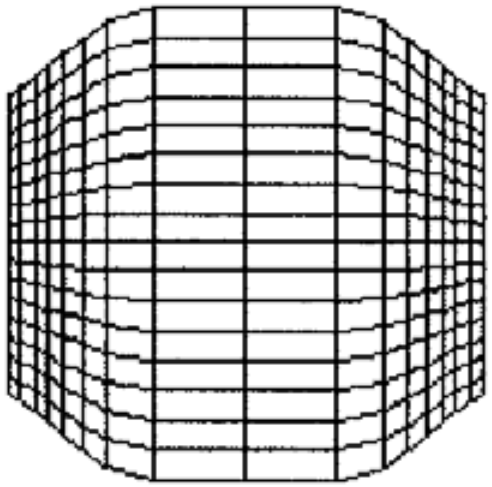


Piecewise Non-Continuous Magnification Functions

- Bifocal Display, Perspective Wall



Bifocal Display

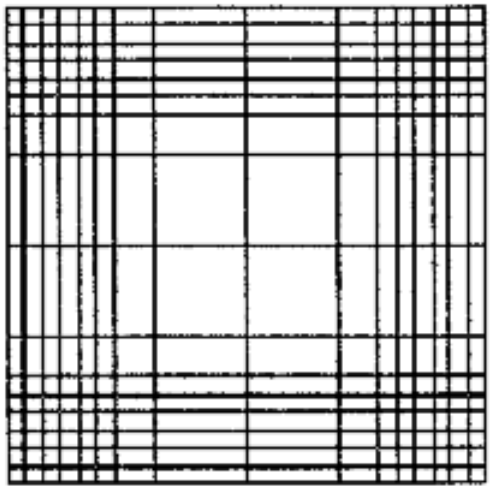


Perspective Wall

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

Bifocal Display

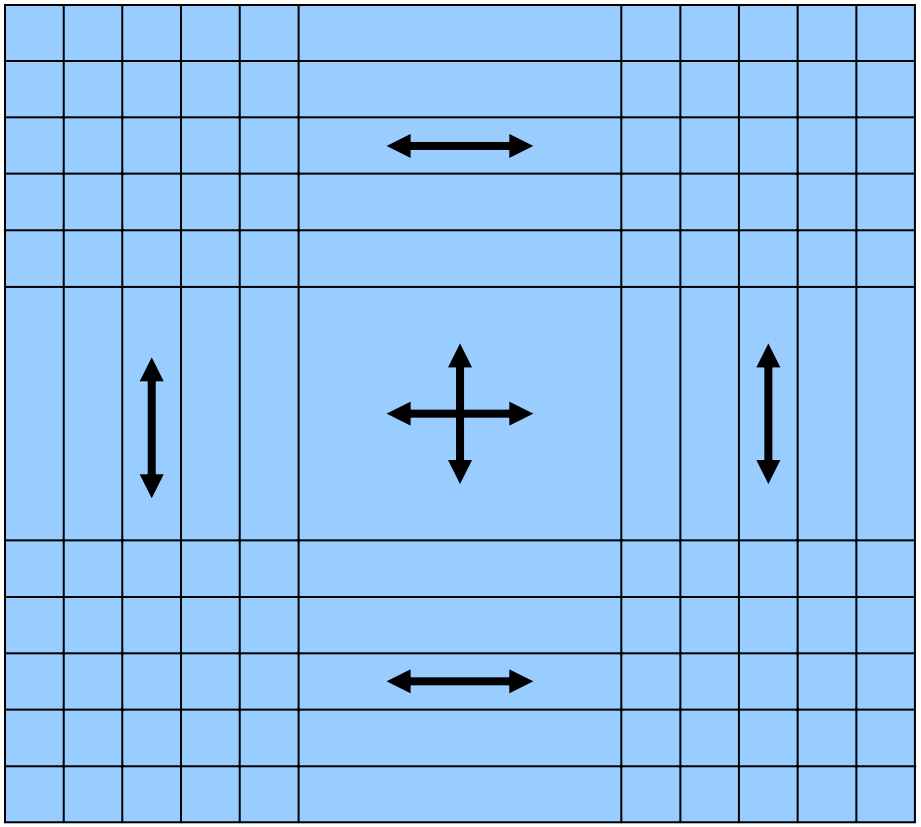
- Combination of detail view and two distorted side views
- Can be applied in 2D
  - Since the corners are distorted by the same amount in x and y, it's just scaled, not distorted

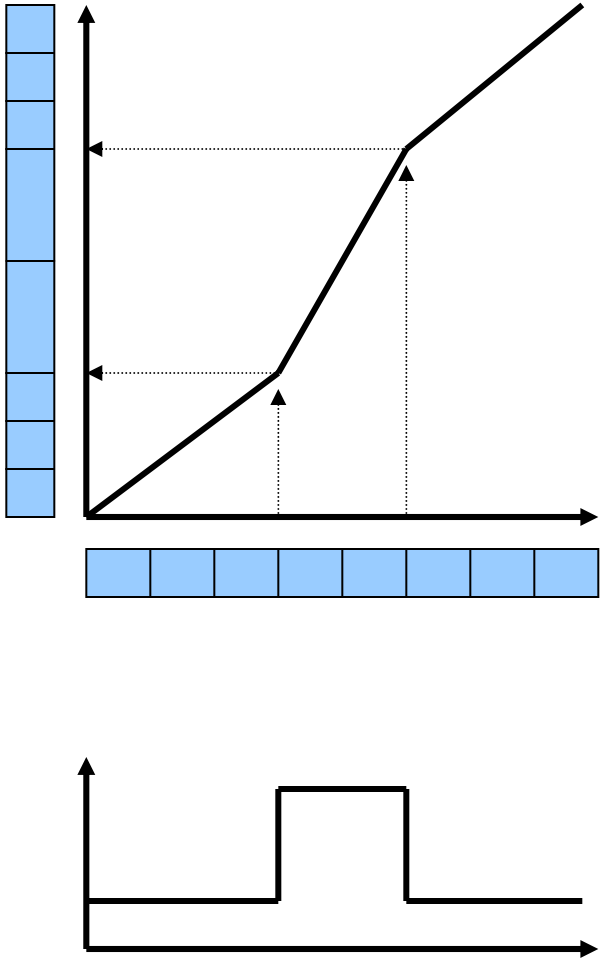


From http://www.sims.berkeley.edu/courses/is247/s02/lectures/ZoomingFocusContextDistortion.ppt

Bifocal Display

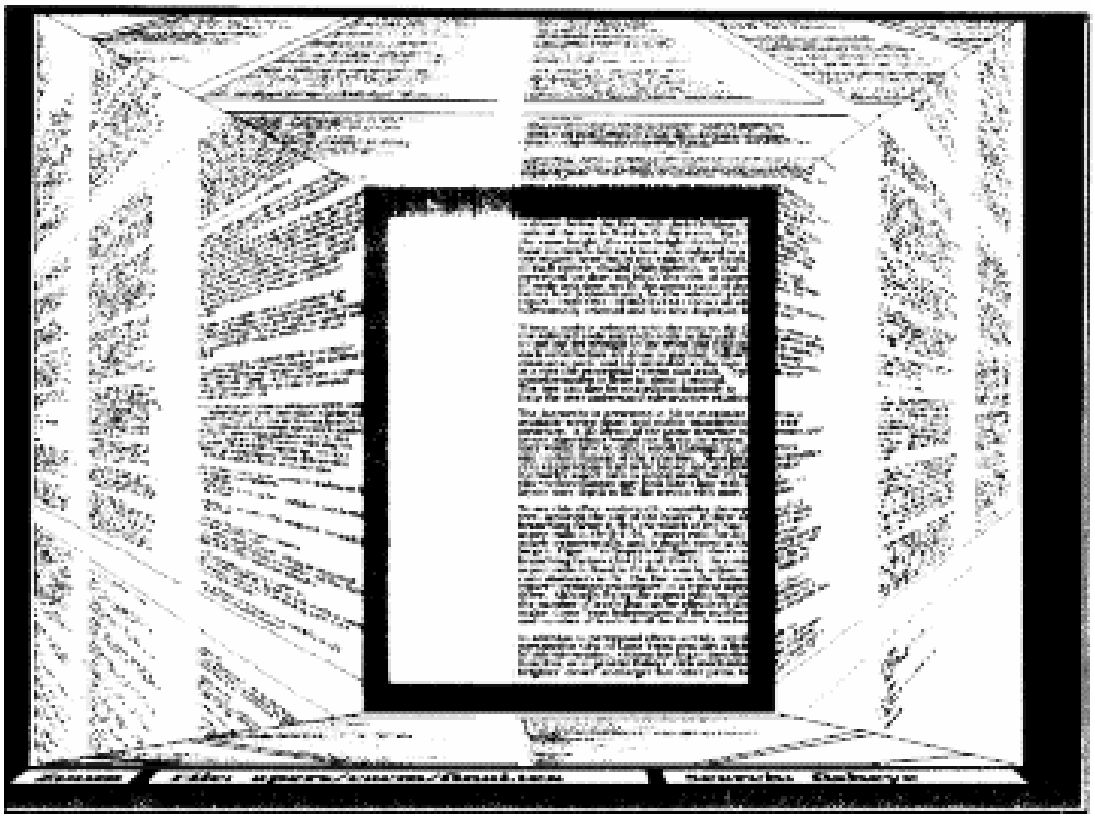
Disadvantage: 1 dimensional stretching on the 4 sides

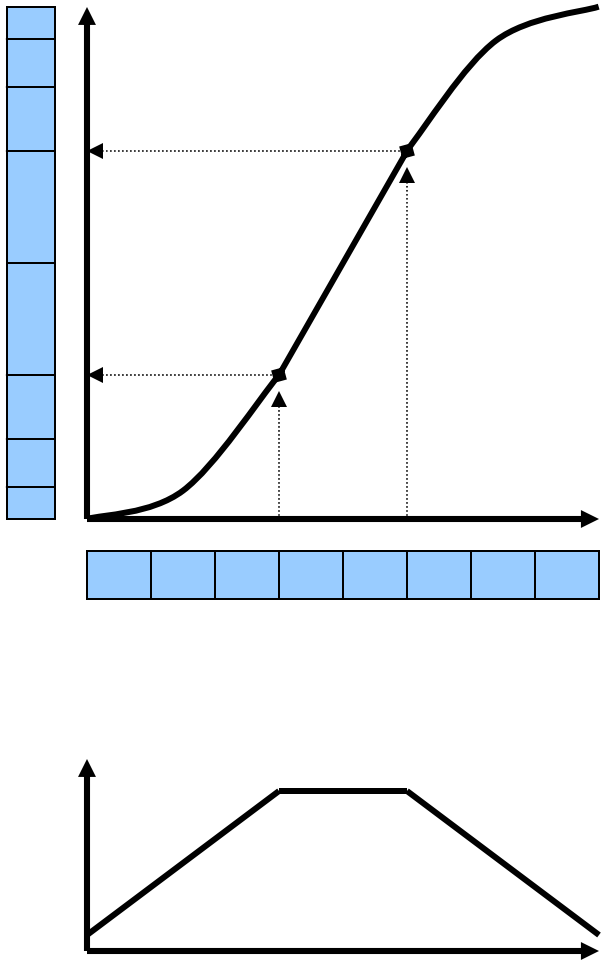




From http://people.cs.vt.edu/~north/infoviz/lecture11.ppt

Document Lens

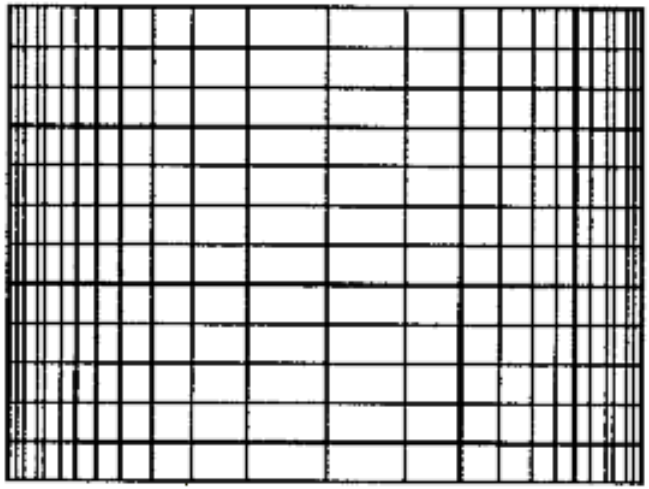




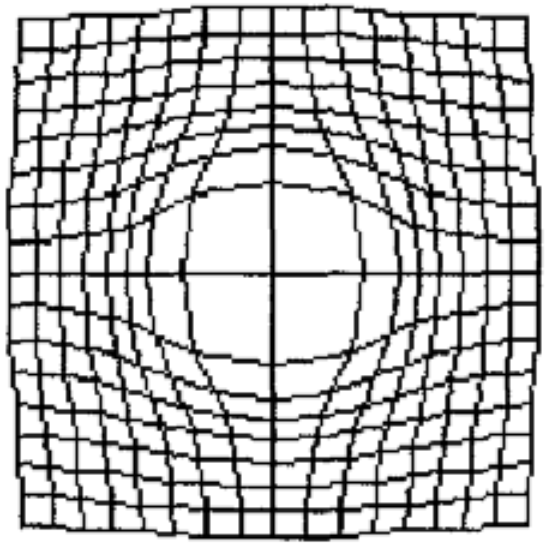
From http://people.cs.vt.edu/~north/infoviz/lecture11.ppt

Continuous Magnification Functions

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



1D Fisheye

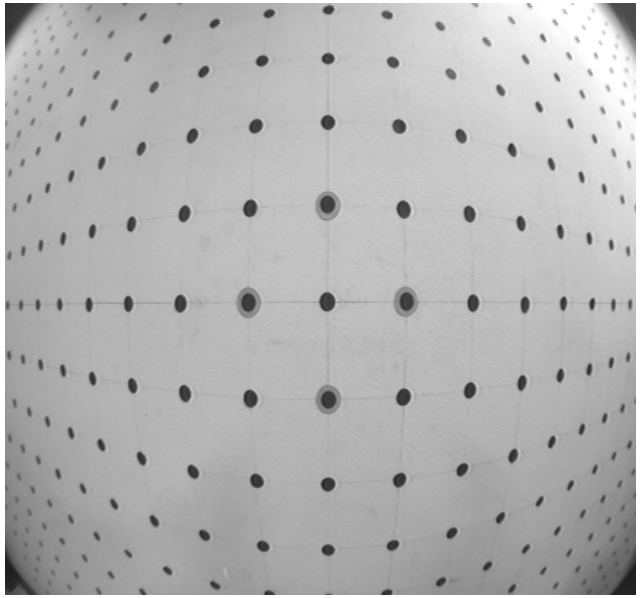


2D Polyfocal

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

Fisheye View

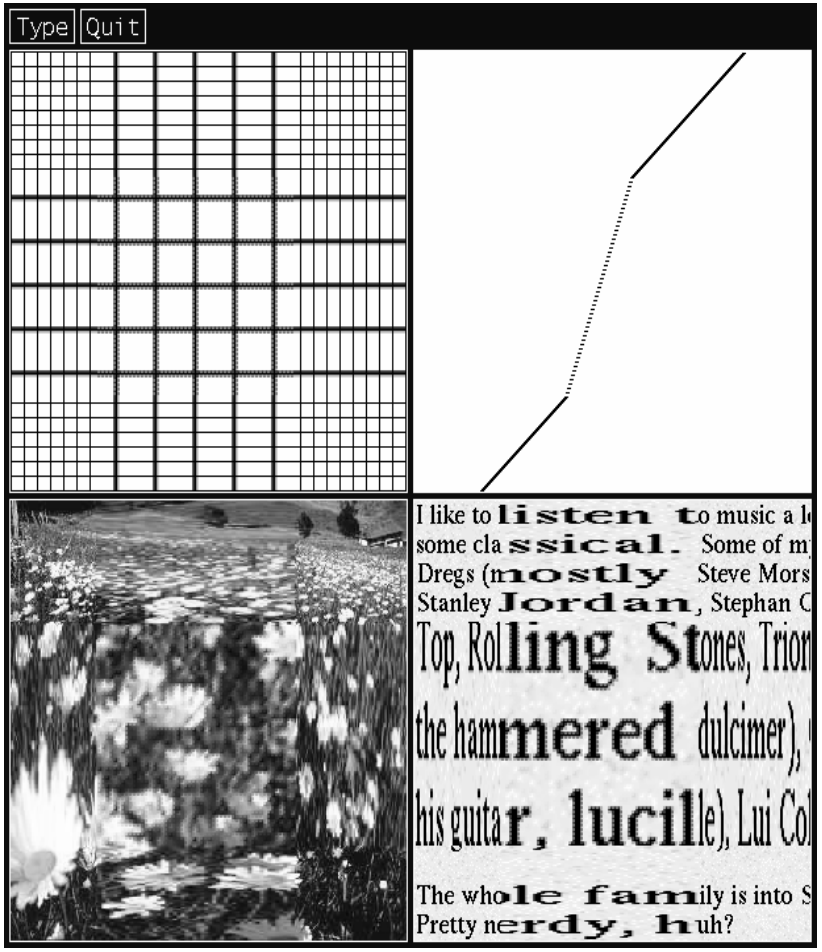
- Thresholding
  - Information elements have numbers based on relevance and distance from point of focus
  - Value then determines what information is to presented or suppressed



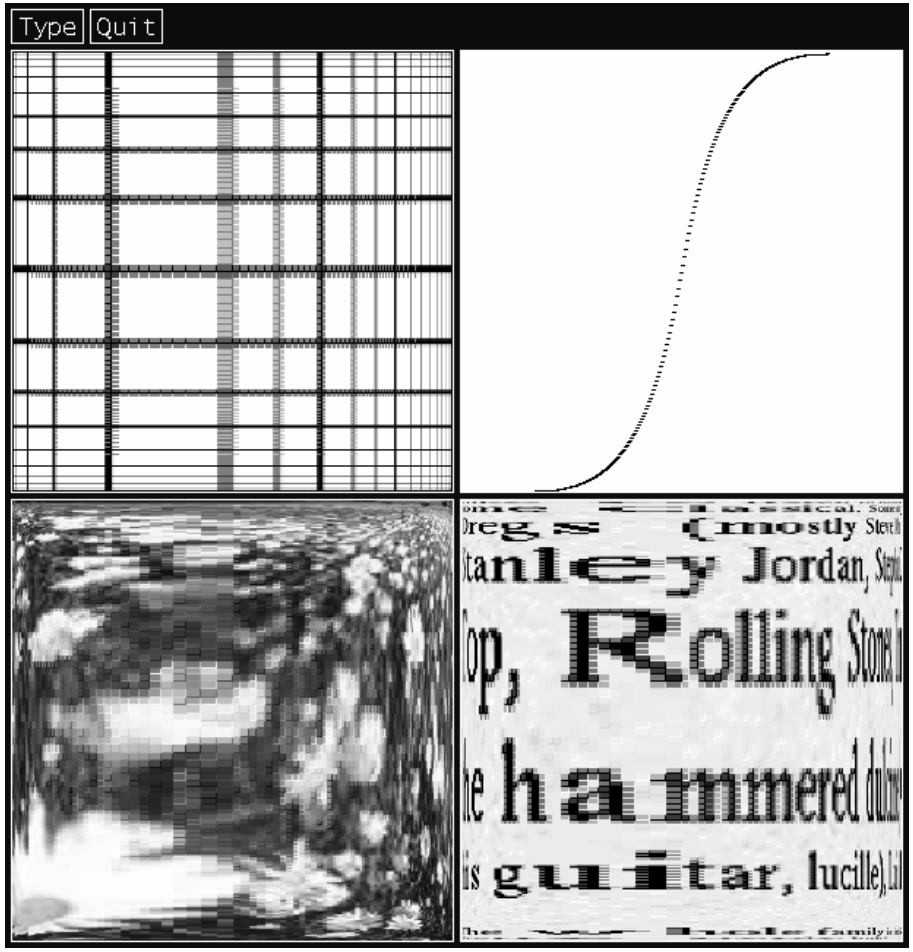
Polar Fisheye View
Image from Shishir Shaw
University of Texas, Austin
www.adires.com/~castleman/proj_02.html

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

Comparisons



Bifocal View

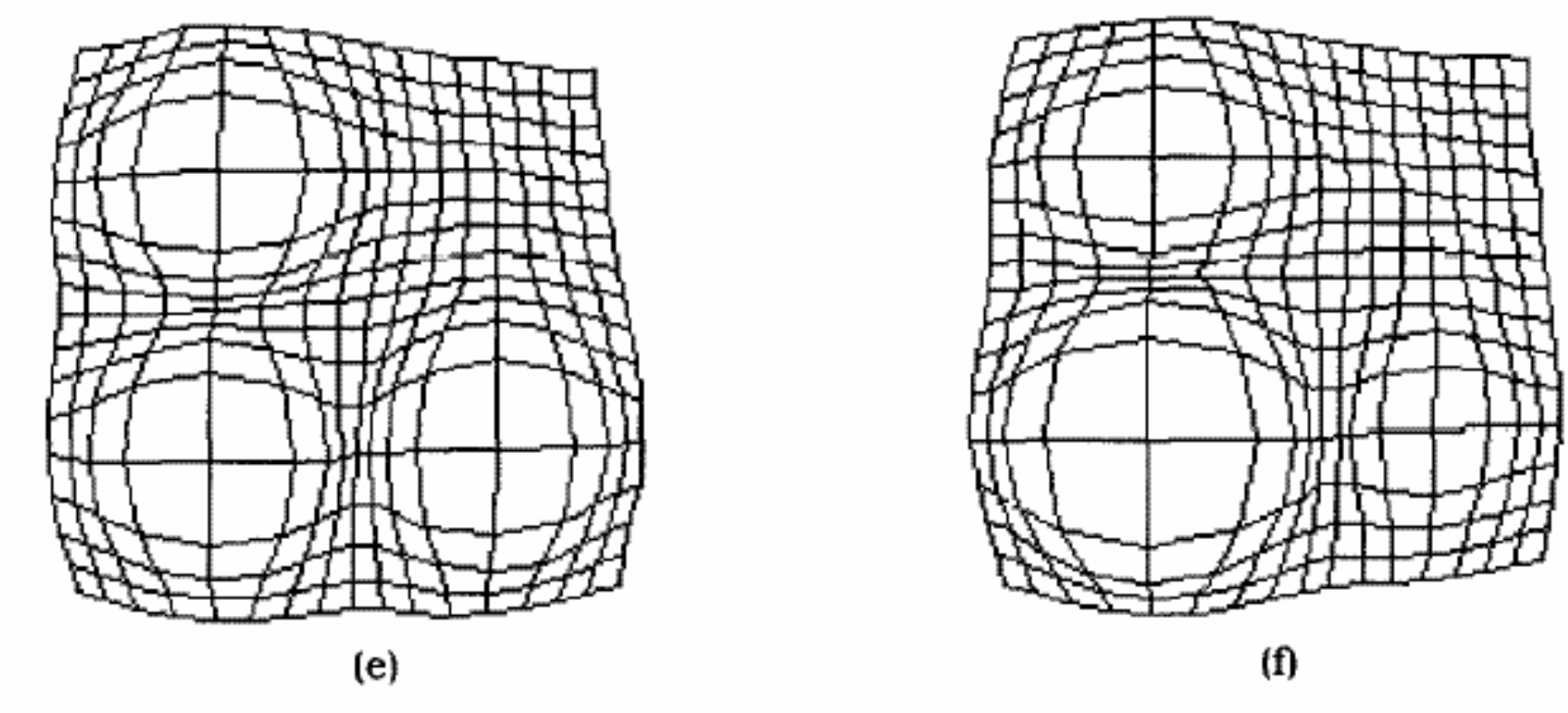


Polyfocal View

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



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

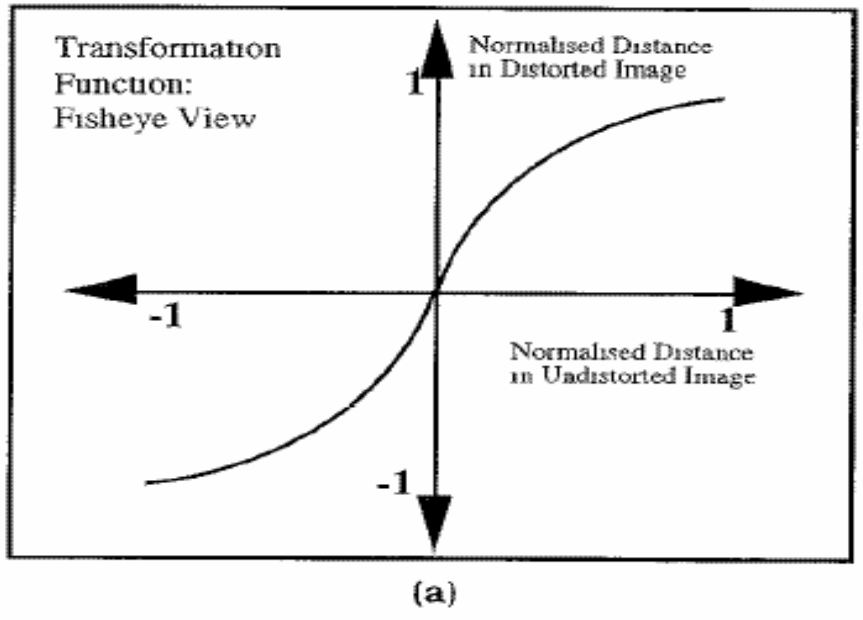
- Originally proposed by Furnas (1986), but many variations of applications.
- Basic idea: more relevant information presented in great detail; the less relevant information presented as an abstraction.
- Relevance is computed on basis of the importance of information elements and their distance to the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

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

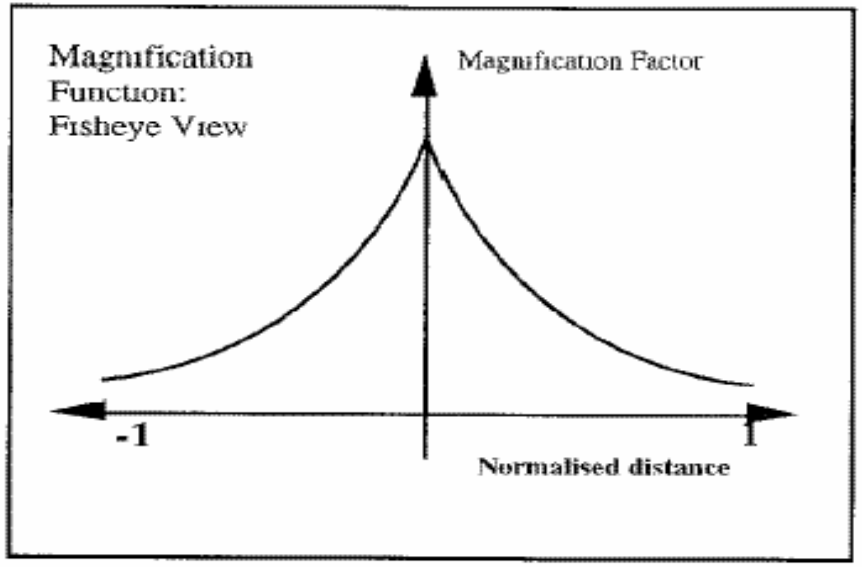
(Continued)

- 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.

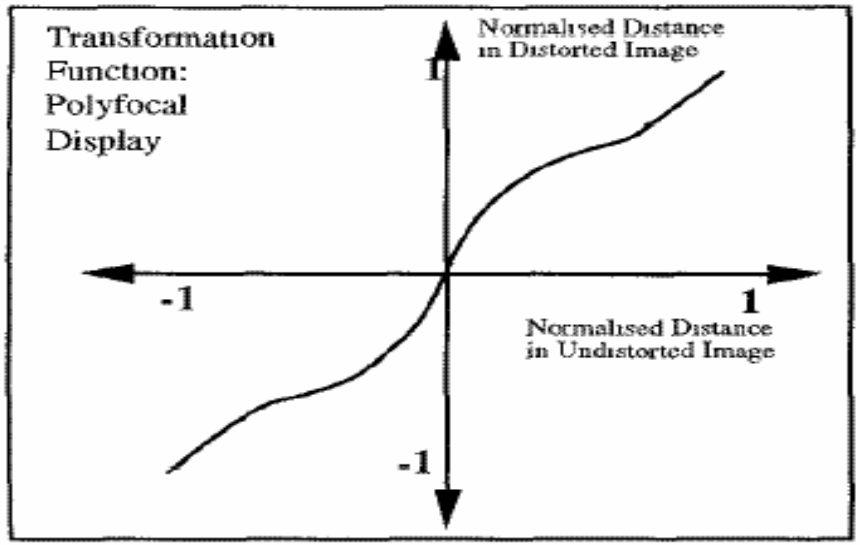
From http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/0324.fengdongdu.ppt


Transformation
Function:
Fisheye View
Normalised Distance
in Distorted Image
1
-1
1
-1
Normalised Distance
in Undistorted Image

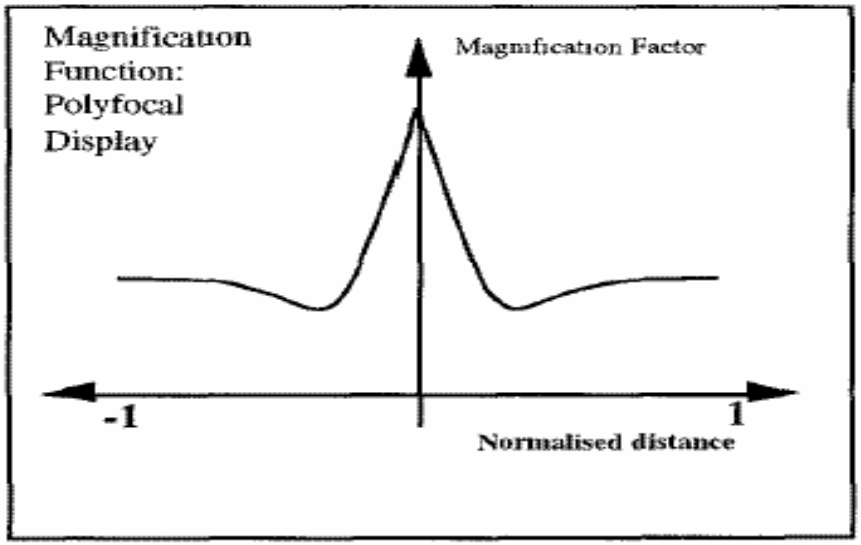
(a)


Magnification
Function:
Fisheye View
Magnification Factor
-1
1
Normalised distance

(b)


Transformation
Function:
Polyfocal
Display
Normalised Distance
in Distorted Image
1
-1
1
-1
Normalised Distance
in Undistorted Image

(a)


Magnification
Function:
Polyfocal
Display
Magnification Factor
-1
1
Normalised distance

(b)

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

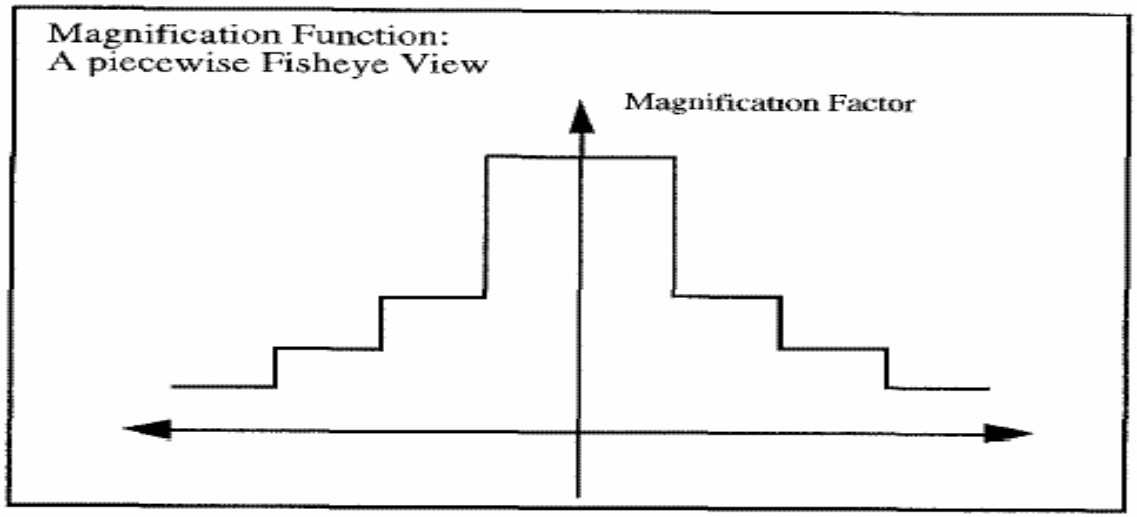
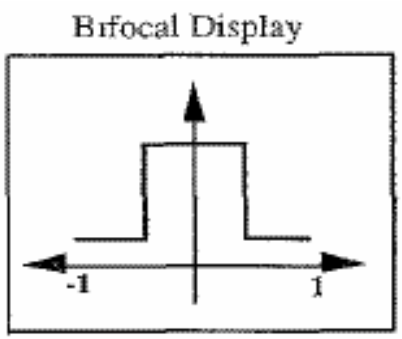
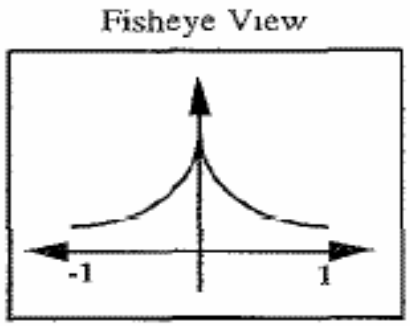
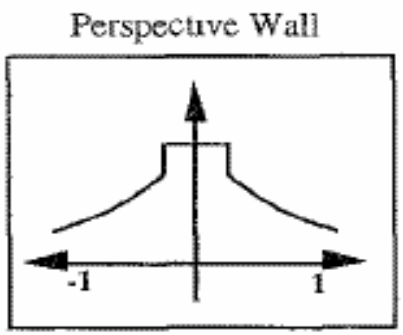
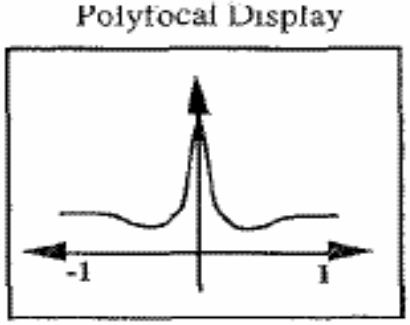


Fig. 14. The magnification function of a piecewise Fisheye View.







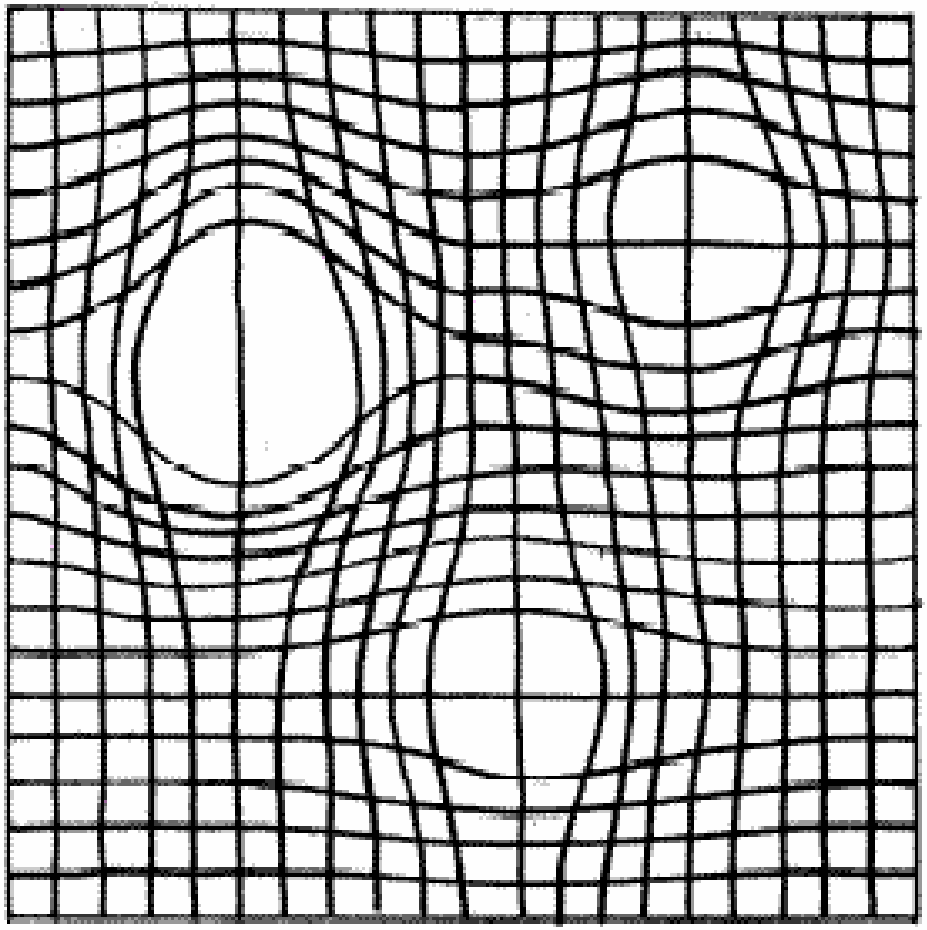


Unified Theory

- 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