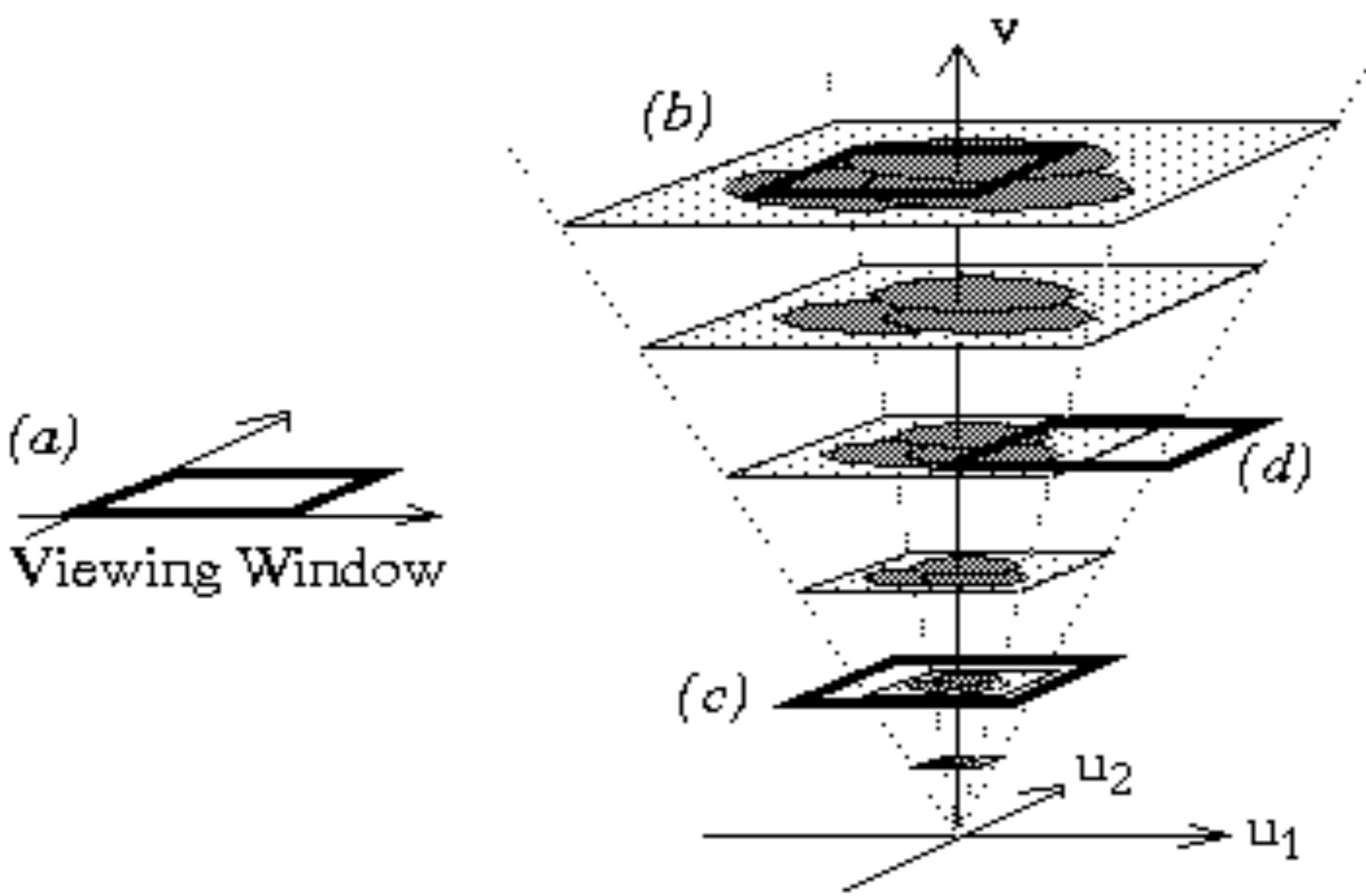
3 Information Visualization

3.1 Motivation and Examples
3.2 Basics of Human Perception
3.3 Principles and Terminology
3.4 Standard Techniques for Visualization
3.5 Further Examples

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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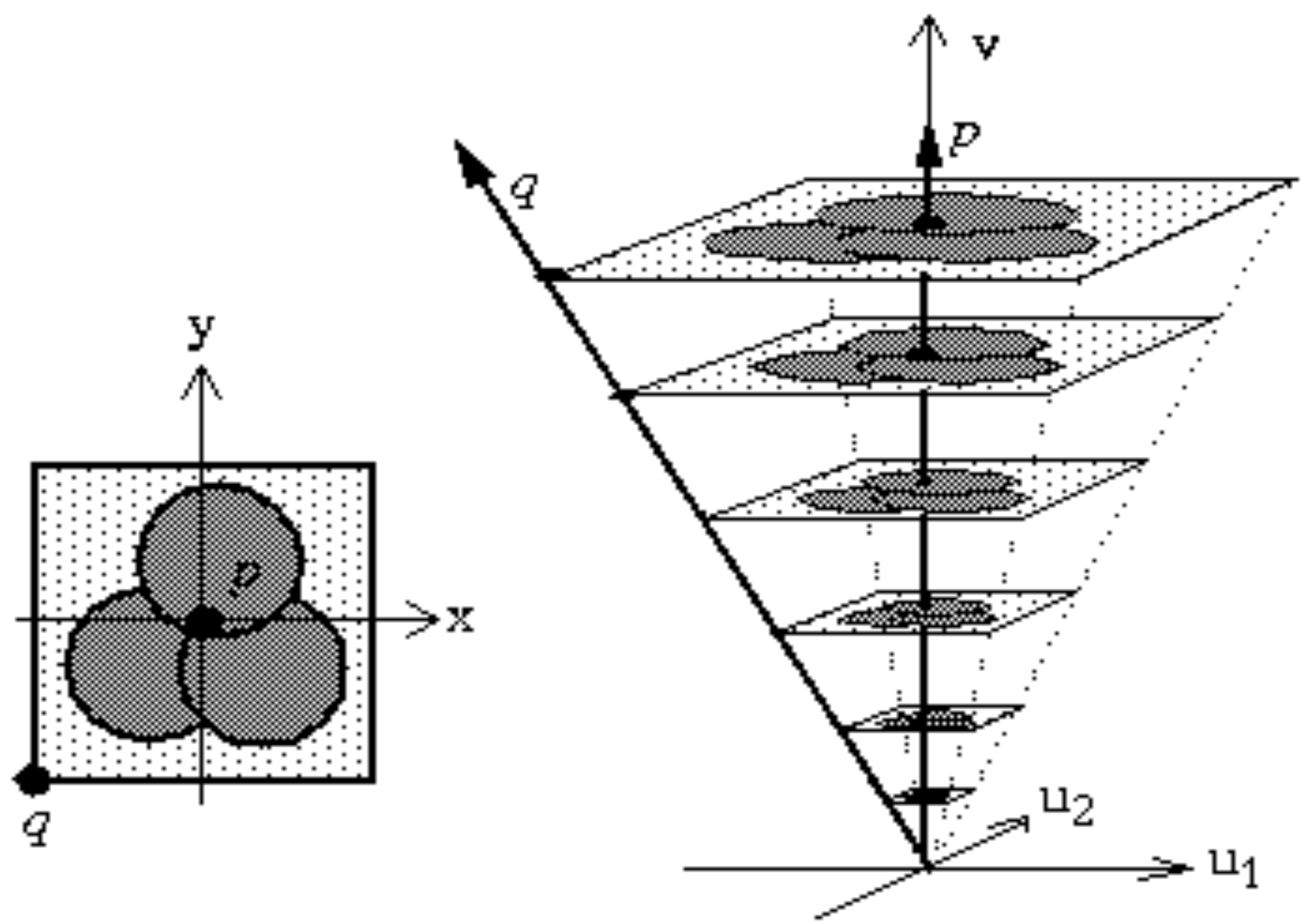
Space-Scale Diagrams
(Furnas & Bederson 95)

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



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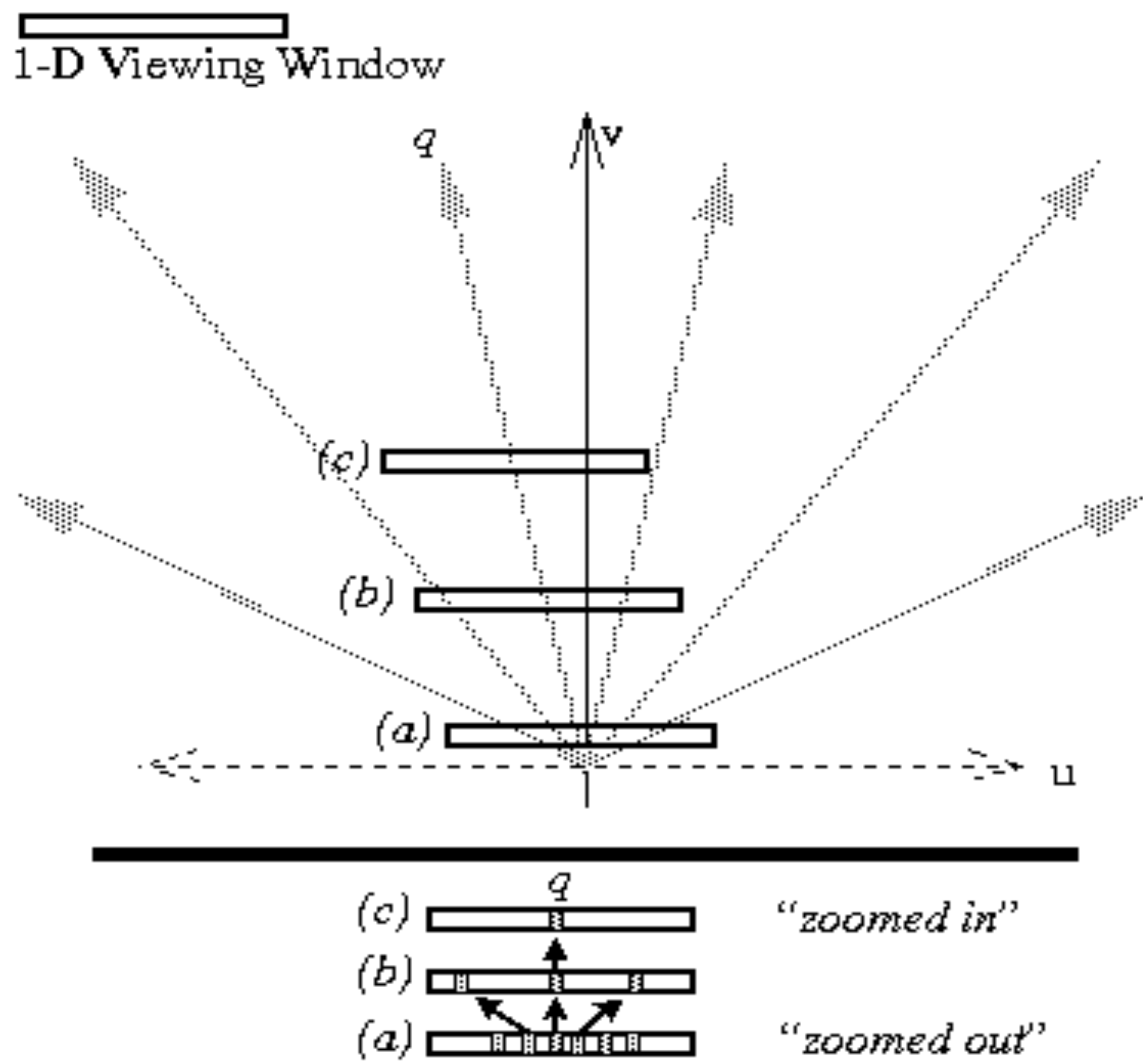
Space-Scale Diagrams
(Furnas & Bederson 95)

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



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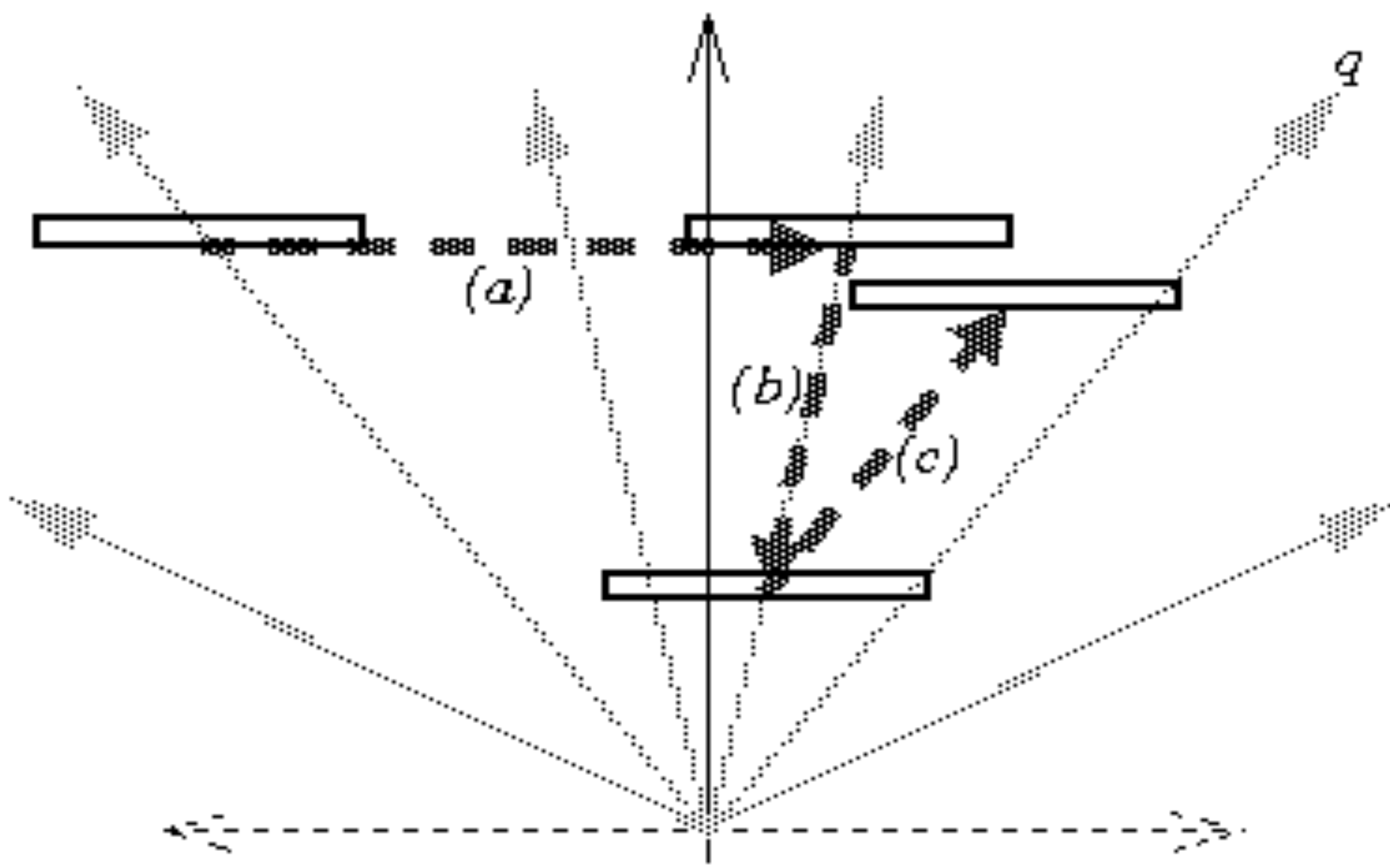
Space-Scale Diagrams
(Furnas & Bederson 95)

- 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

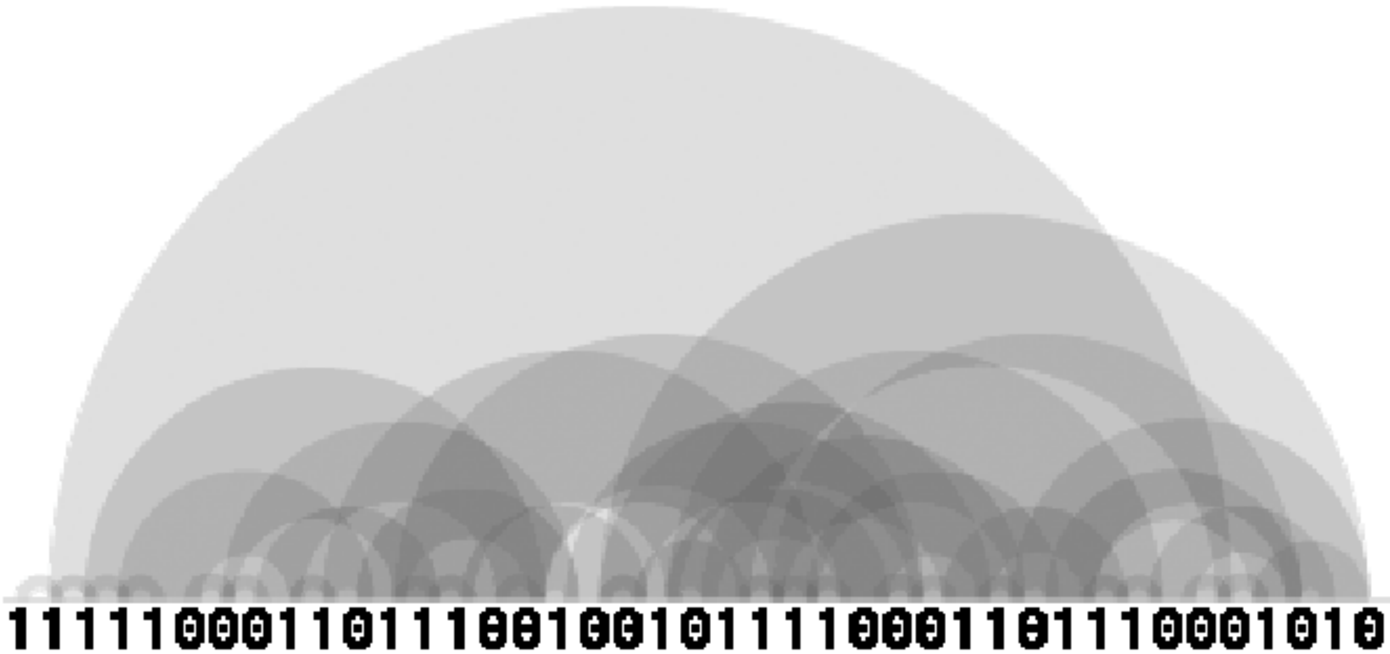
http://hci.uni-konstanz.de/research/projects/mediovis

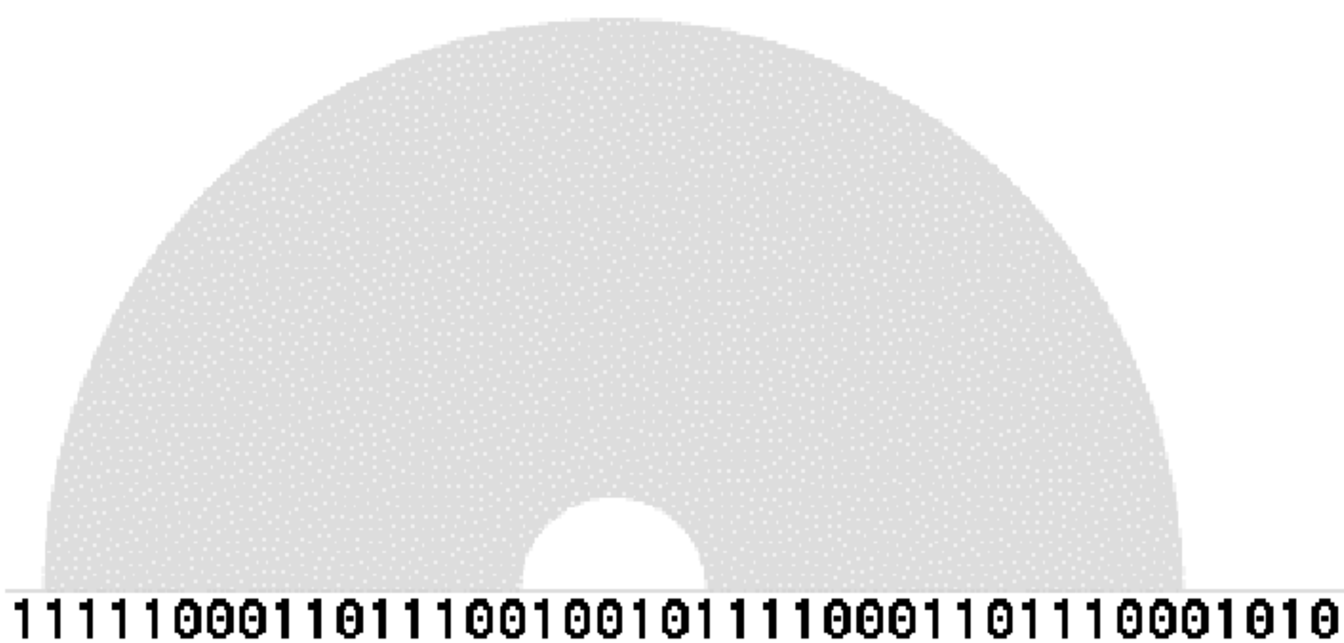
Arc Diagrams

- Visualization method for representing complex patterns of repetition in string data.
  - Arc diagrams scale efficiently for strings that contain many instances of the same subsequence.
  - idea of visualizing only a subset of all possible pairs of matching substrings.
  - highlight just the subsequences essential to understanding the string's structure

Arc Diagrams - Basics

Arc Diagram – Level of Detail

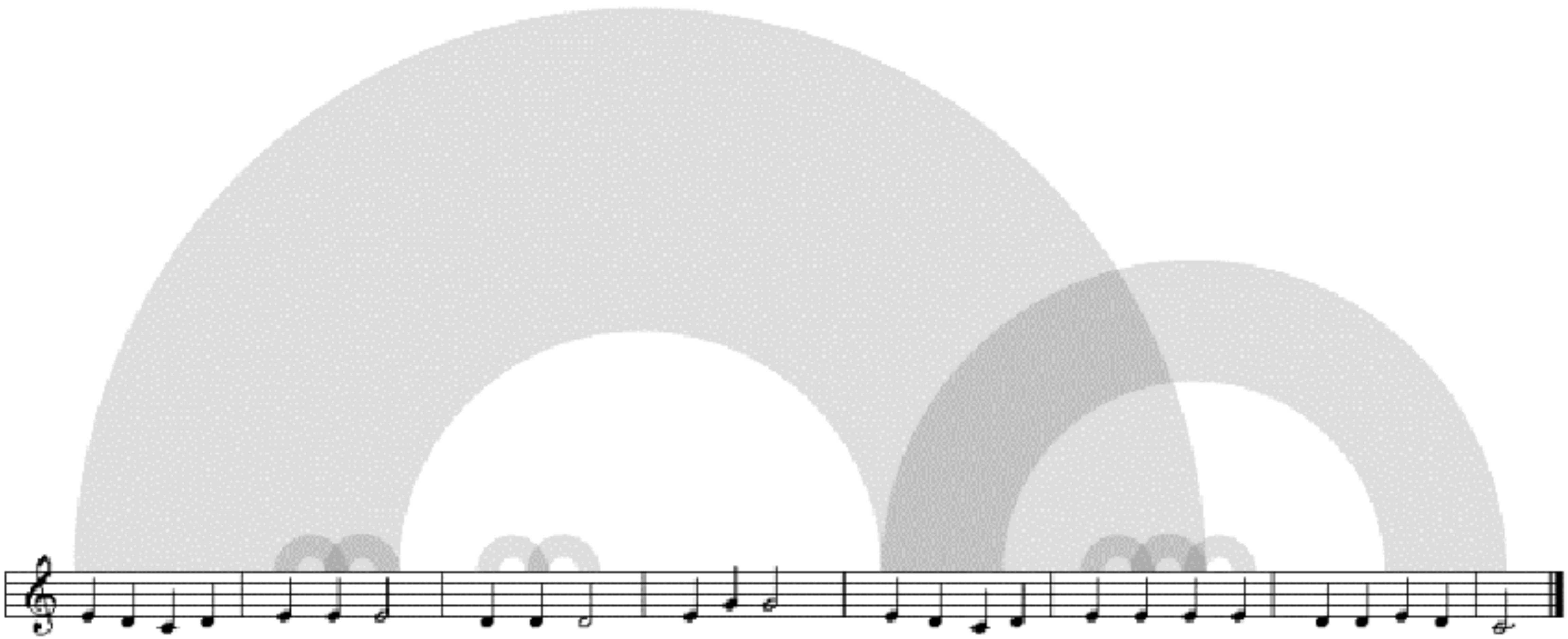




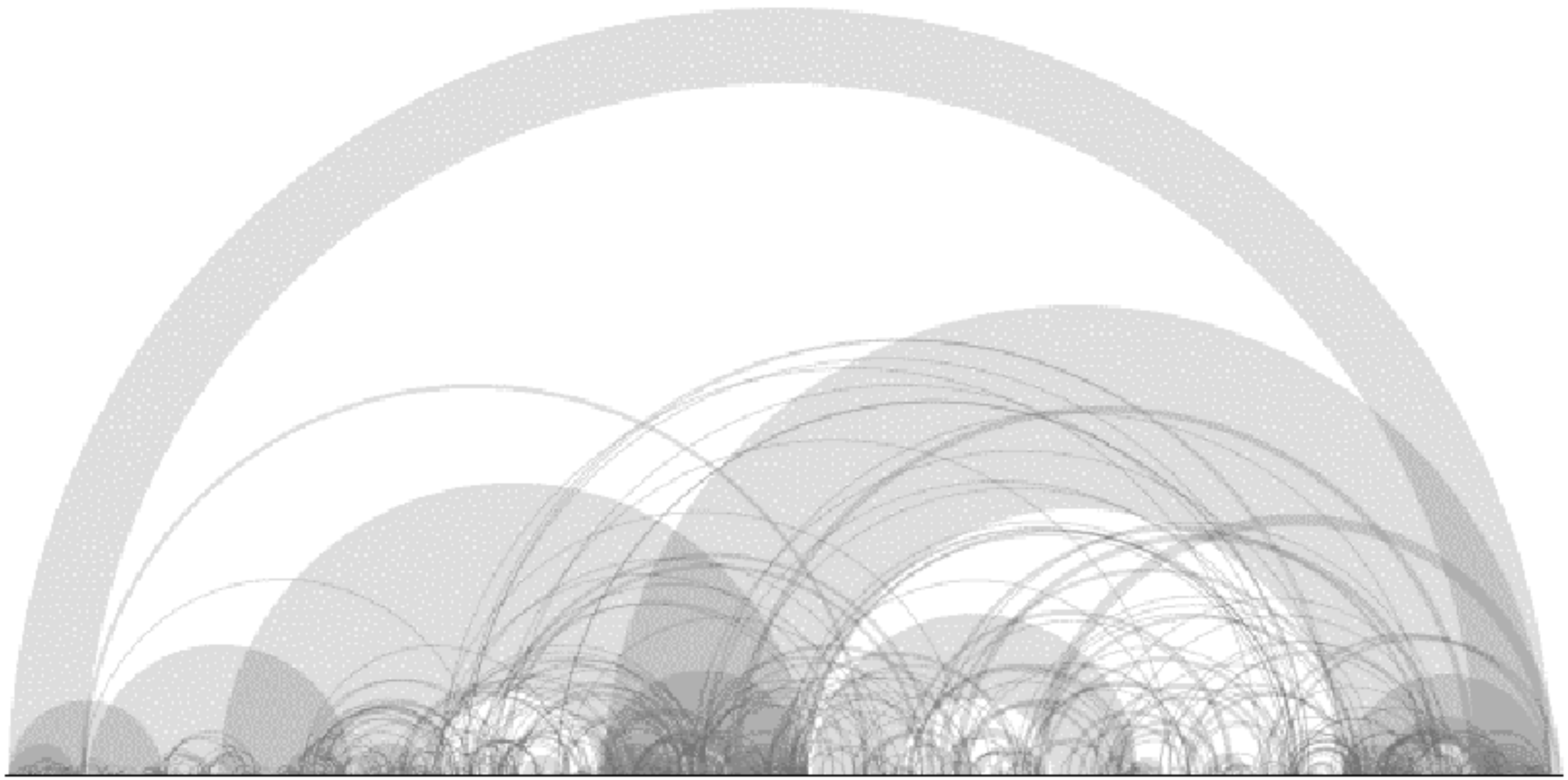
Applied to

- Music
- DNA
- Web pages
- Byte code

Arc Diagram applied to Music



Arc Diagram applied to Music "für Elise"



- More details
  Martin Wattenberg. Arc Diagrams: Visualizing Structure in Strings
  IBM Watson Research Center, Technical report 2002-11

Thread Arcs

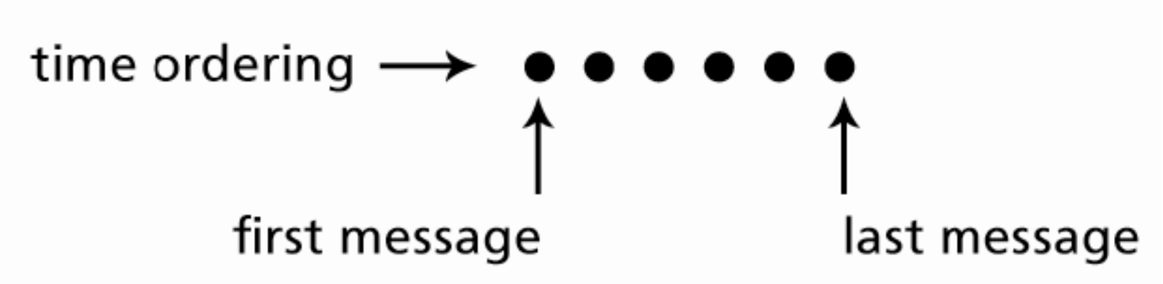
- Thread Arcs combine the chronology of messages with the branching tree structure of a conversational thread
- Benefits
  - Chronology
  - Relationships
  - Stability
  - Compactness
  - Attribute Highlighting
  - Scale
  - Interpretation/Sense

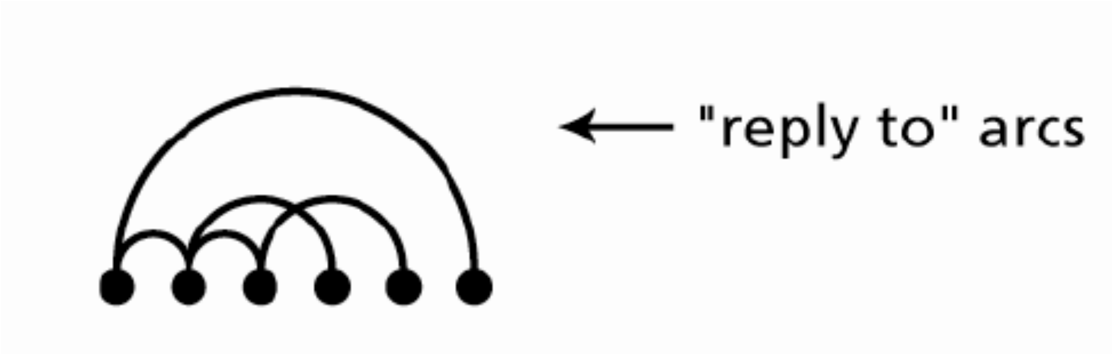
Bernard Kerr, 2003

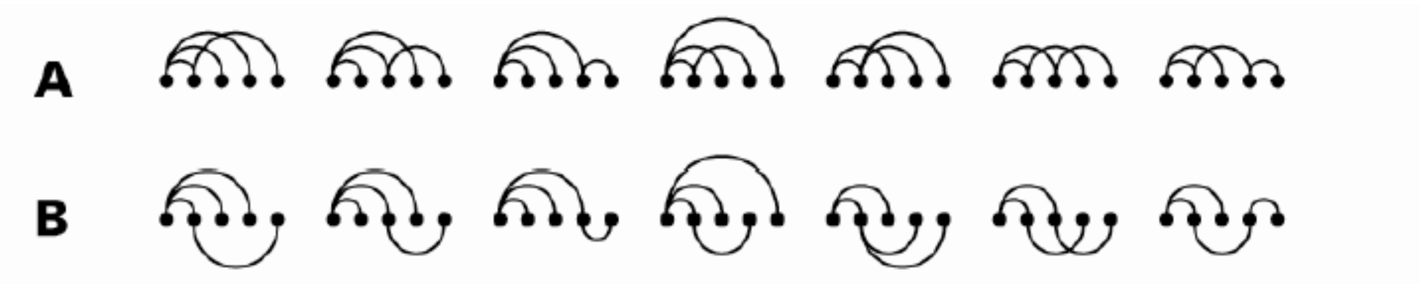
http://www.research.ibm.com/remail/threadarcs.html

Thread Arcs for Emails

- **Visualization**
  - Linear layout of message nodes connected by relationship arcs.
  - Each circular node represents a message in the thread.
  - *Chronology* of the thread is encoded by the position
  - The width of a Thread Arc is a linear function of the size of the thread
  - *Compact visualization* if height is constrained







The relationship between messages are clearer when arcs are draw above and below nodes (B).

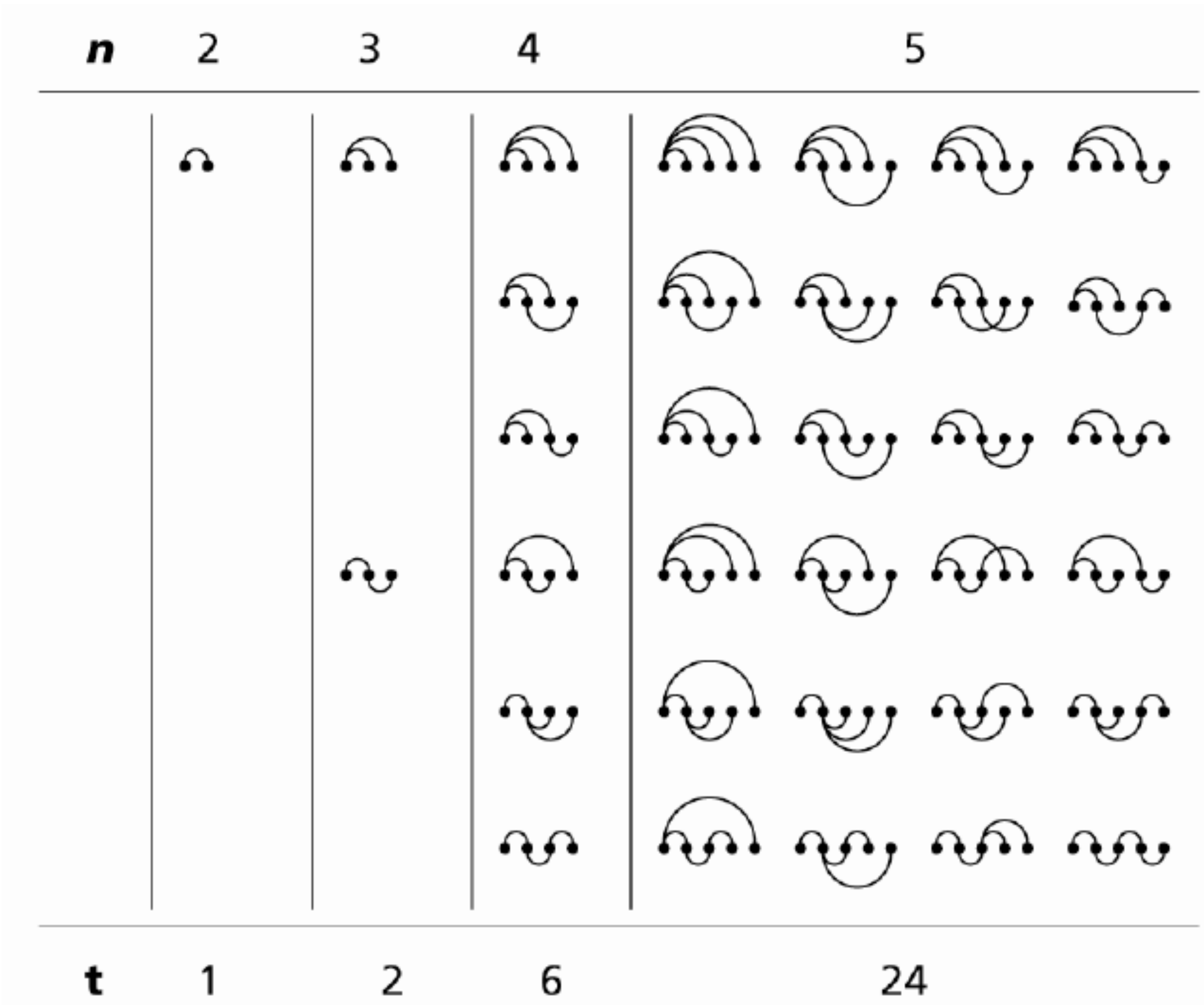
Pseudo code for drawing a thread arc

To make a Thread Arc

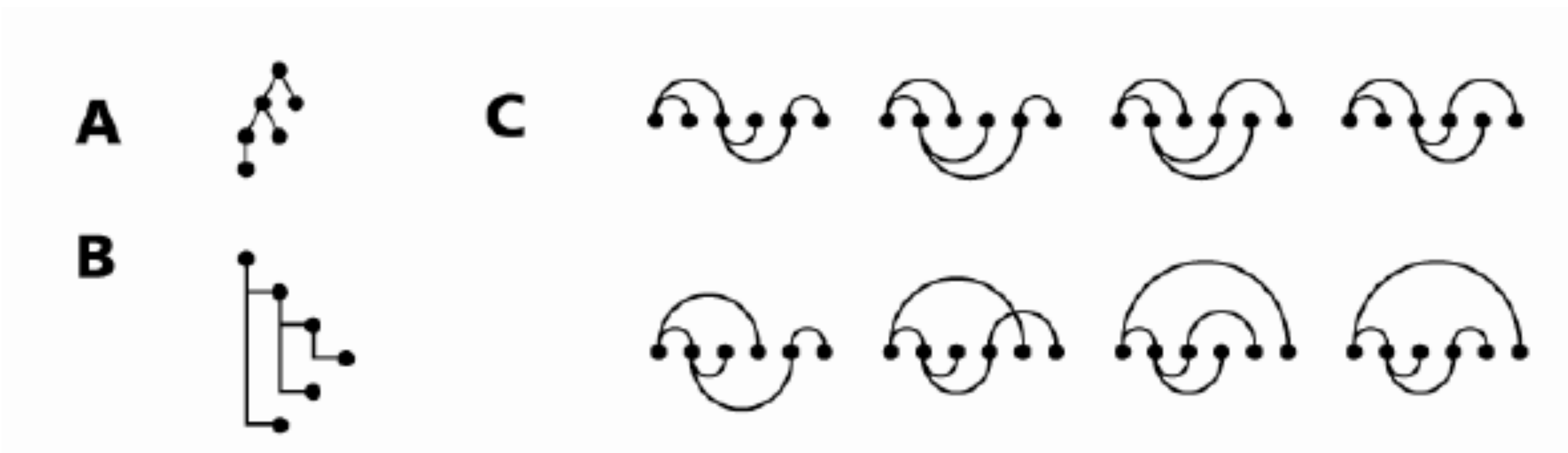
```
sort all messages chronologically
find the generation depth of each message

for each message
    if the message is the root message then
        place the node at the starting position
        don't draw an arc
    else
        place the message to the right of the last message
        if the message generation depth is odd then
            draw an arc above the line to the message's parent
        else
            draw an arc below the line to the message's parent
next message
```

Space of Possible Thread Arcs (5 Messages)



Chronological Information in the Thread Arcs

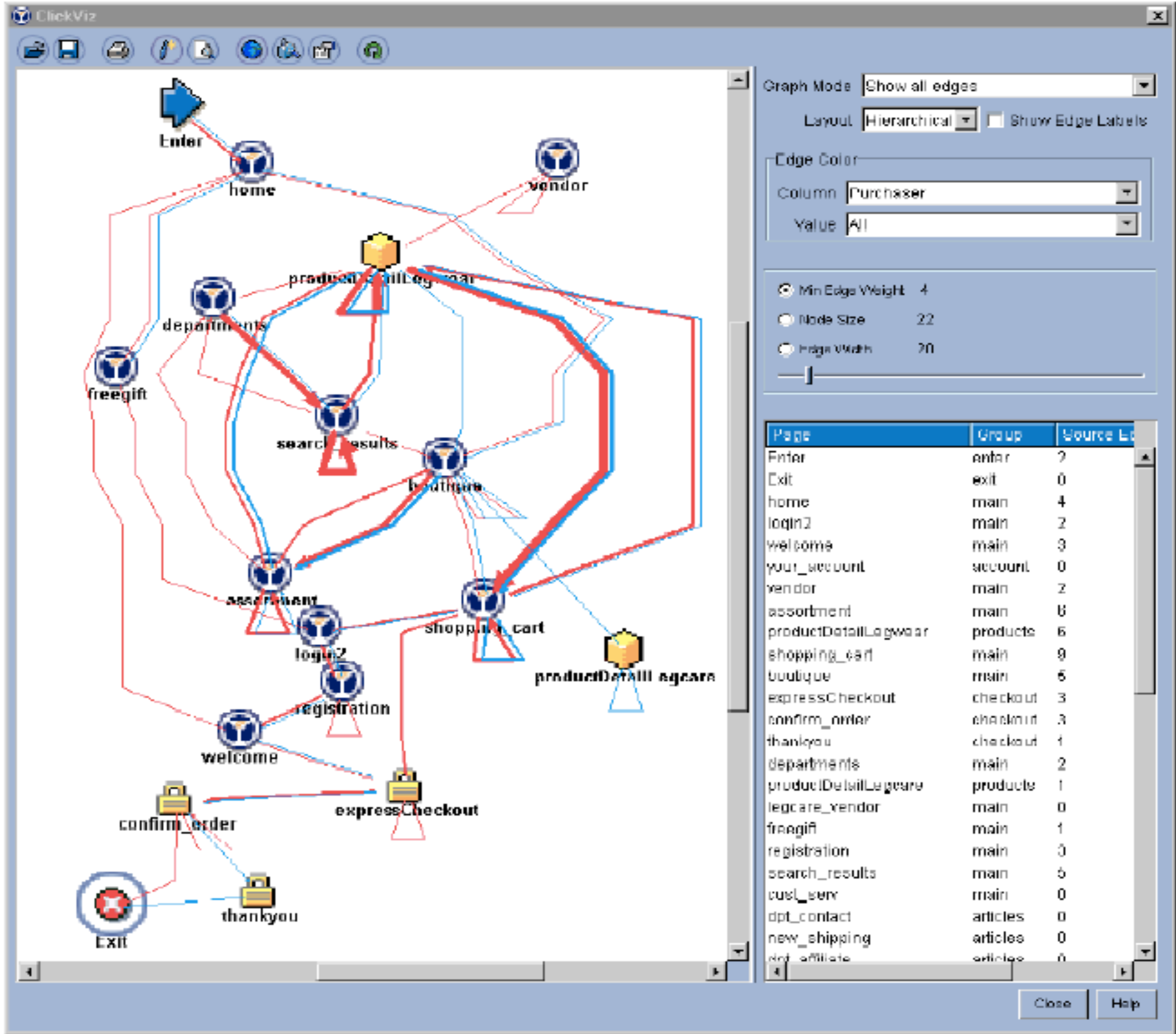


Example Email Client using Thread Arcs

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

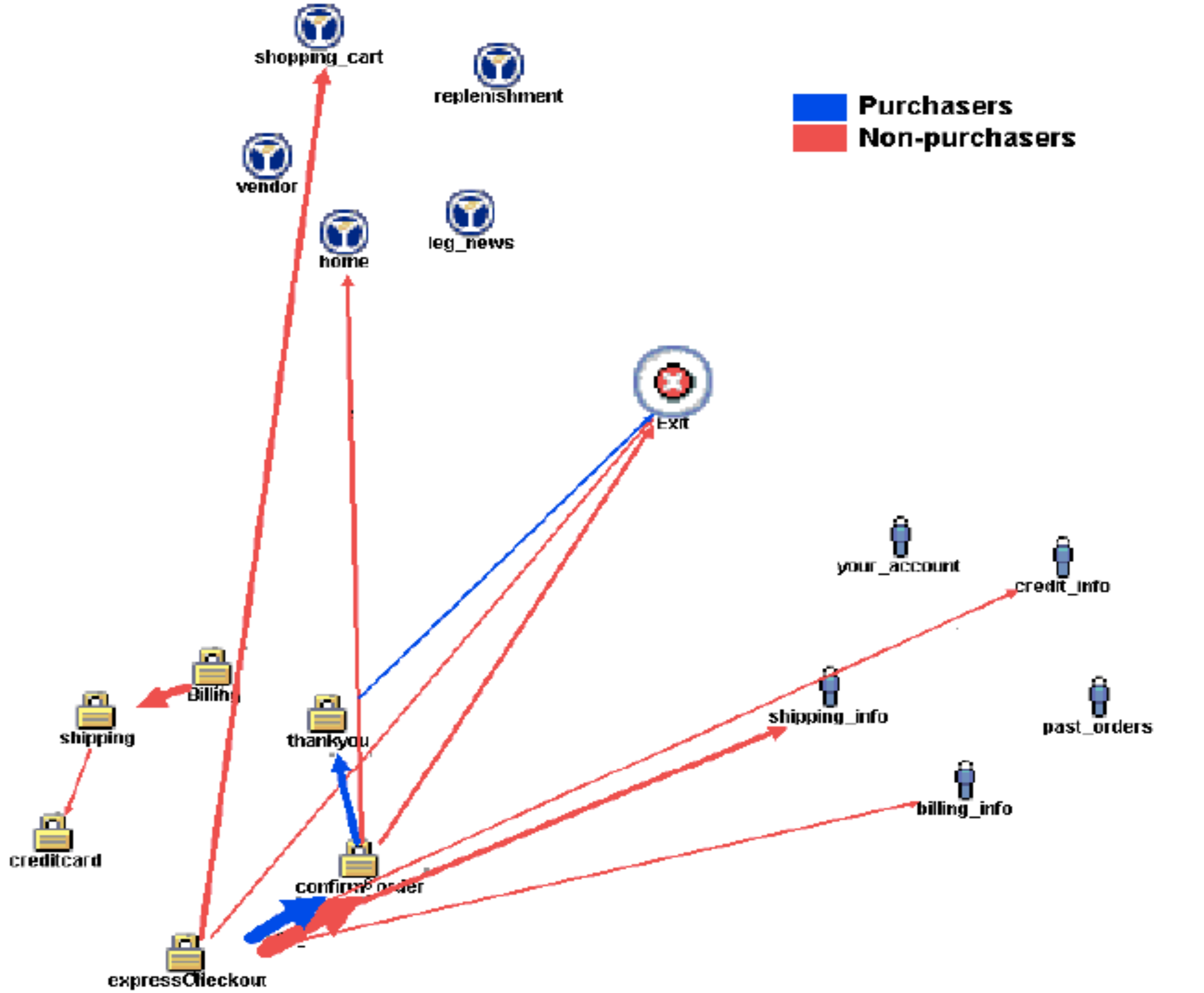


Figure 2. Circular layout. All the checkout pages are grouped (lower left). Red edges that emanate from the checkout pages to other parts of the site represent non-purchasers who are abandoning the checkout process.

- Brainerd et al.

Click stream Visualization

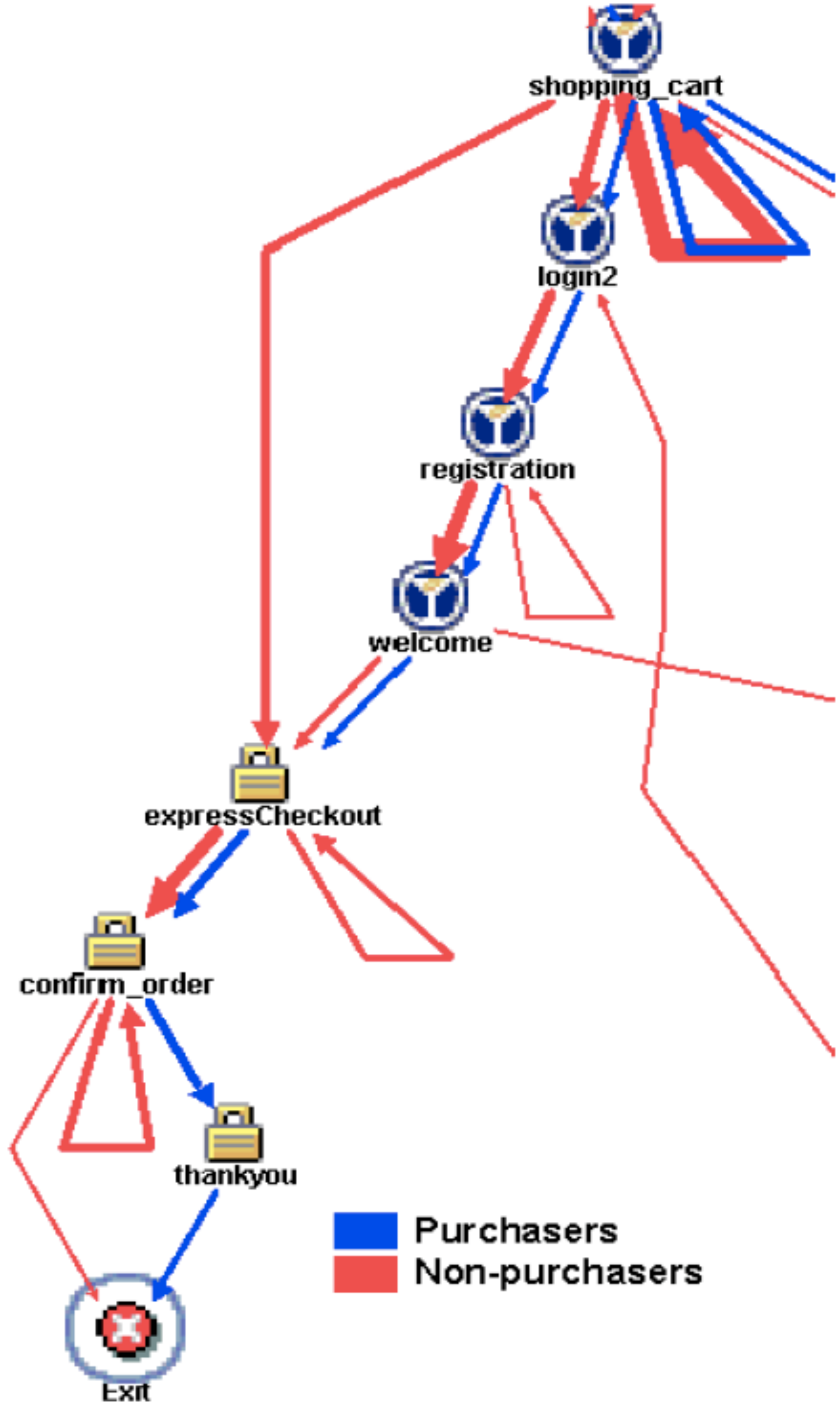
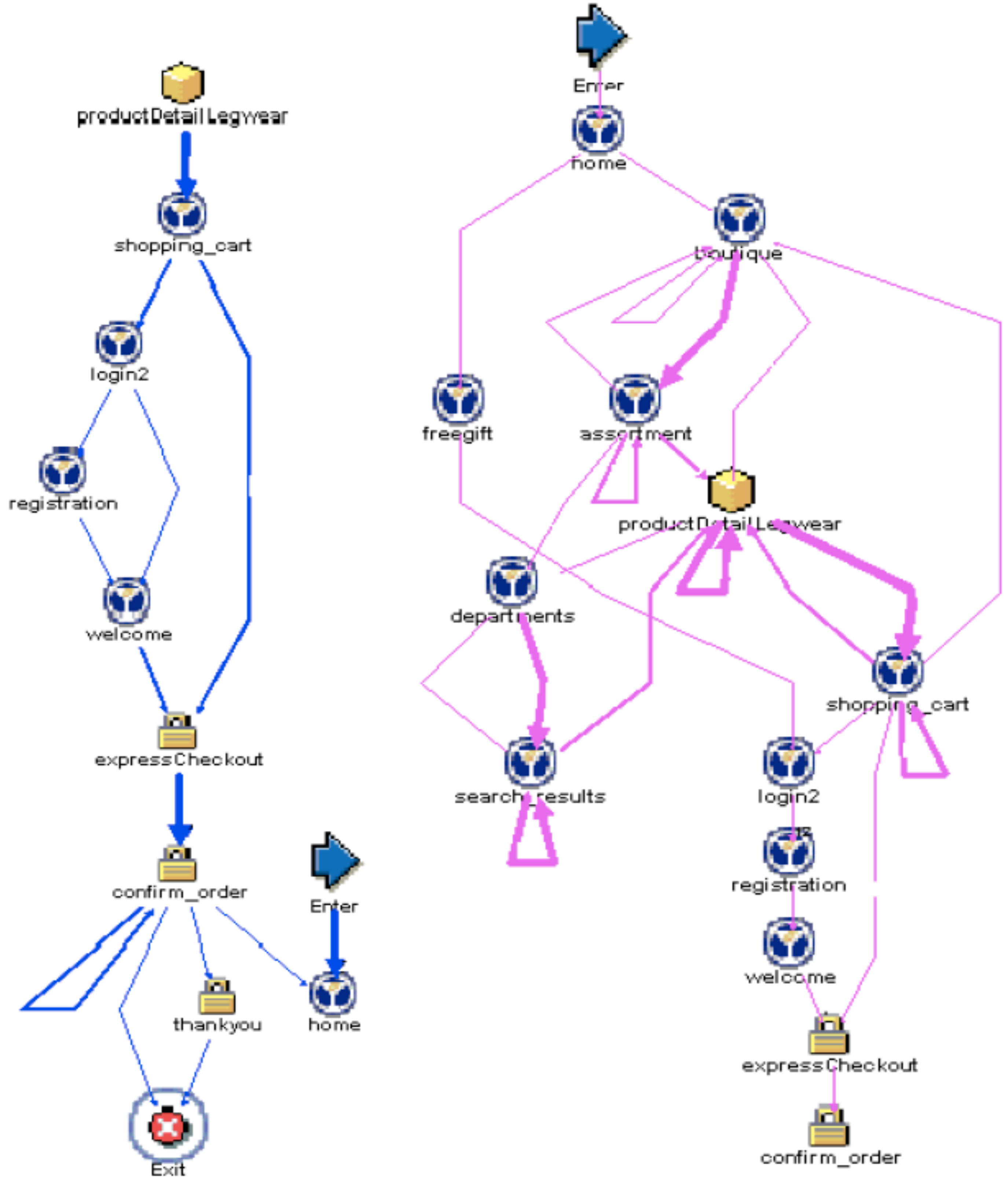


Figure 4. Checkout process. Purchasers take a direct route through the checkout process, whereas non-purchasers show a more haphazard route, including self-edges and early abandonment, possibly indicating a confusing checkout process.

- Brainerd et al.

Click stream Visualization



(a) Males (b) Females

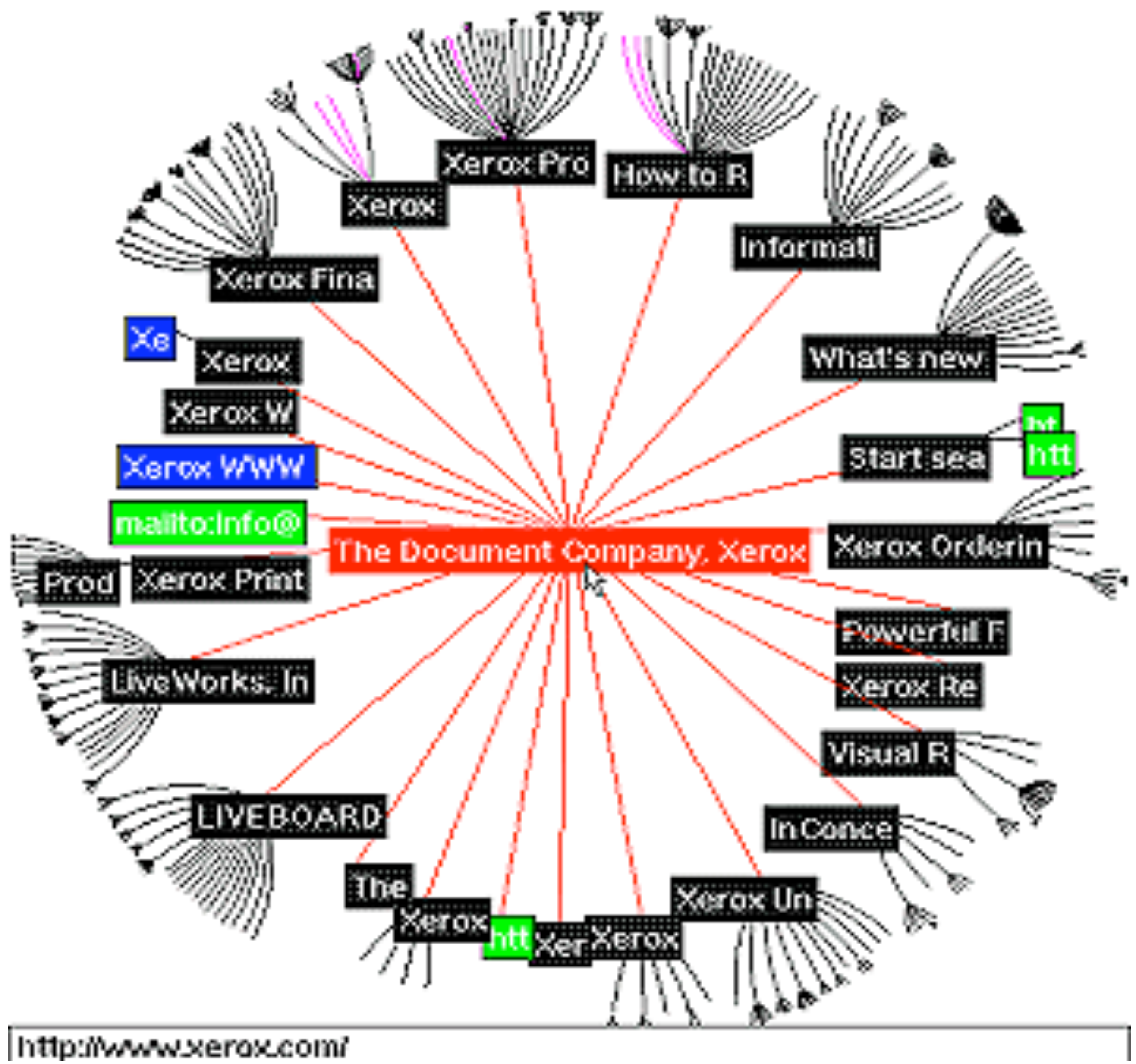
Figure 3. Gender Differences: Males tend to navigate in specific, direct patterns, whereas women's navigation patterns include much more browsing, utilizing much more of the site.

- Brainerd et al.

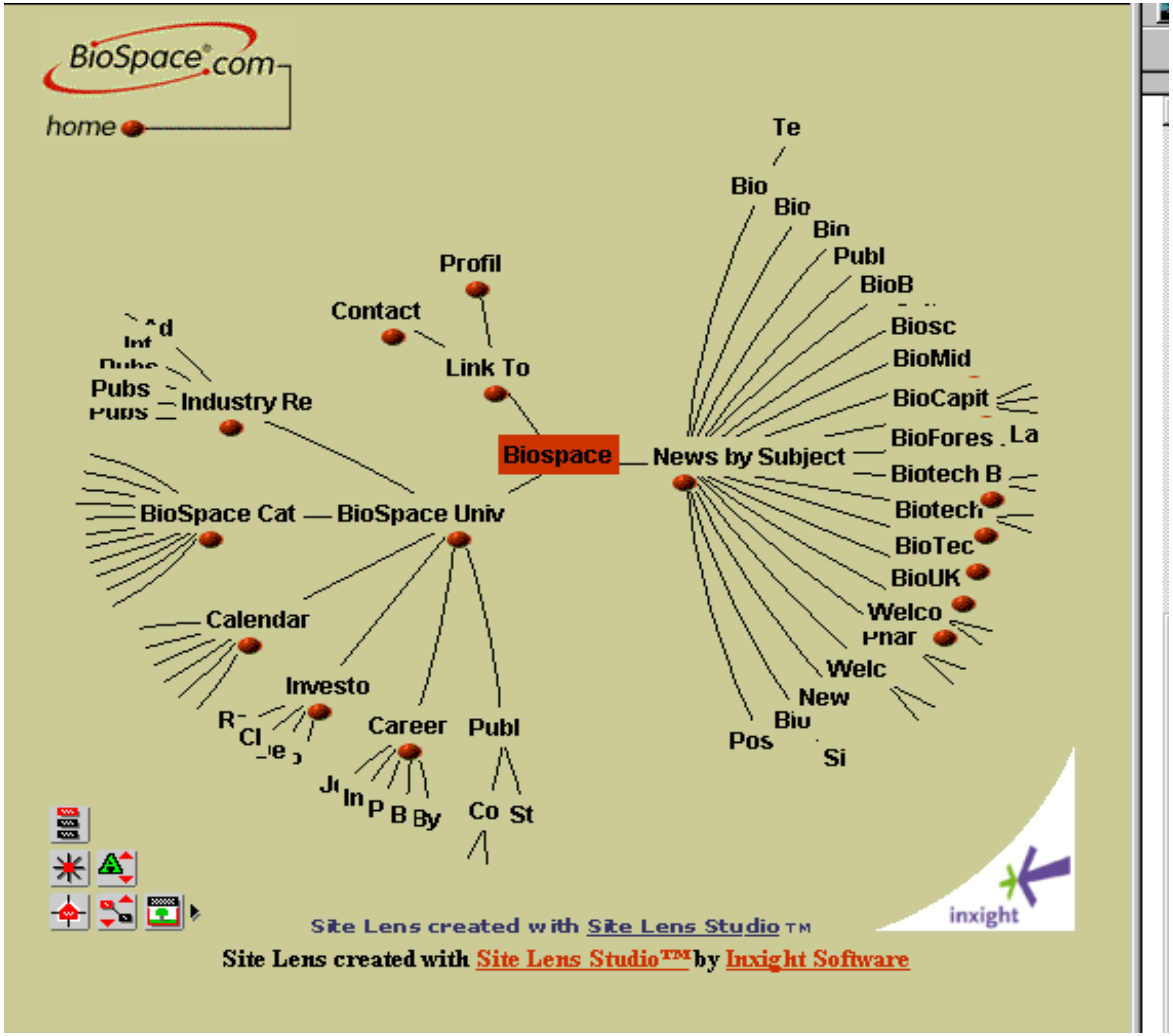
Hyperbolic Browser

- 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

Hyperbolic Tree Browser
(Lamping et al. 95)

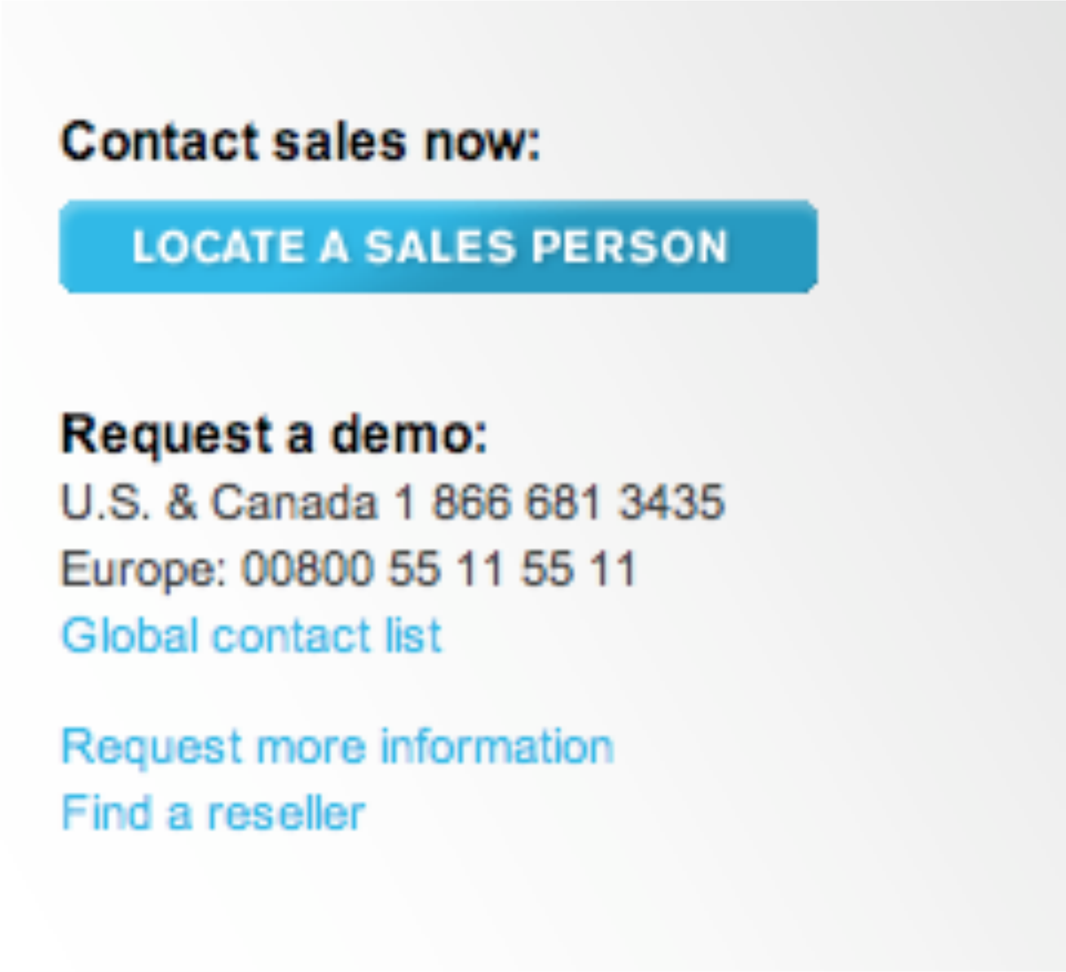


Inxight's Hyperbolic Browser



Hyperbolic Tree Views

- Nice demos on the Web
  - www.inxight.com ..oops, bought by SAP as of 06/2008, demos offline 8(
  - 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

The Fisheye View Metaphor

The **fisheye view** is a metaphor coming from the fisheye lens used in photography. Such a wide angle lens distorts an image in the way that things in the central area appear enlarged, while things aside appear small.

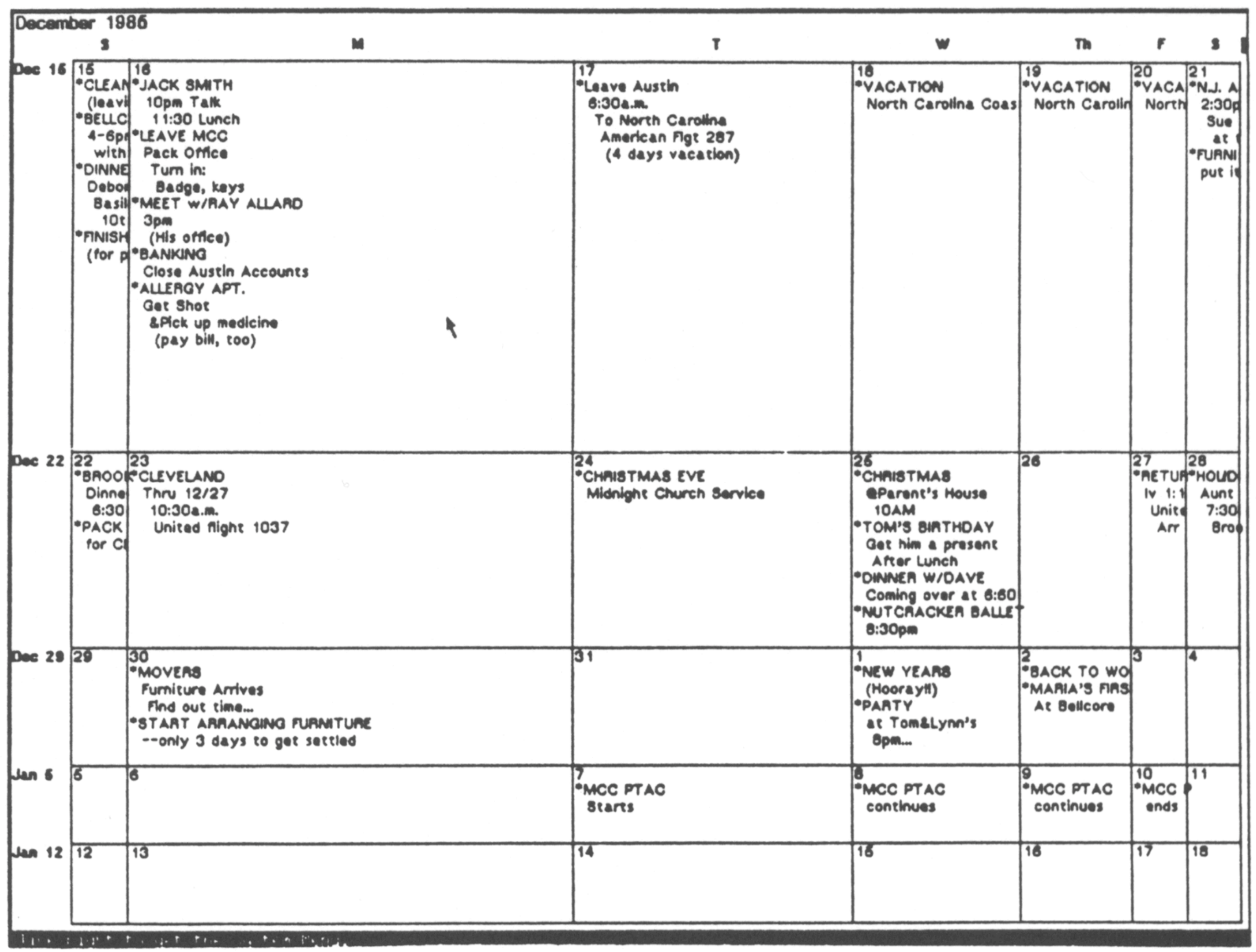
Taken from the internet: www.rolfwegst.com

The idea behind the fisheye is enlarging the focus and keeping the context.

The Fisheye View Theory

(George W. Furnas
-CHI 1986)

A Fisheye Calendar.



The Fisheye View Theory

Y. K. Leung, M. D. Apperley (1994)
A Review and Taxonomy of Distortion-Oriented Presentation Techniques

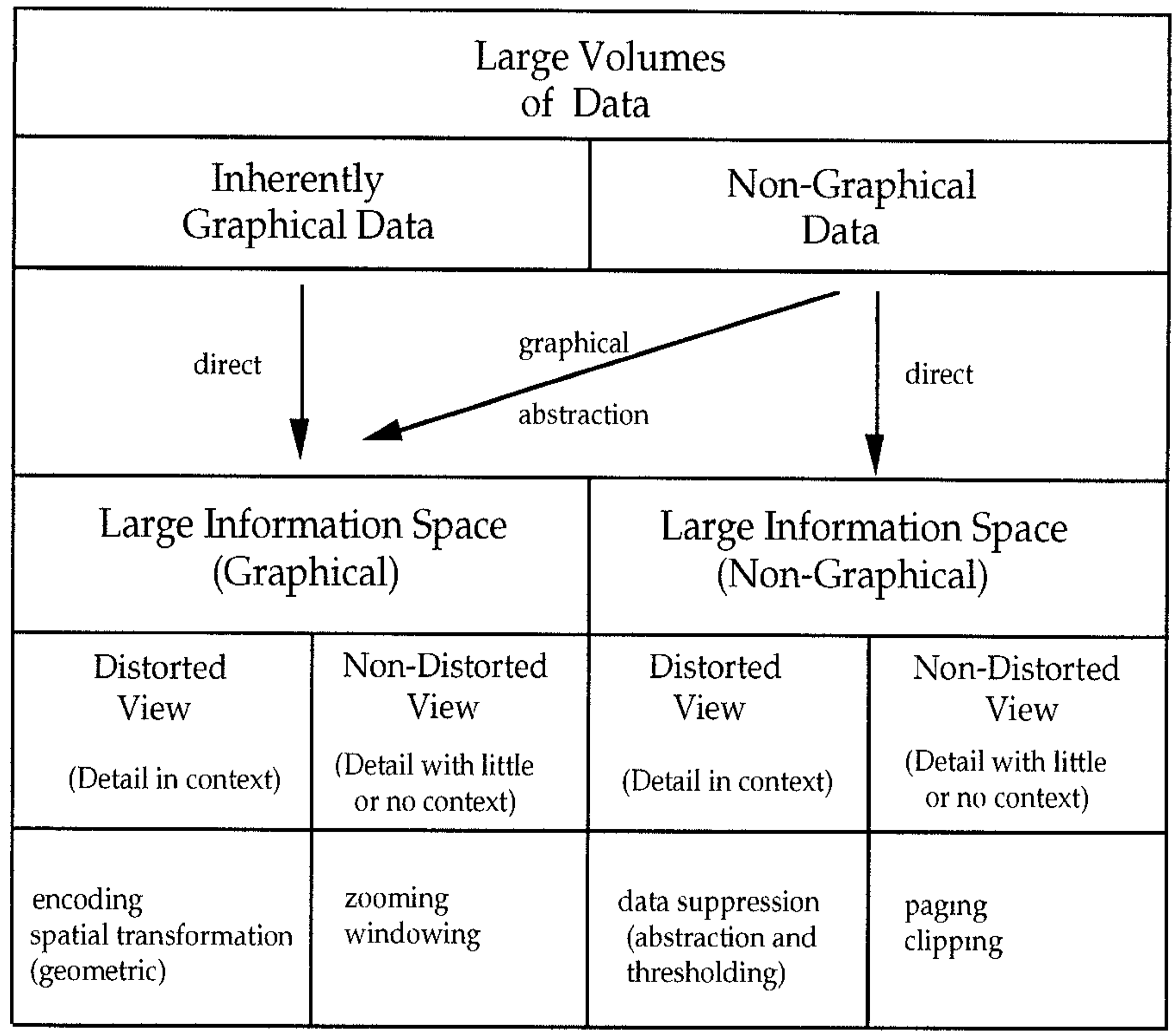
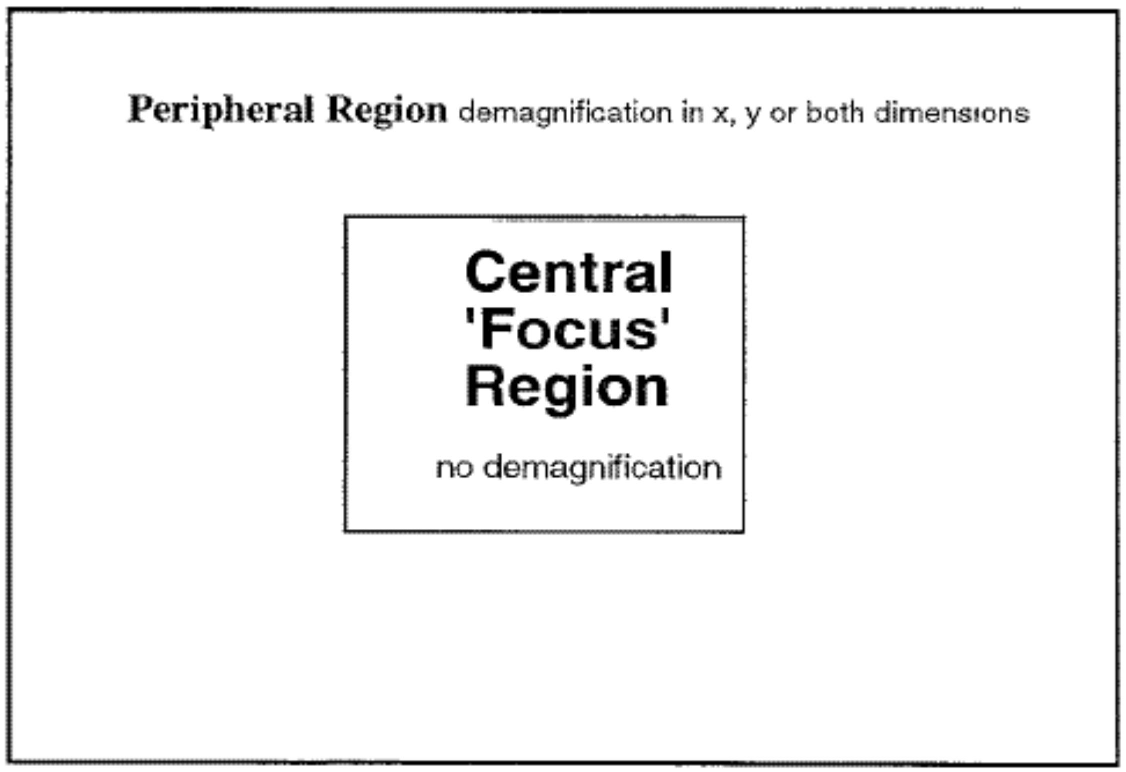


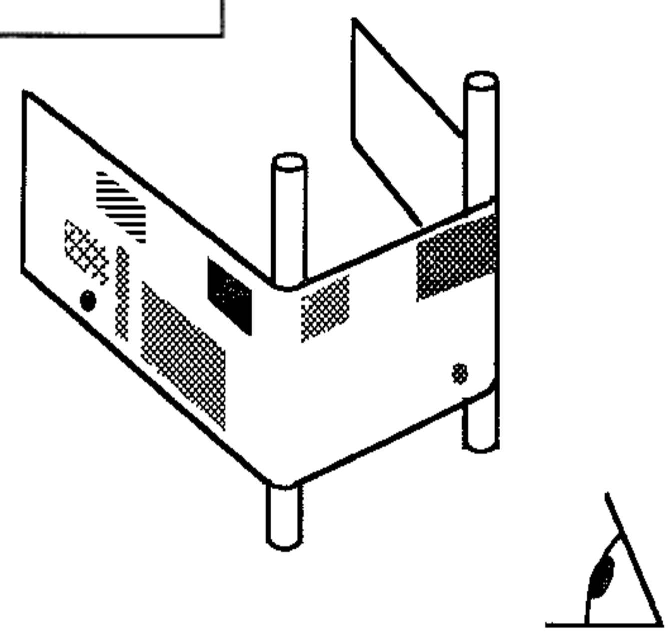
Fig. 1. A taxonomy of presentation techniques for large graphical data spaces.

The Fisheye View Theory

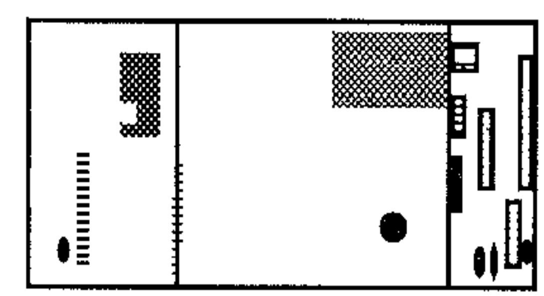
(Y. K. Leung,
M. D. Apperley 1994)



Metaphor of a perspective wall



(a)



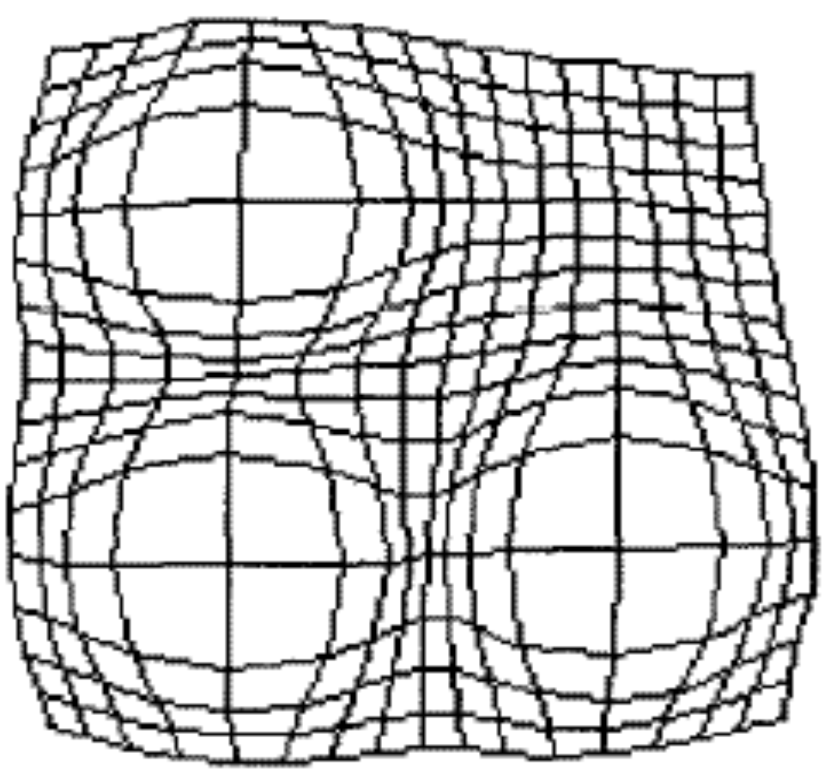
(b)

The Fisheye View Theory

(Y. K. Leung,
M. D. Apperley 1994)

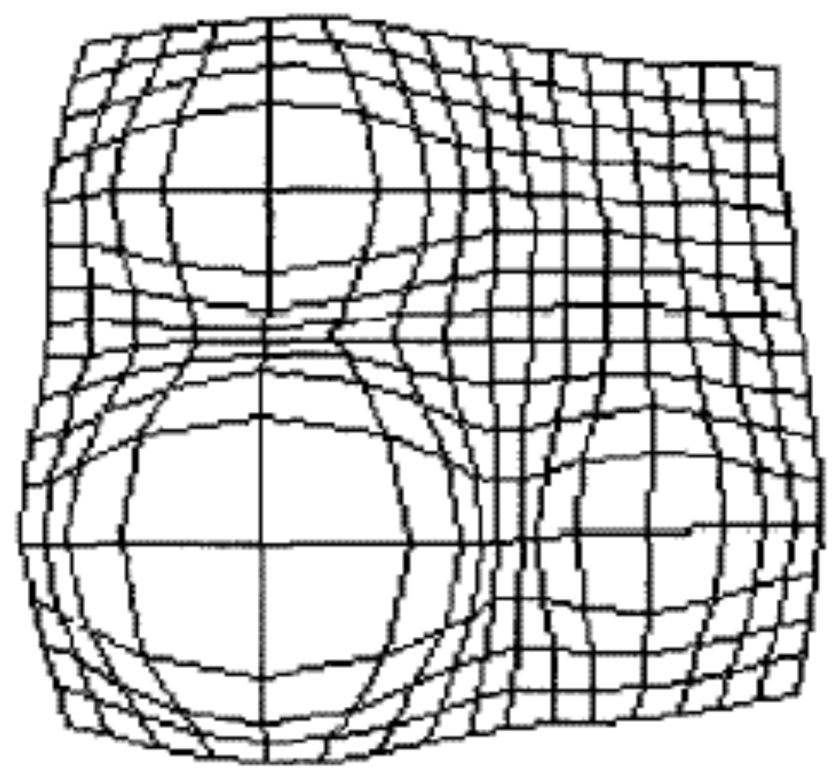
Unified theory of distortion techniques

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



(e)

Multi focal projections



(f)

Fisheye Views Applications

- Semantic fisheyes
- 1-dimensional fisheyes
- 2-dimensional fisheyes
- Fisheyes for precise input

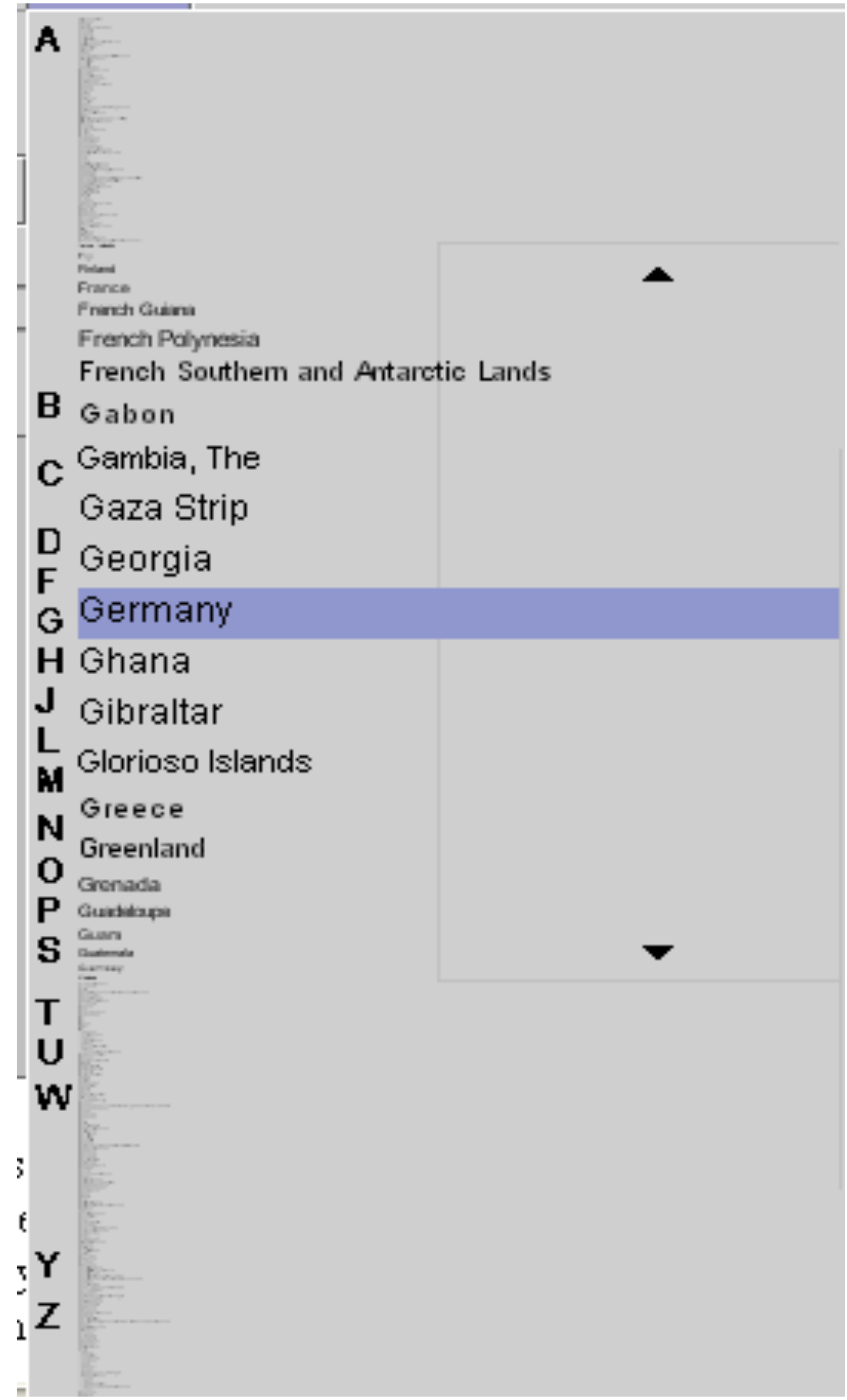
1-dimensional Fisheye

Example: Fisheye Menu

Benjamin B. Bederson.

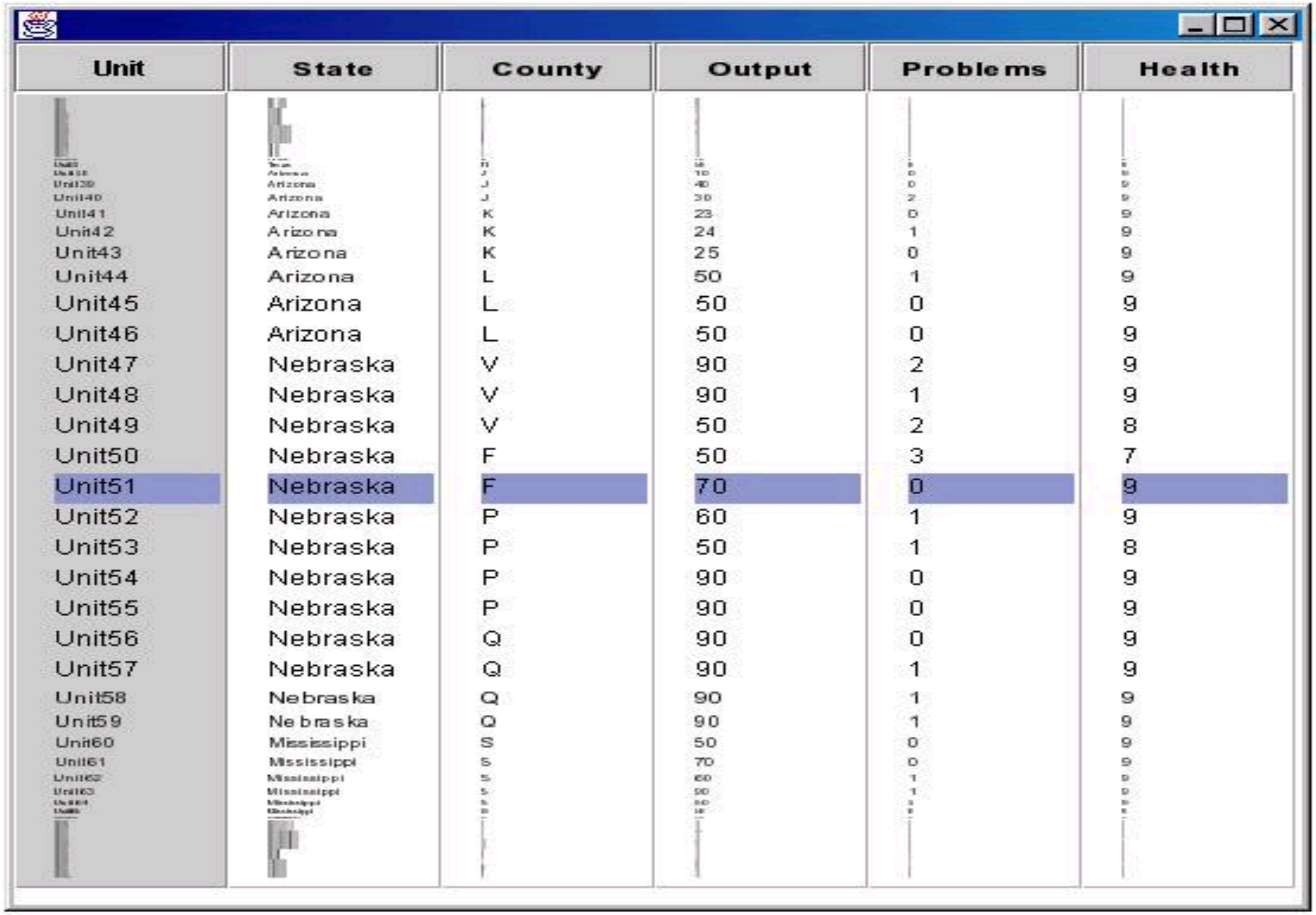
Fisheye Menus. UIST’00

http://www.cs.umd.edu/hcil/fisheyemenu/fisheyemenu-demo.shtml



1-dimensional Fisheye

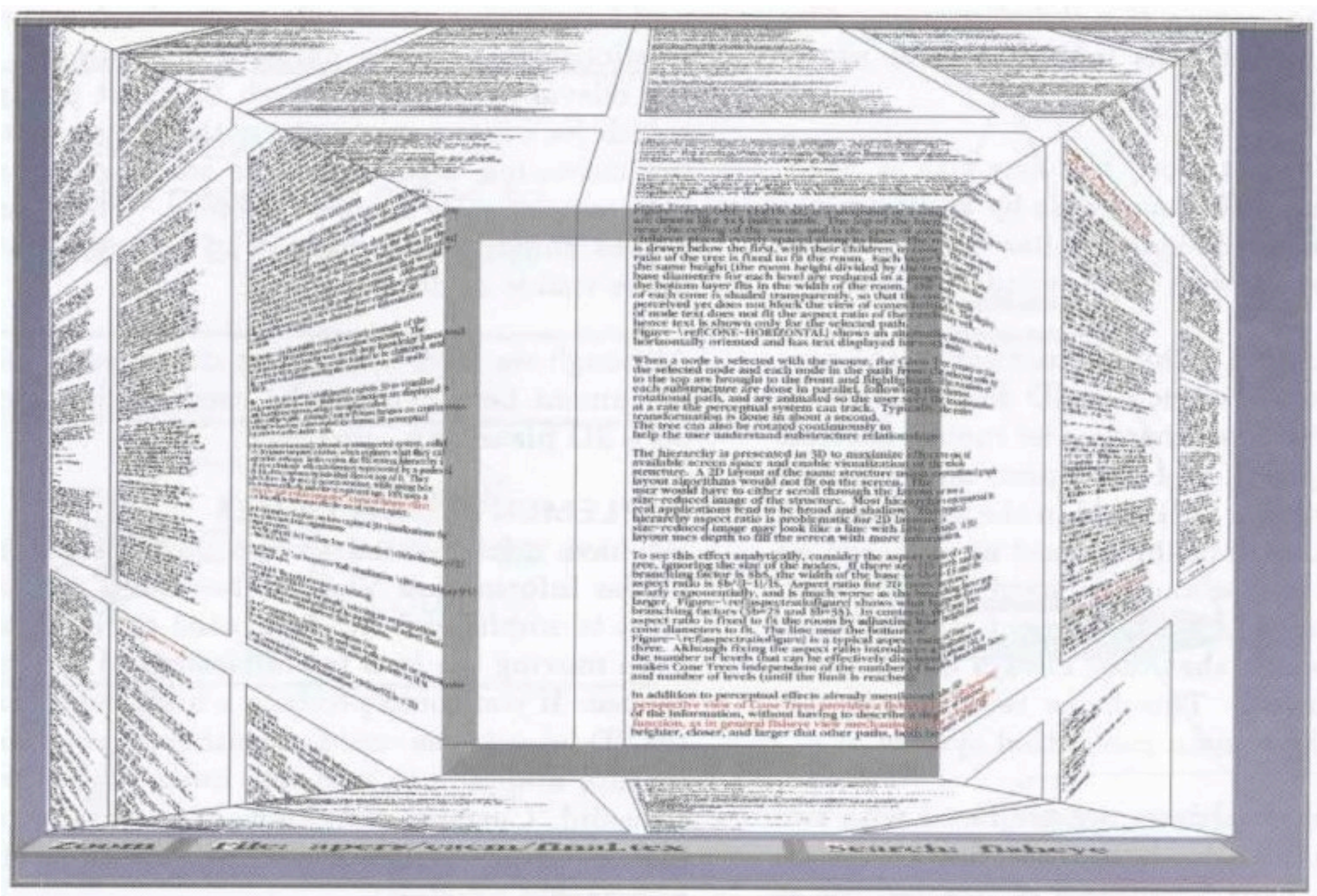
Fisheye Table



2-dimensional Fisheye

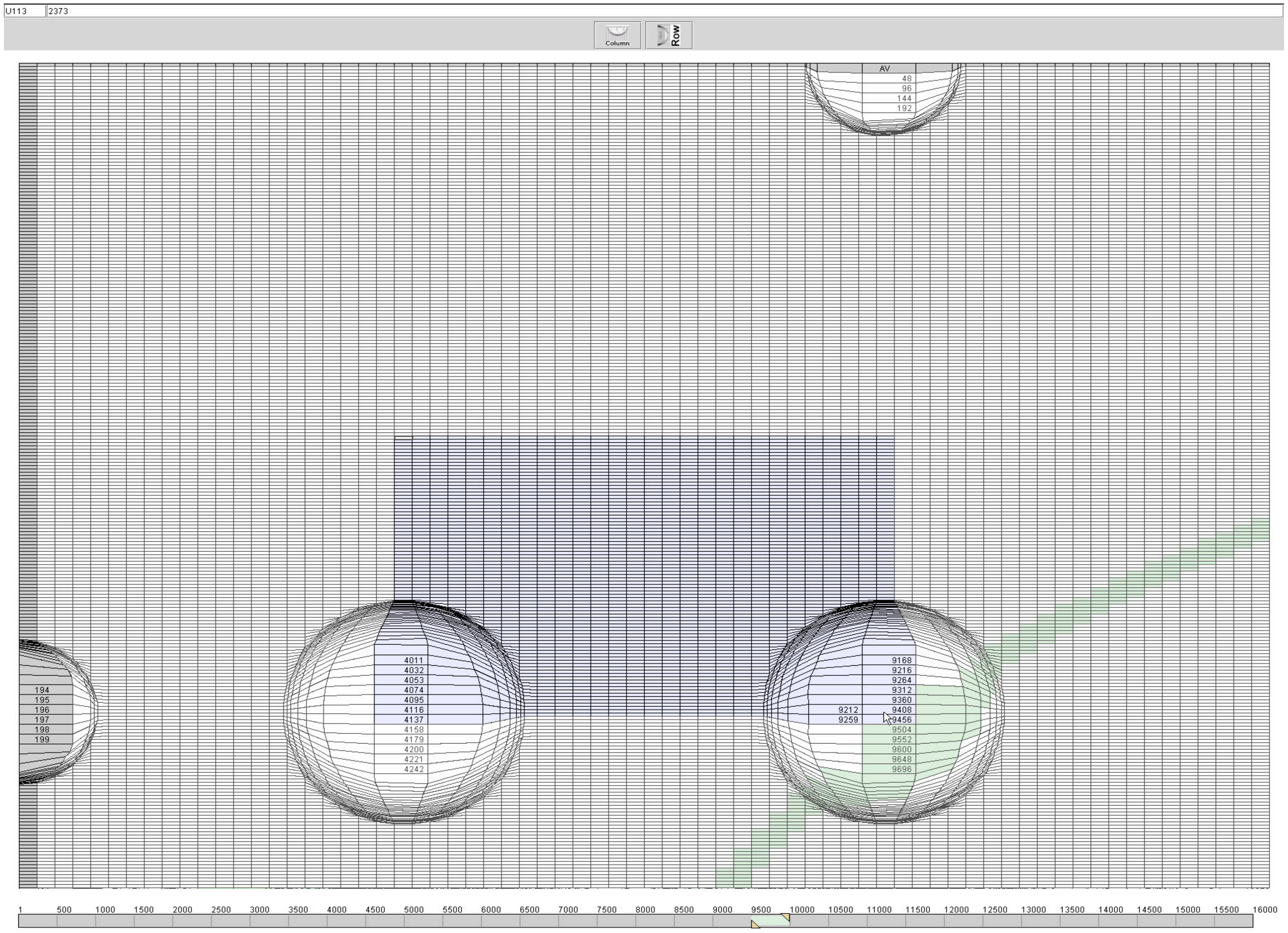
Document Lens

(G.G.Robertson, J:D.Mackinlay
UIST 1993)



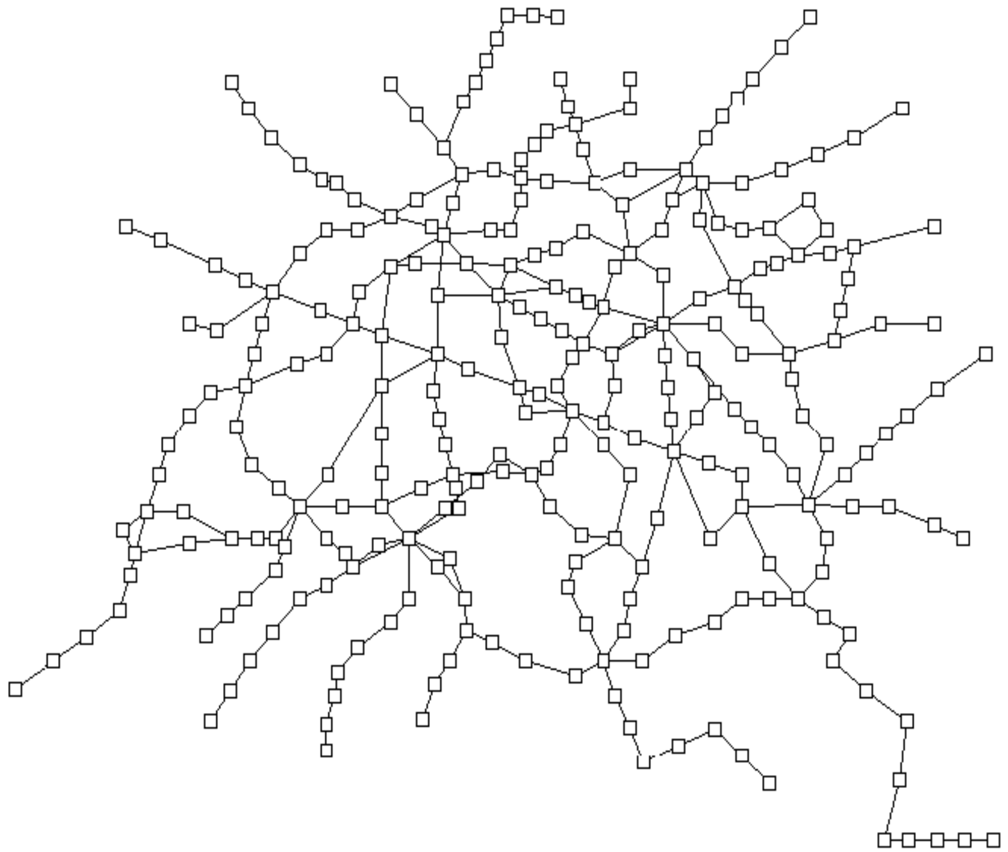
2-dimensional Fisheye

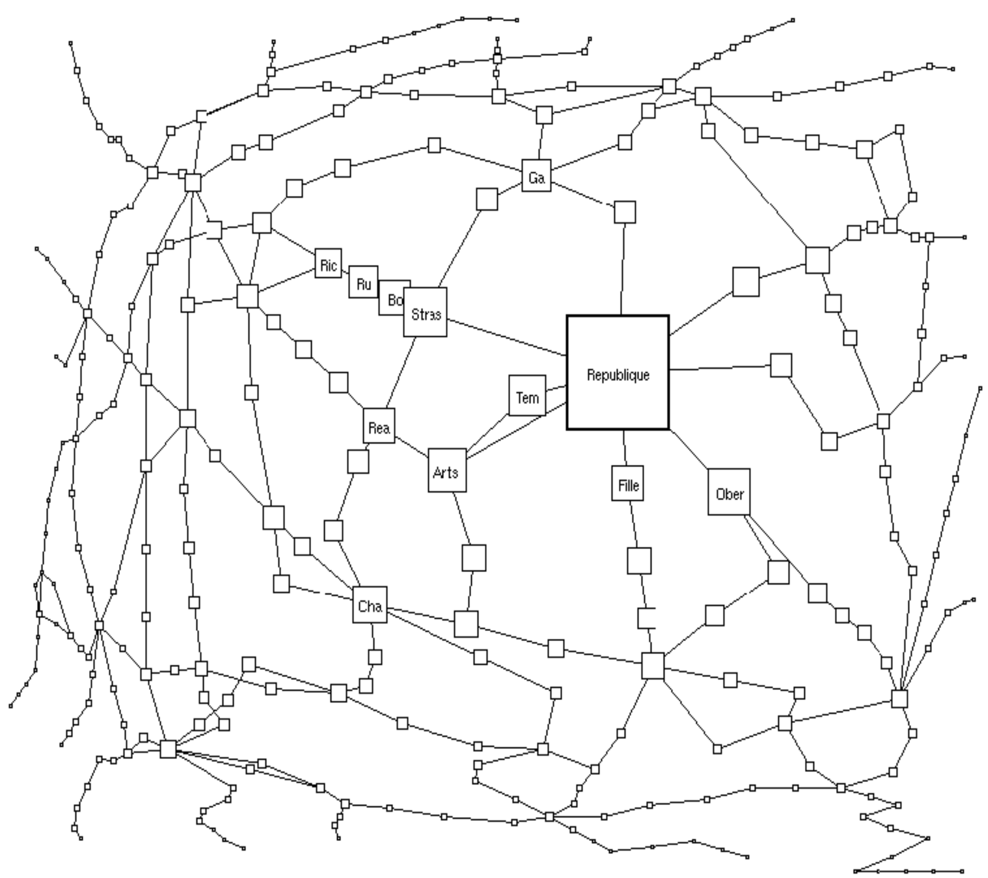
FiCell Project
http://iihm.imag.fr/vernier/



2-dimensional Fisheye

Fisheyes applied to networks



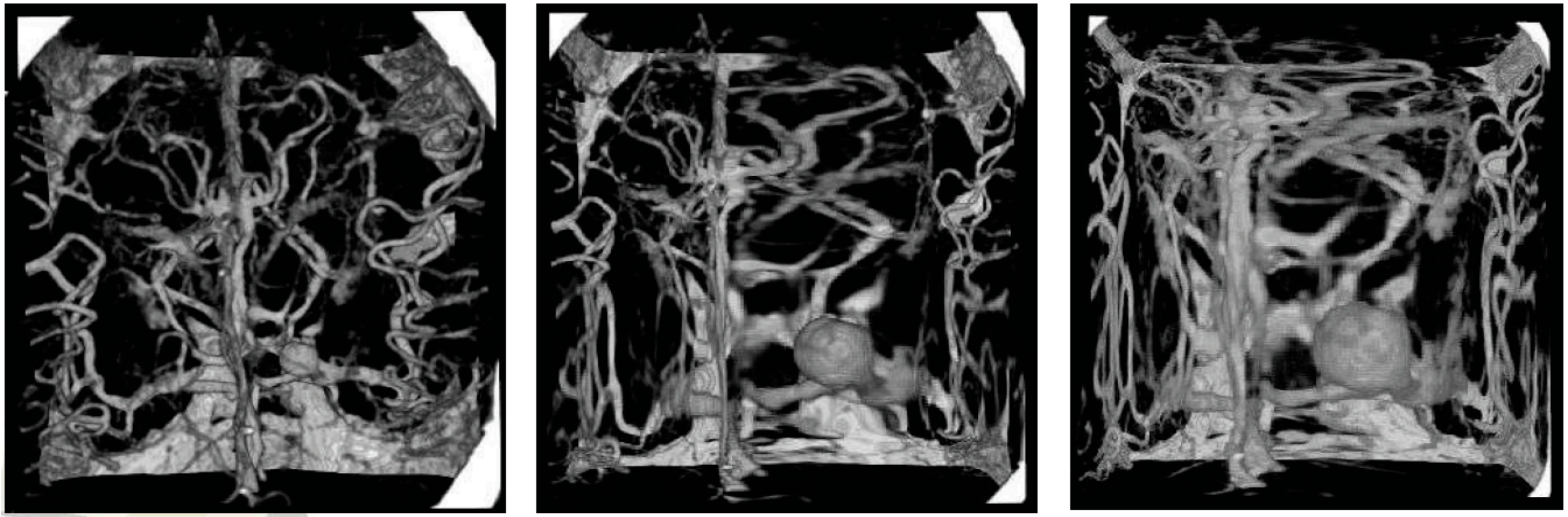


Manojit Sarkar and Marc H. Brown 1992

3-dimensional Fisheye

Marcelo Cohen, Ken Brodlie,

Focus and Context for Volume Visualization,



No distortion 3D cartesian bifocal 3D cartesian fisheye

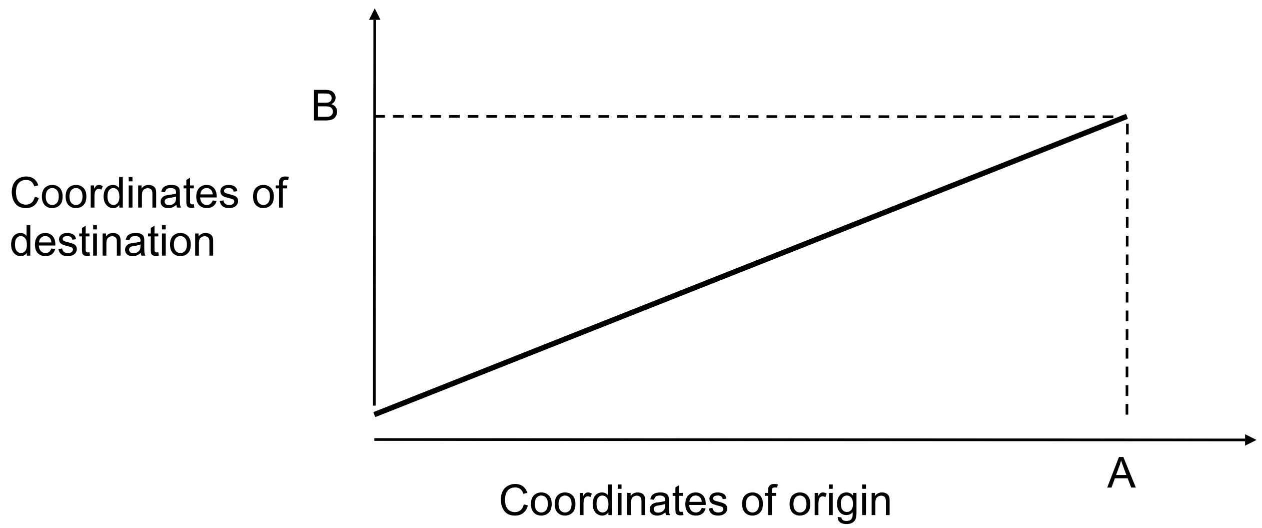
1-dimensional Fisheye

Normal scaling: Display an object of size A on a window of width B

The magnifier function is the first derivate of the transfer function

The transfer function is the integral of the magnifier function

Transfer function T(X)

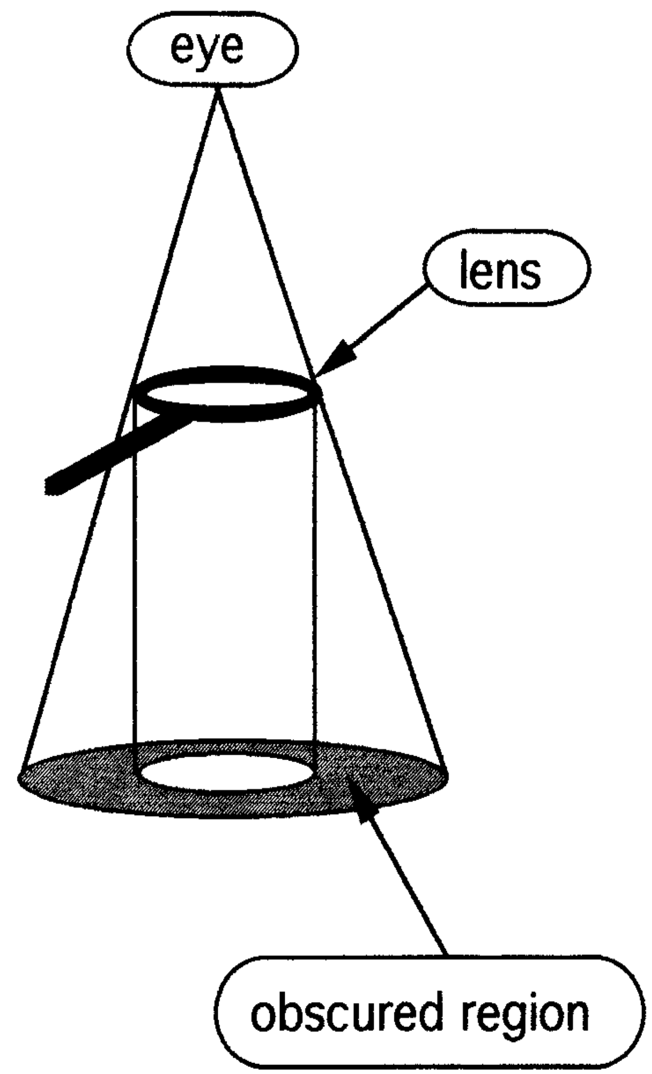


Magnifier function M(X)

1-dimensional Fisheye

The problem with the magnifier:

(G.G.Robertson, J:D.Mackinlay UIST 1993)

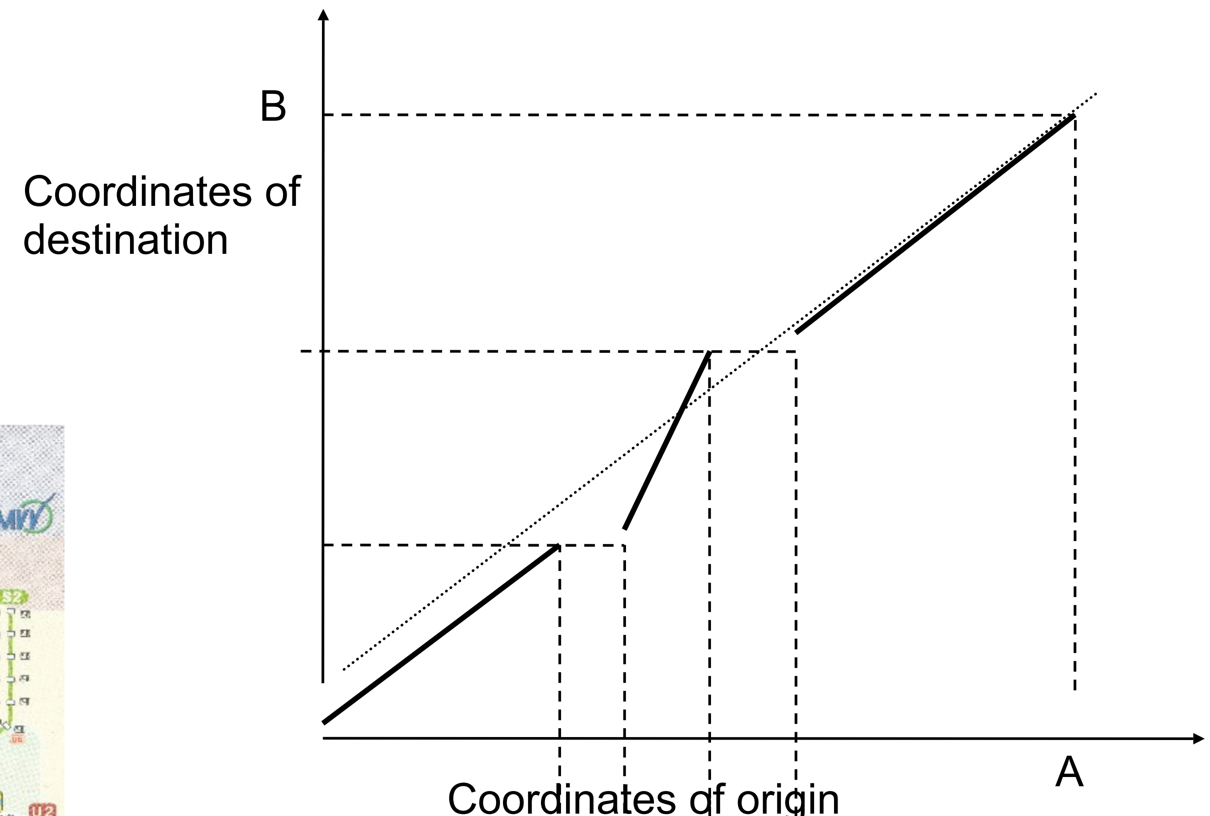


1-dimensional Fisheye

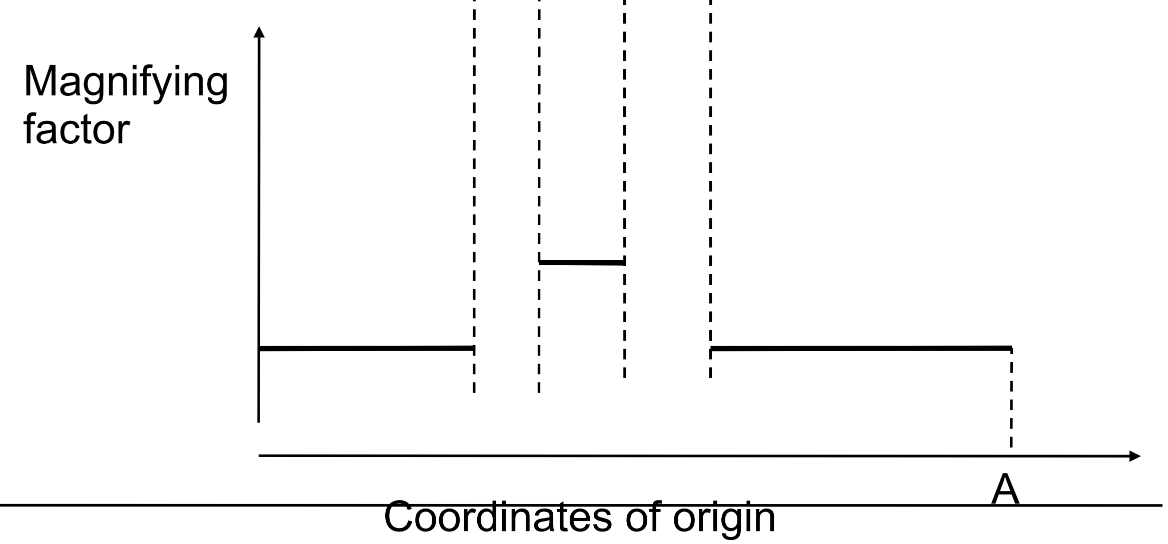
The problem with the magnifier:

Parts of the origin will not appear at the destination.
In the picture below the Central Station is visible, but not Marienplatz

Transfer function T(X)



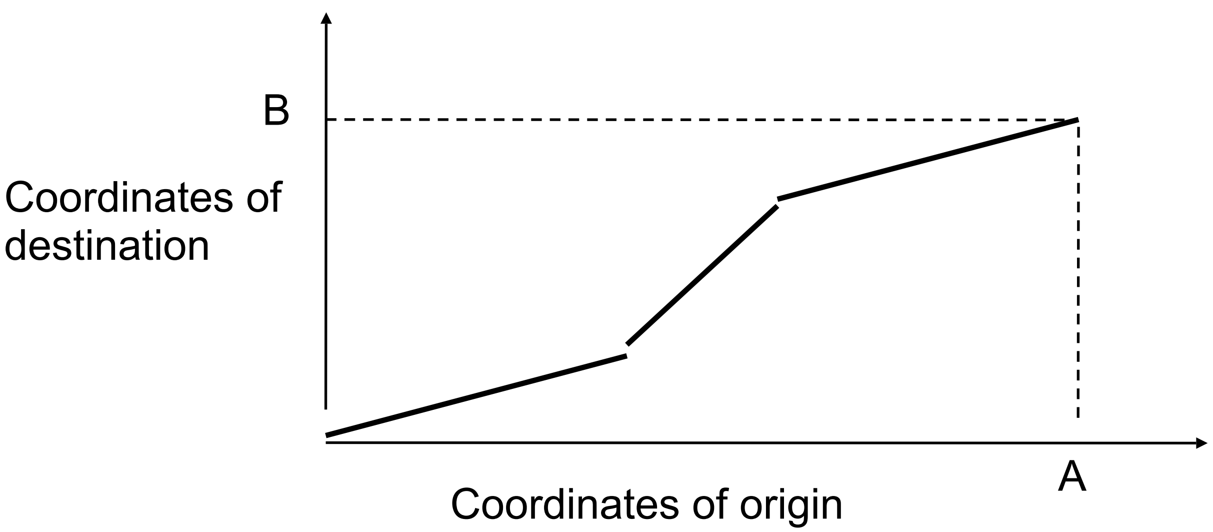
Magnifier function M(X)



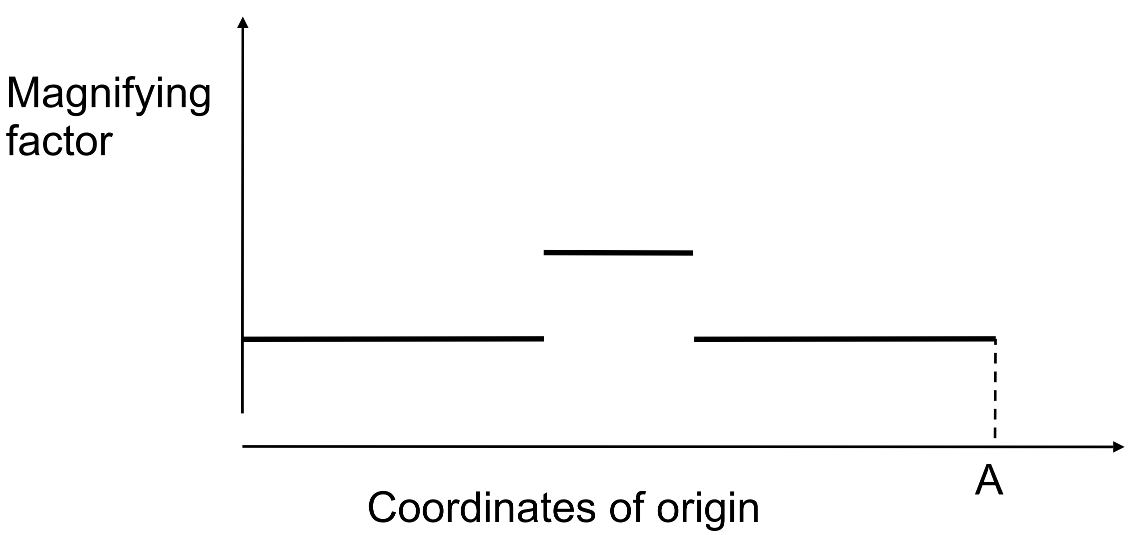
1-dimensional Fisheye

Bifocal:

Transfer function T(X)

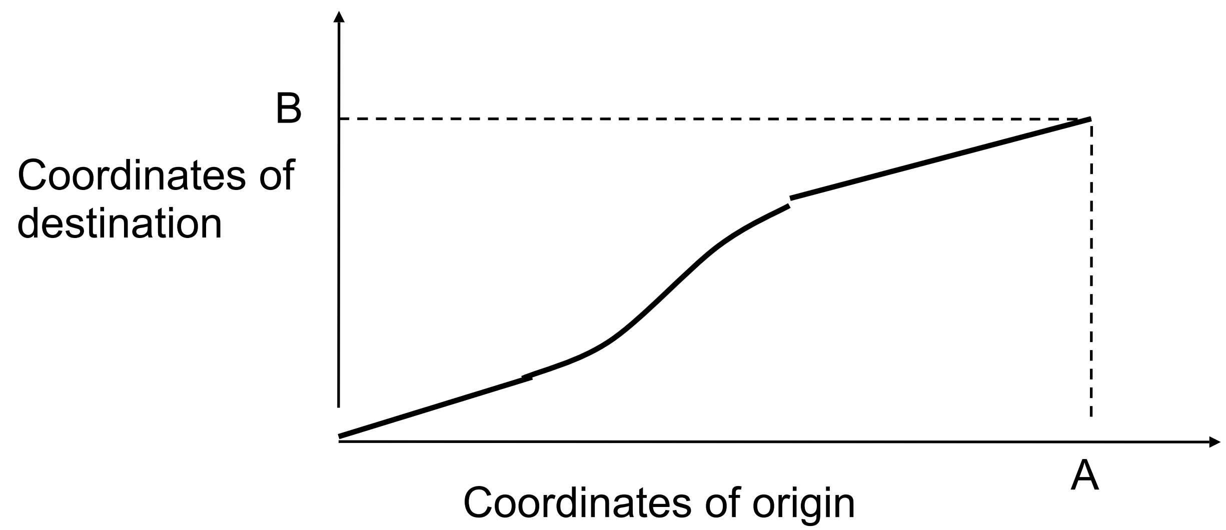


Magnifier function M(X)

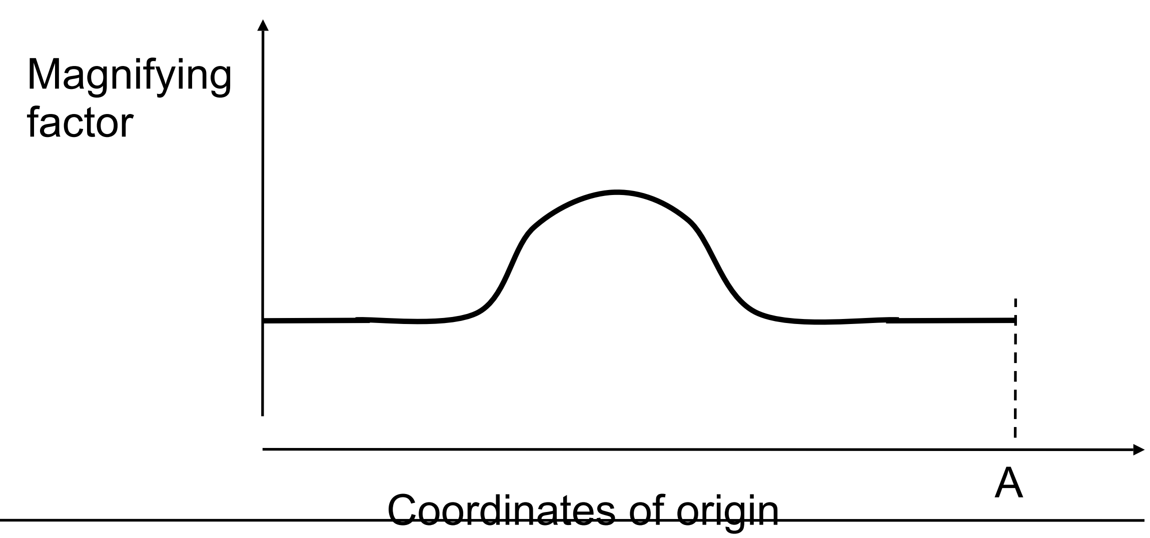


Continuous:

Transfer function T(X)



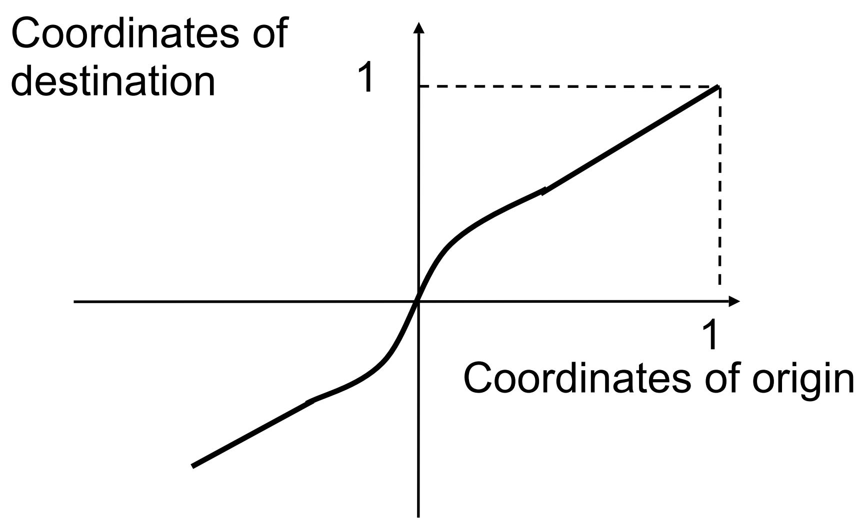
Magnifier function M(X)



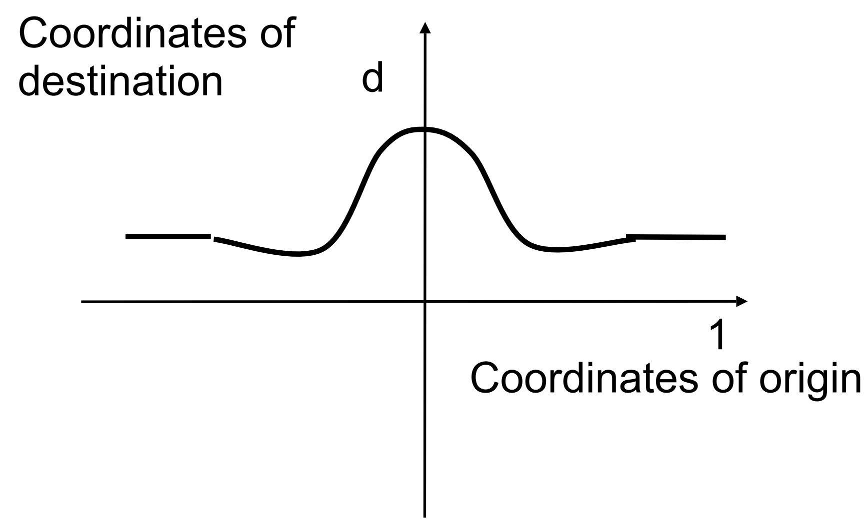
1-dimensional Fisheye

To have transfer function independent of window sizes and resolutions it is common to work with normalized coordinates, i.e. working with intervals from -1 to 1.

Transfer function T(x)



Magnifier function M(x)



$T(X) = (1 + d) * X / (d * X + 1)$

$M(X) = (d + 1) / (d * X +1)^2$

2-dimensional Fisheye

Applying transfer functions for x- and y-coordinates independently does not give a nice result.

2-dimensional Fisheye

The transfer function for X should depend on Y. For Y=0 in normalized coordinates the transfer function for x should be the 1-dimensional fish eye transfer function T(X). For y=1 it should be the undistorted transfer function T_u , normally $T_u(X) = X$.

This can be achieved by a weighting function W(Y) with values from 0 to 1. (“function morphing”)

$T(X, Y) = (1-W(Y)) * T(X) + W(Y) * T_u(X)$; $W(0) = 0$; $W(1) = 1$;

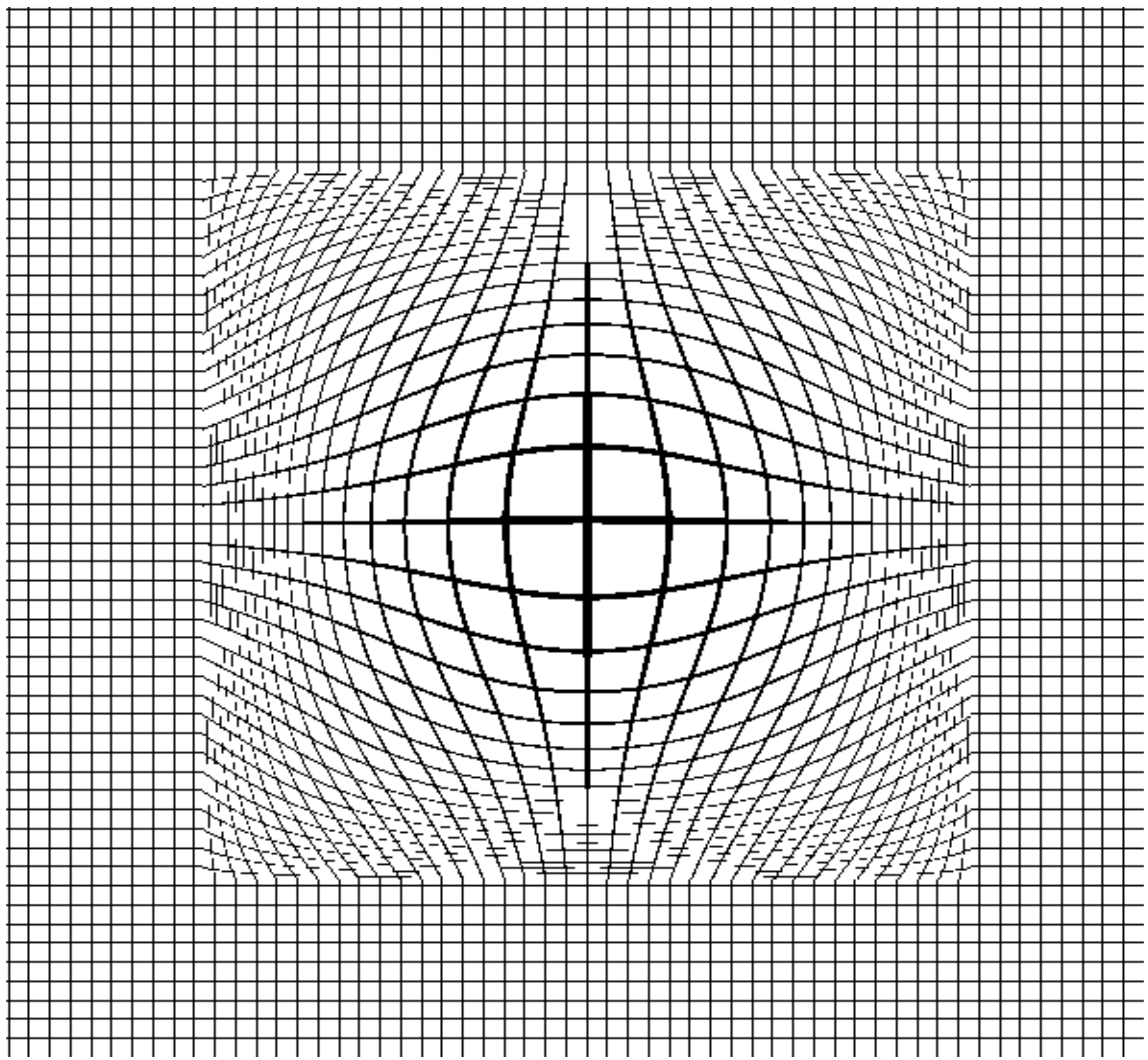
Examples:
$W(Y) = Y$
$W(Y) = Y^2$

2-dimensional Fisheye

Continuous transfer function

using Cartesian coordinates

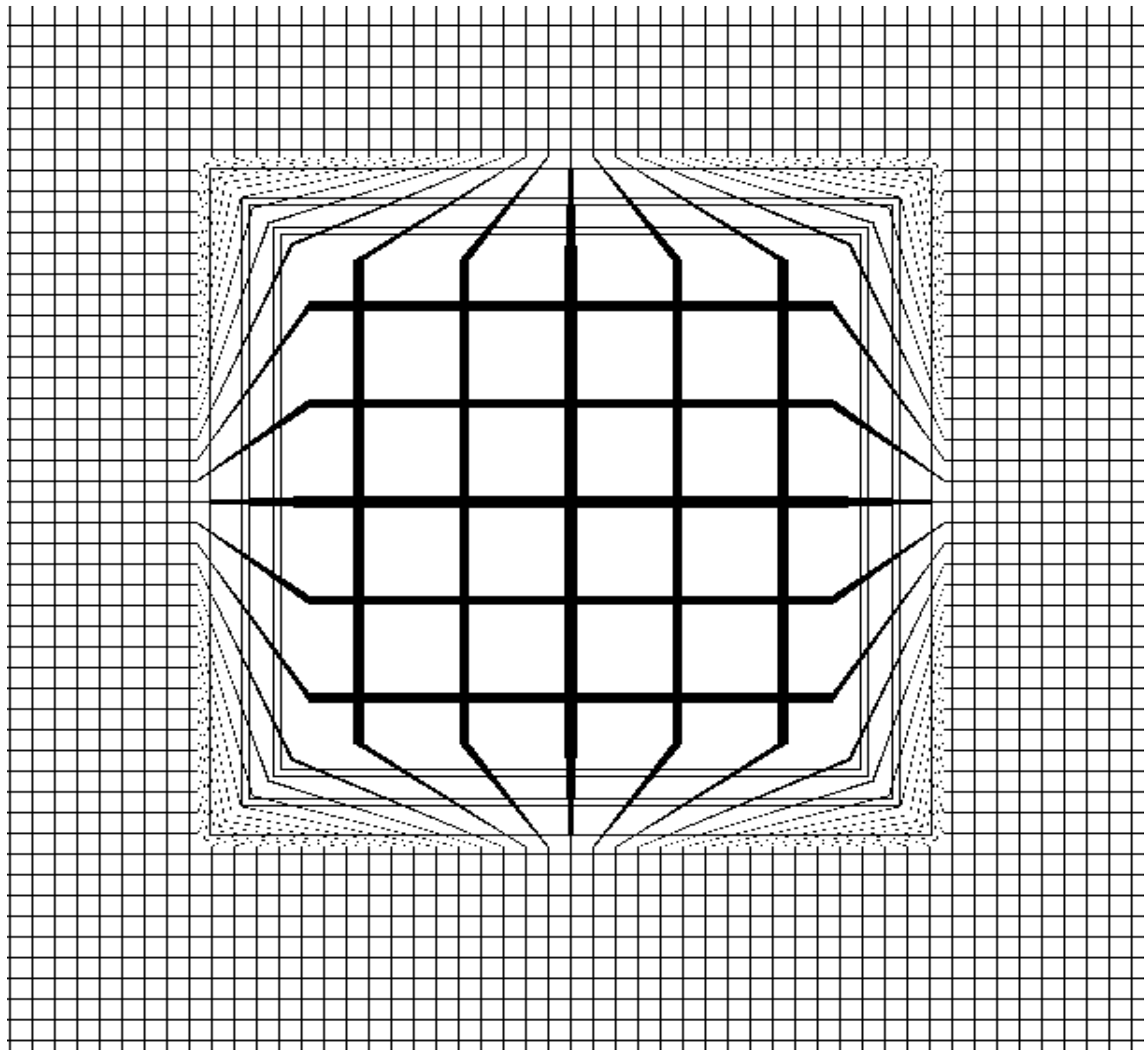
The visualization of the fisheye visualization



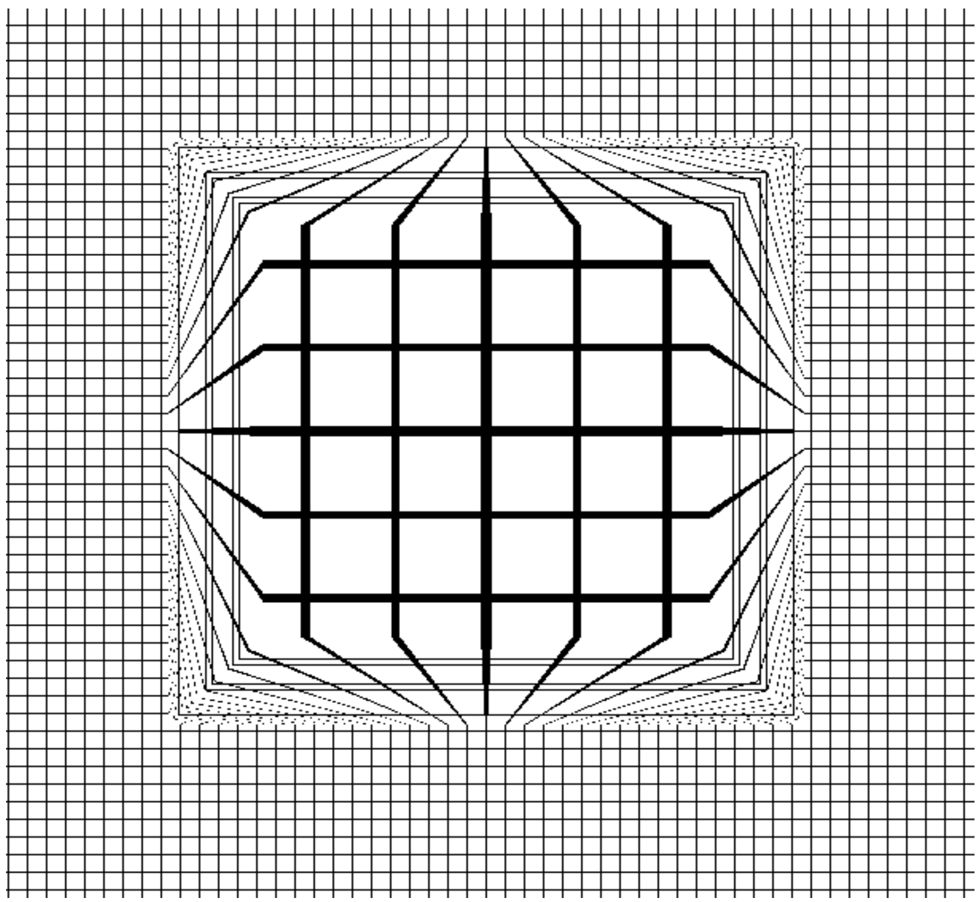
2-dimensional Fisheye

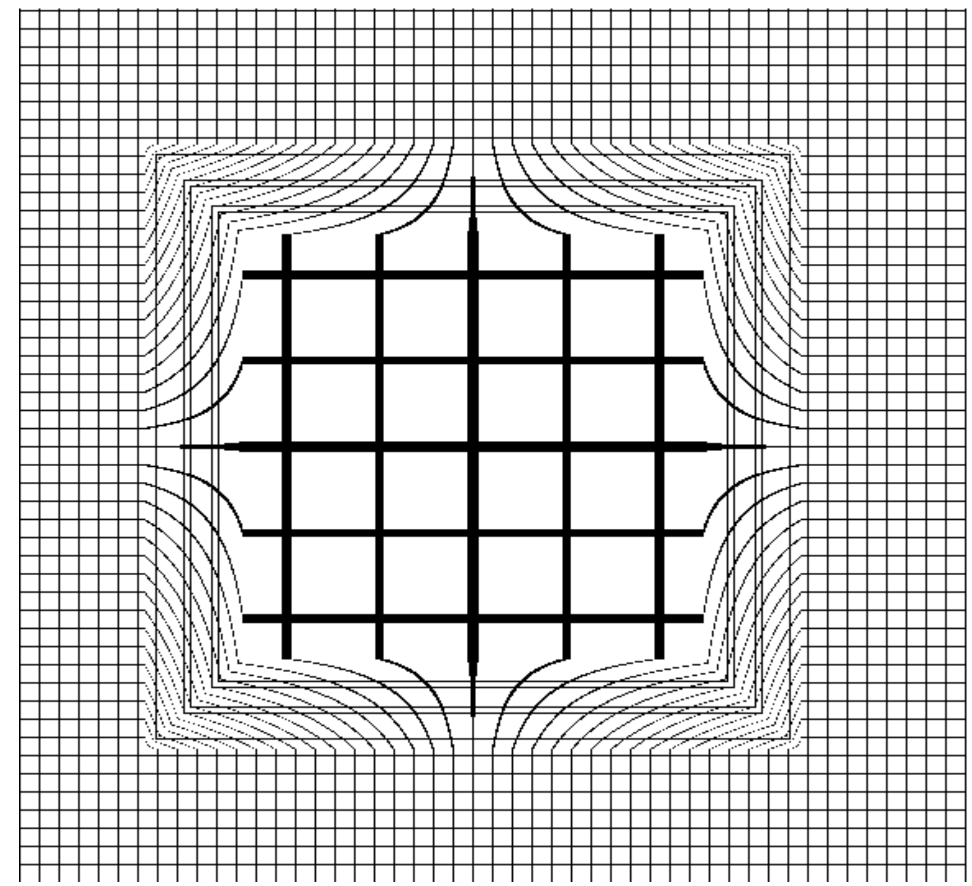
Bifocal
transfer
function

using
Cartesian
coordinates



2-dimensional Fisheye





What is the difference?

2-dimensional Fisheye

Using polar coordinates

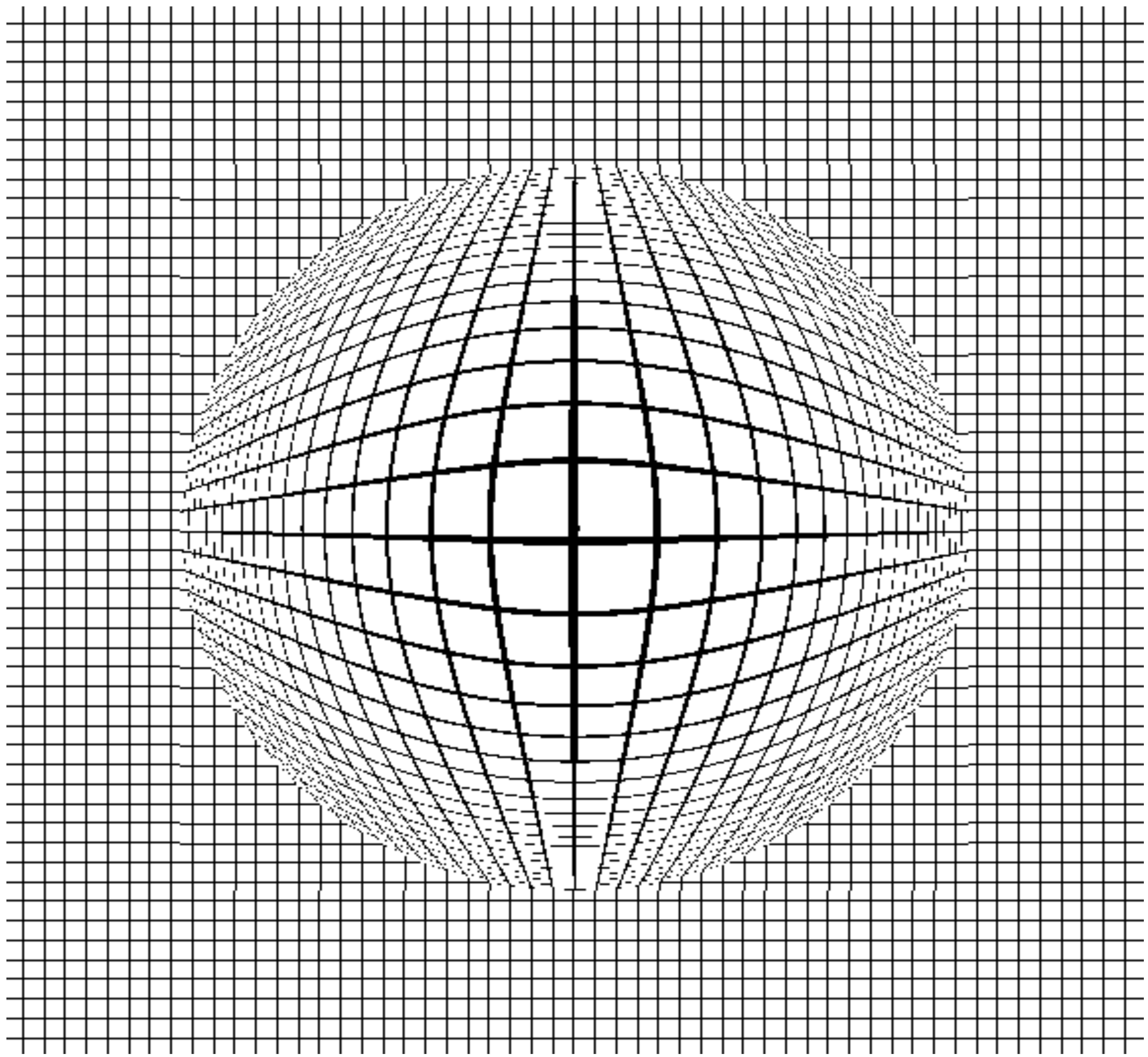
Because a fish eye should not twist the picture, the transfer function does not depend on the angular coordinate. So the transfer function for the 1-dim. case can be used for the radial coordinate.

$$T(r, \varphi) = (T_{1dim}(r), \varphi)$$

2-dimensional Fisheye

Continuous transfer function

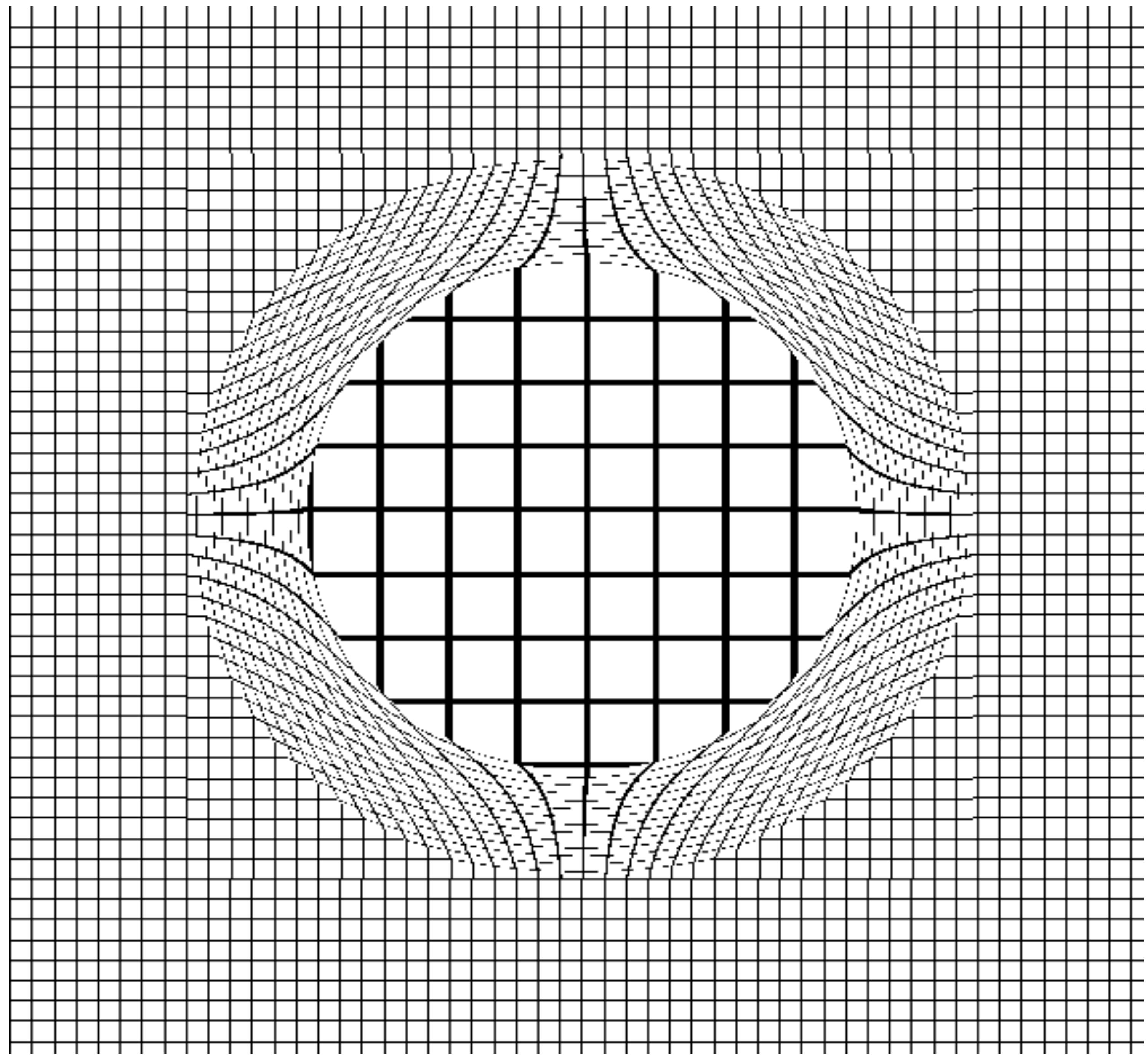
using polar coordinates



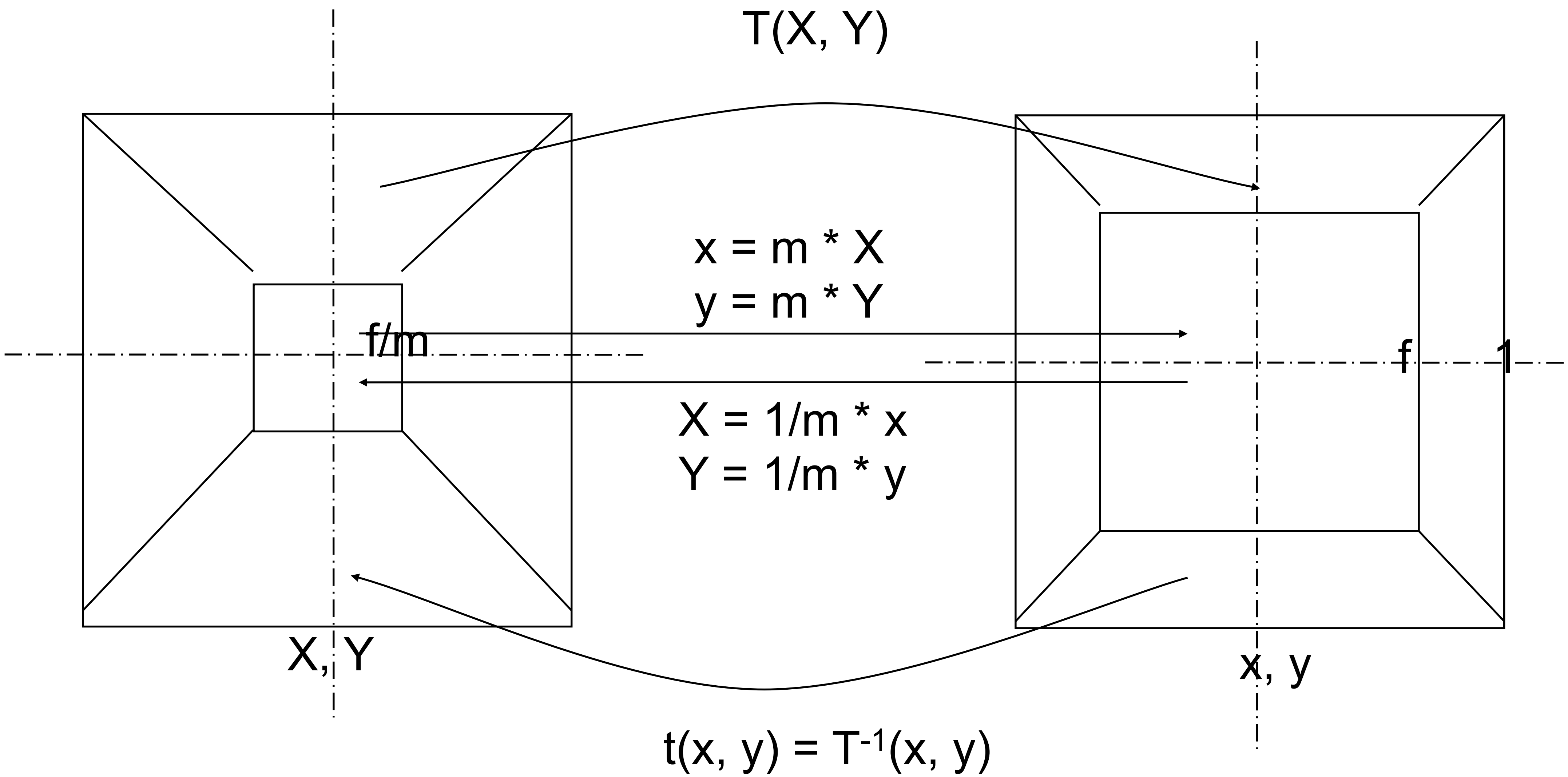
2-dimensional Fisheye

Bifocal transfer function

using polar coordinates



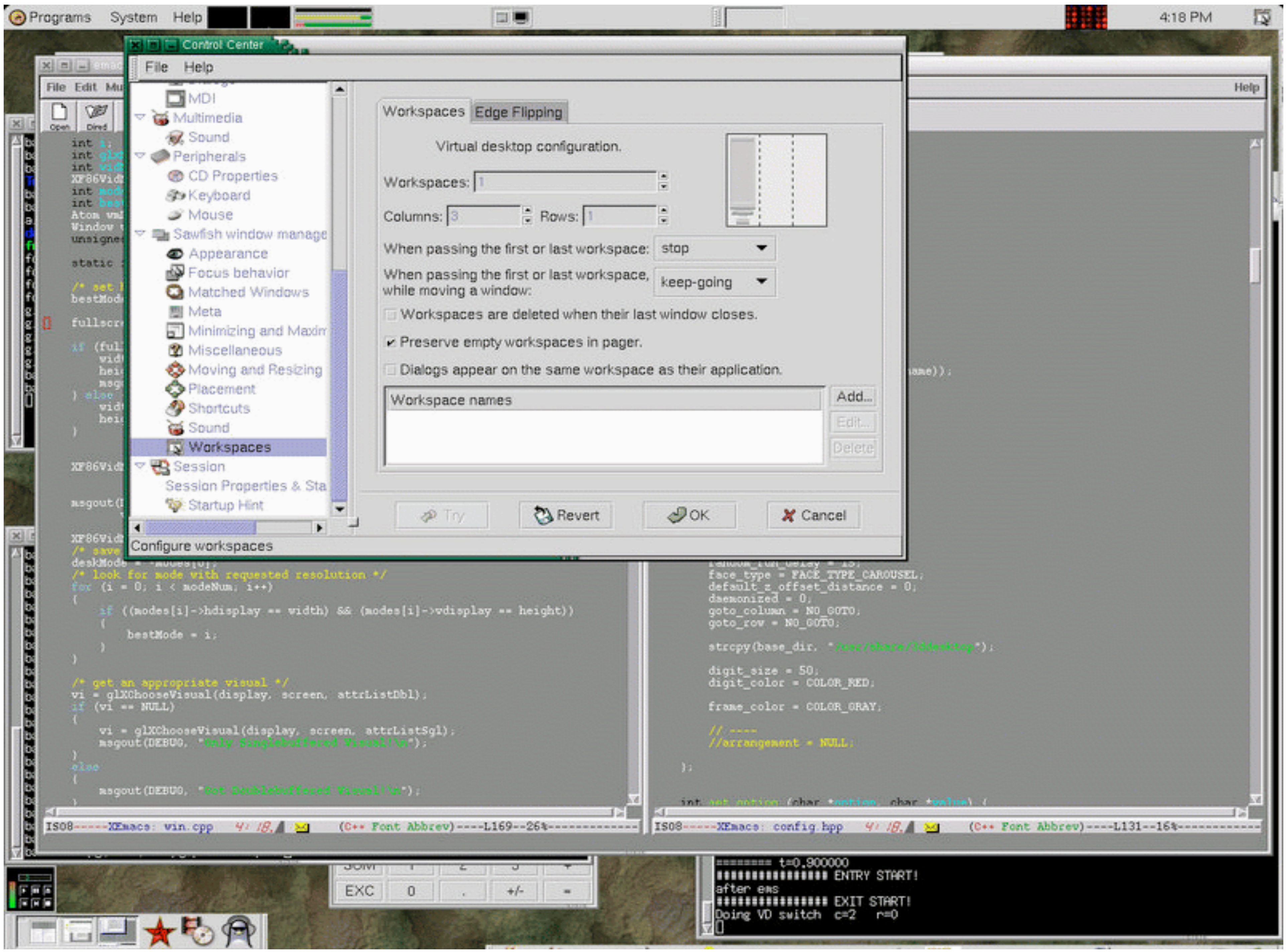
2-dimensional Fisheye



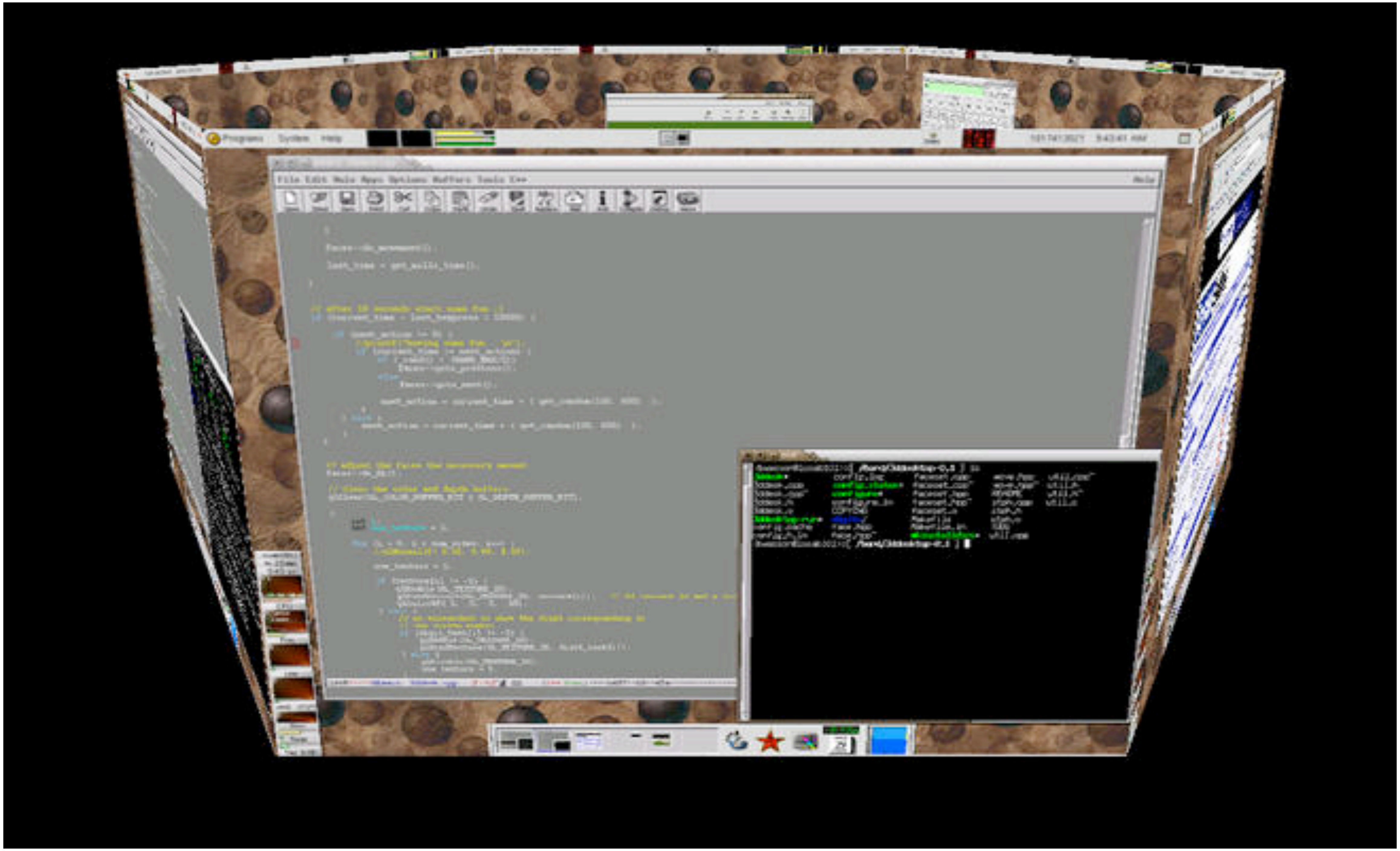
Hints for Programming

- For bitmaps iterate over the pixel of the destination bitmap using the inverse transfer function $(X,Y) = T^{-1}(x, y)$
  - No pixels are left out
  - The number of pixel are less
- The multiplication of integers and floats may have unexpected results!

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

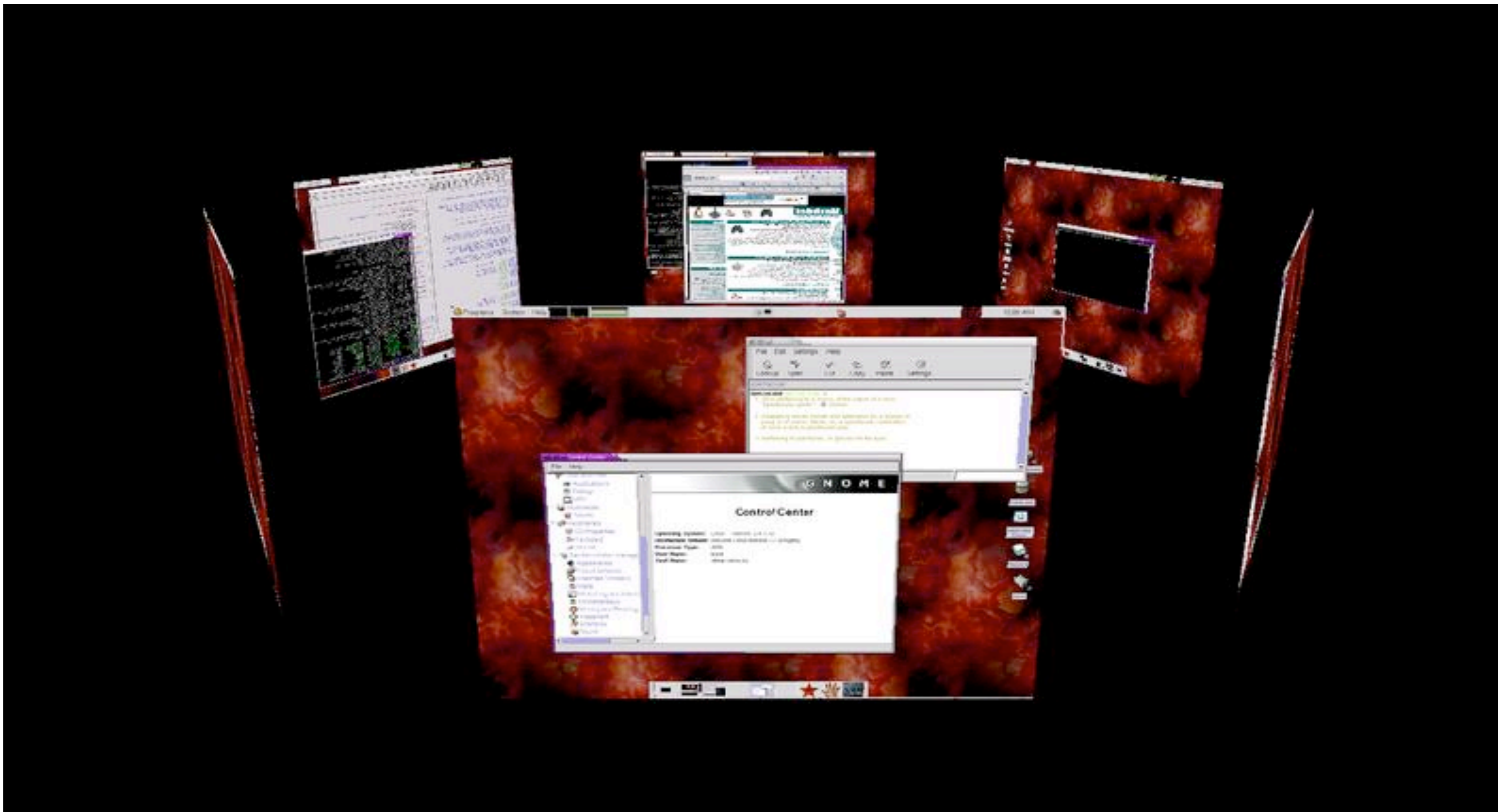


3D Desktop - http://desk3d.sourceforge.net/
switching virtual desktops in 3D



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

switching virtual desktops in 3D



Sun: Project Looking Glass functional 3D-Desktop

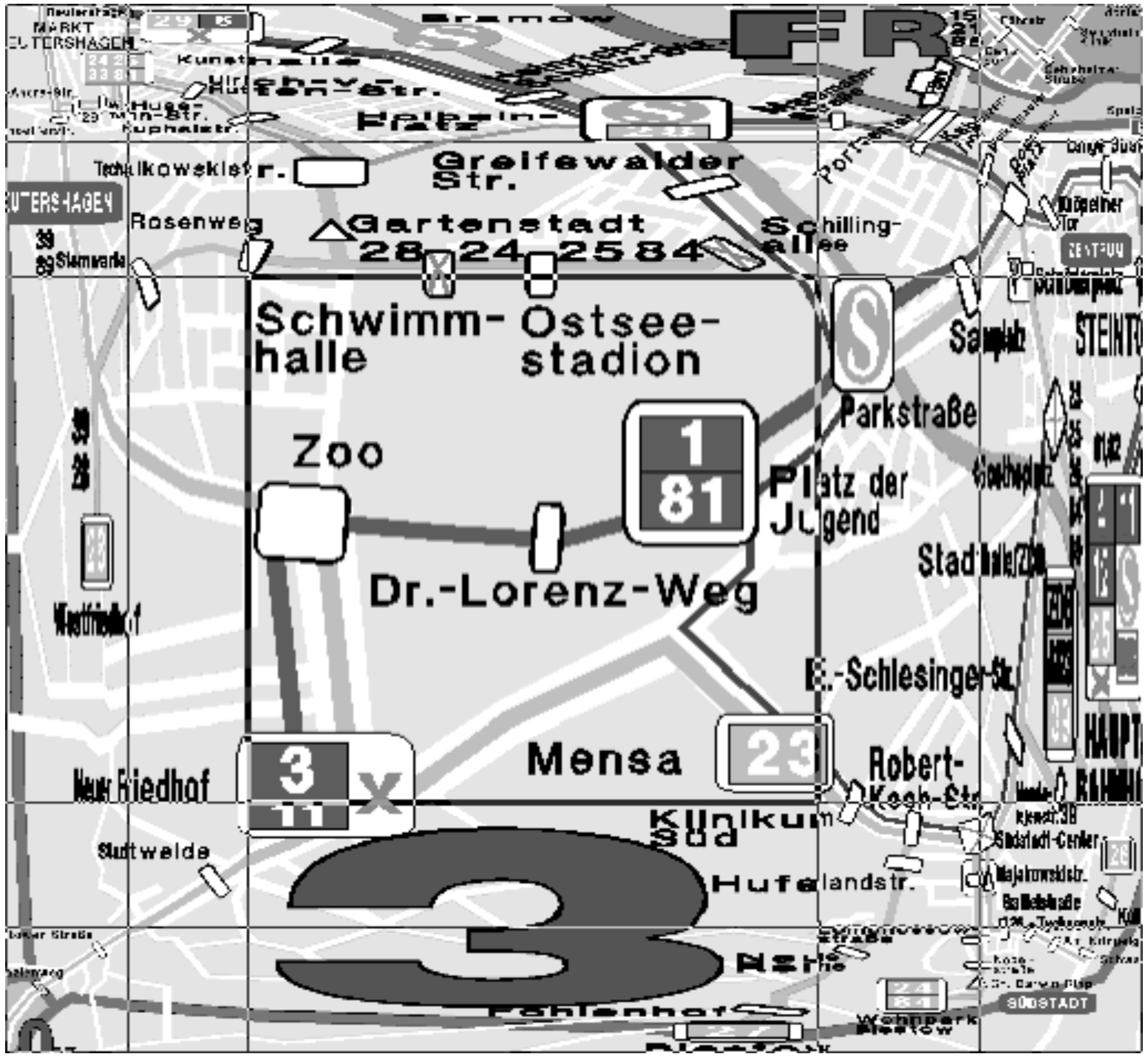
Video ~ 6min

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

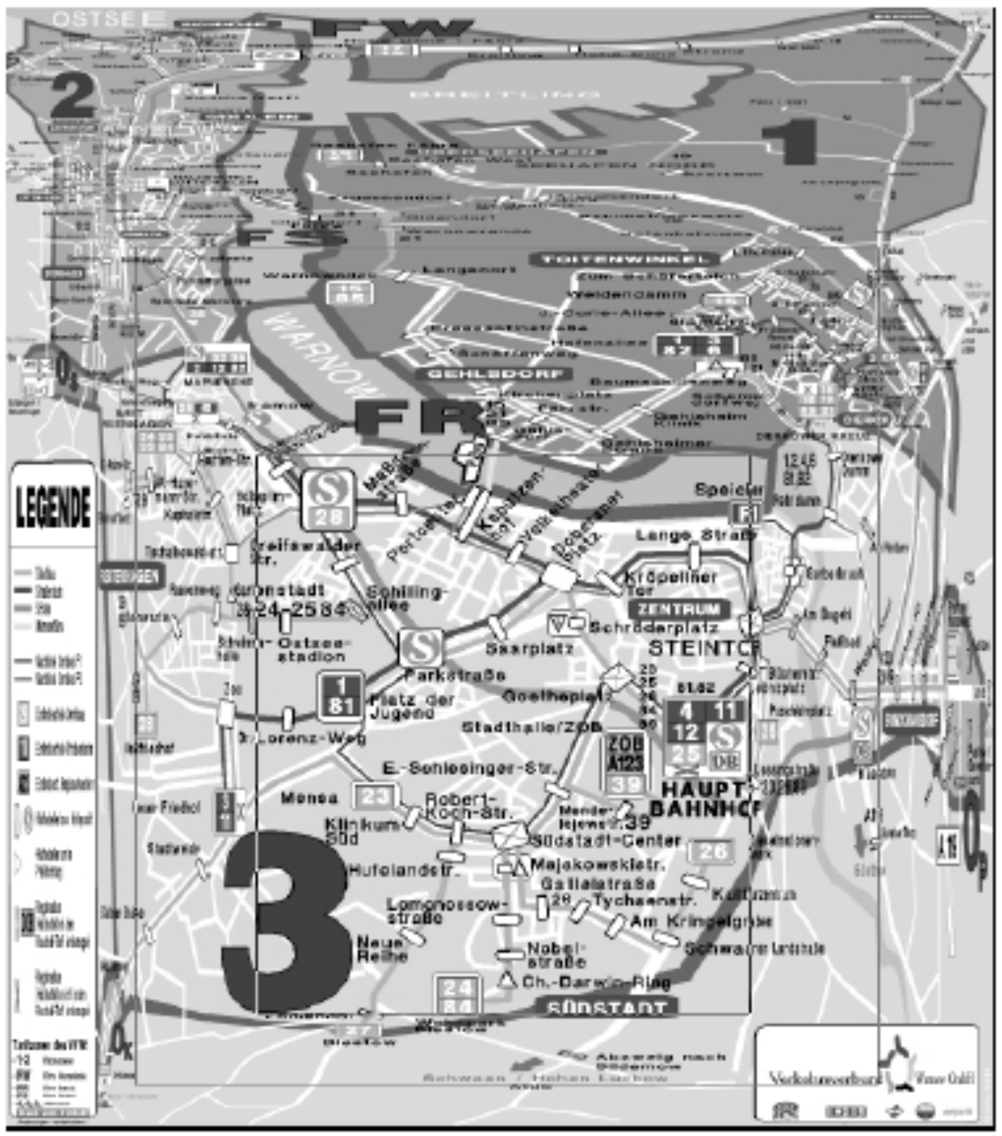


Figure 3: Rectangular fish eye view example

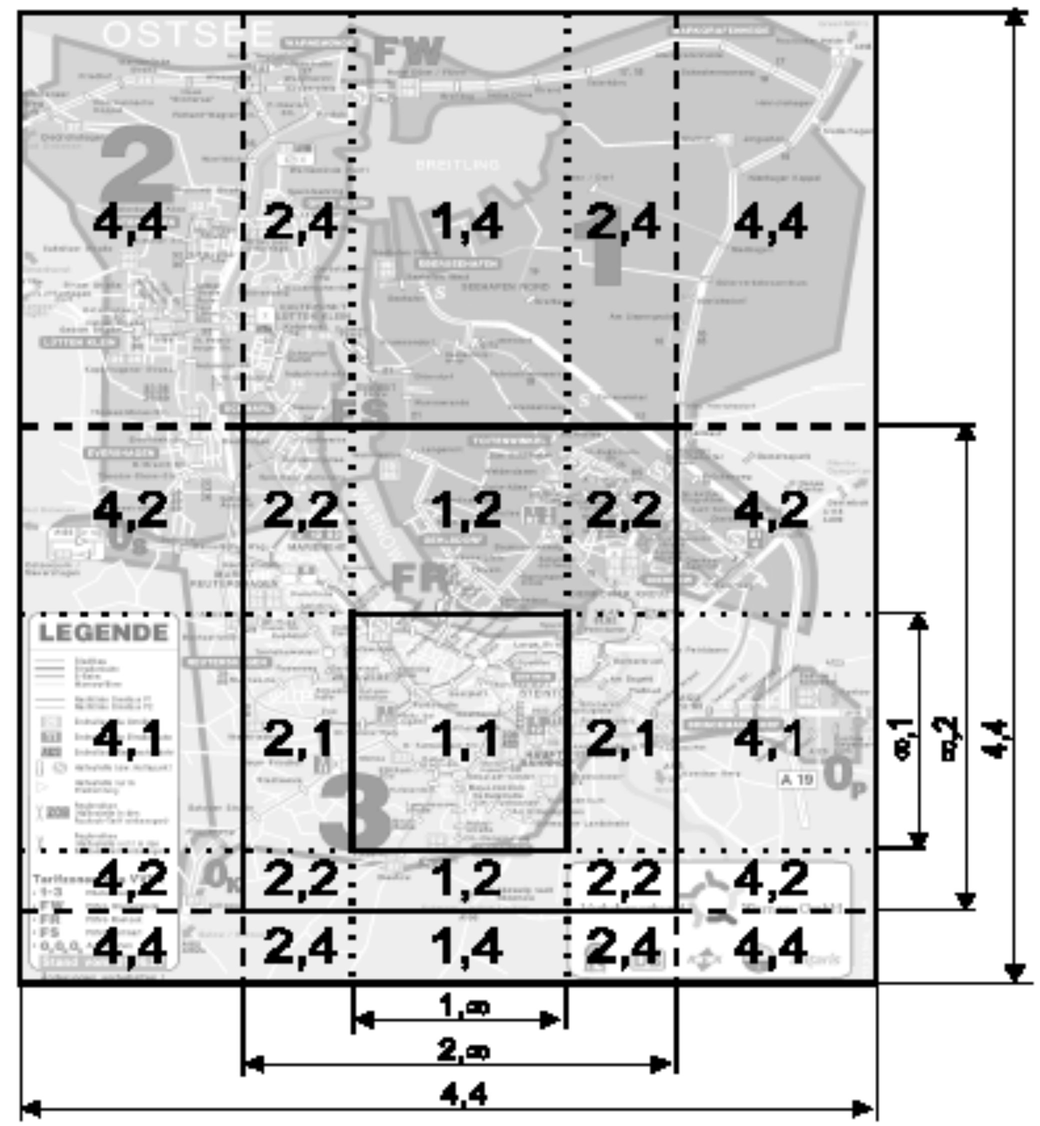


Figure 4: Generating RoI grid

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

Providing context for map navigation