

# 3 Information Visualization

3.1 Motivation and Examples

3.2 Basics of Human Perception

3.3 Principles and Terminology

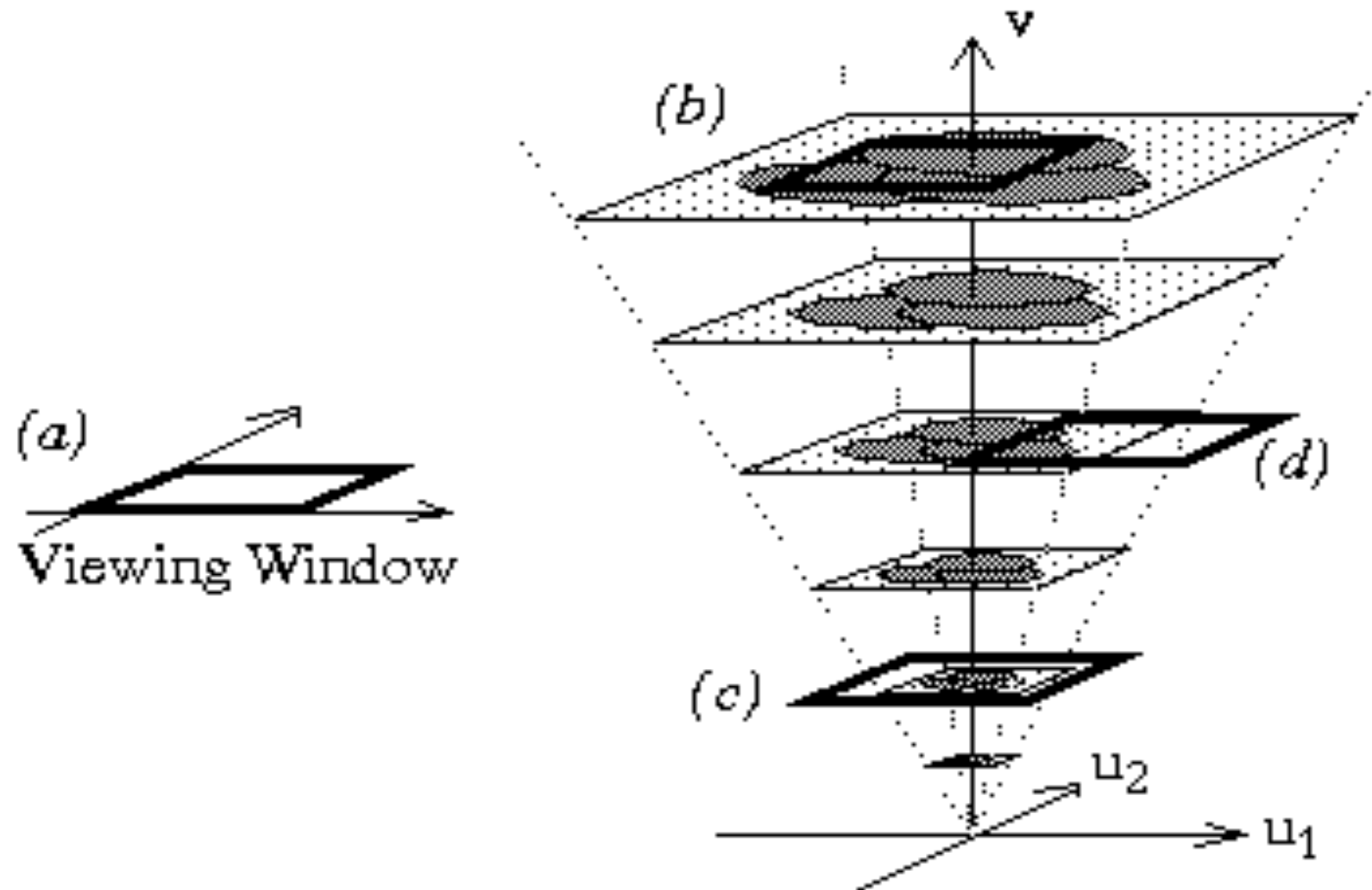
3.4 Standard Techniques for Visualization

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

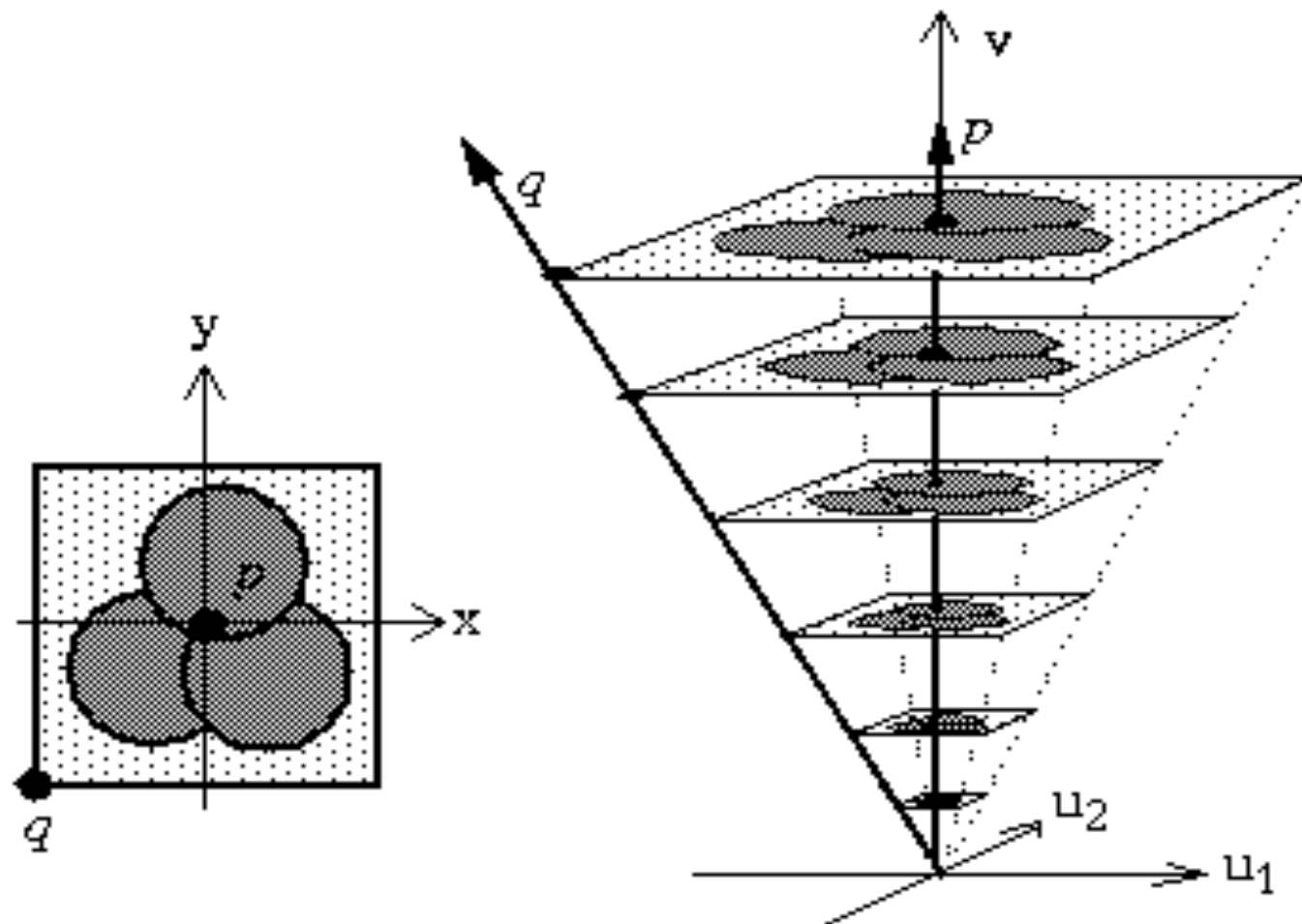


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# Space-Scale Diagrams

(Furnas & Bederson 95)

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

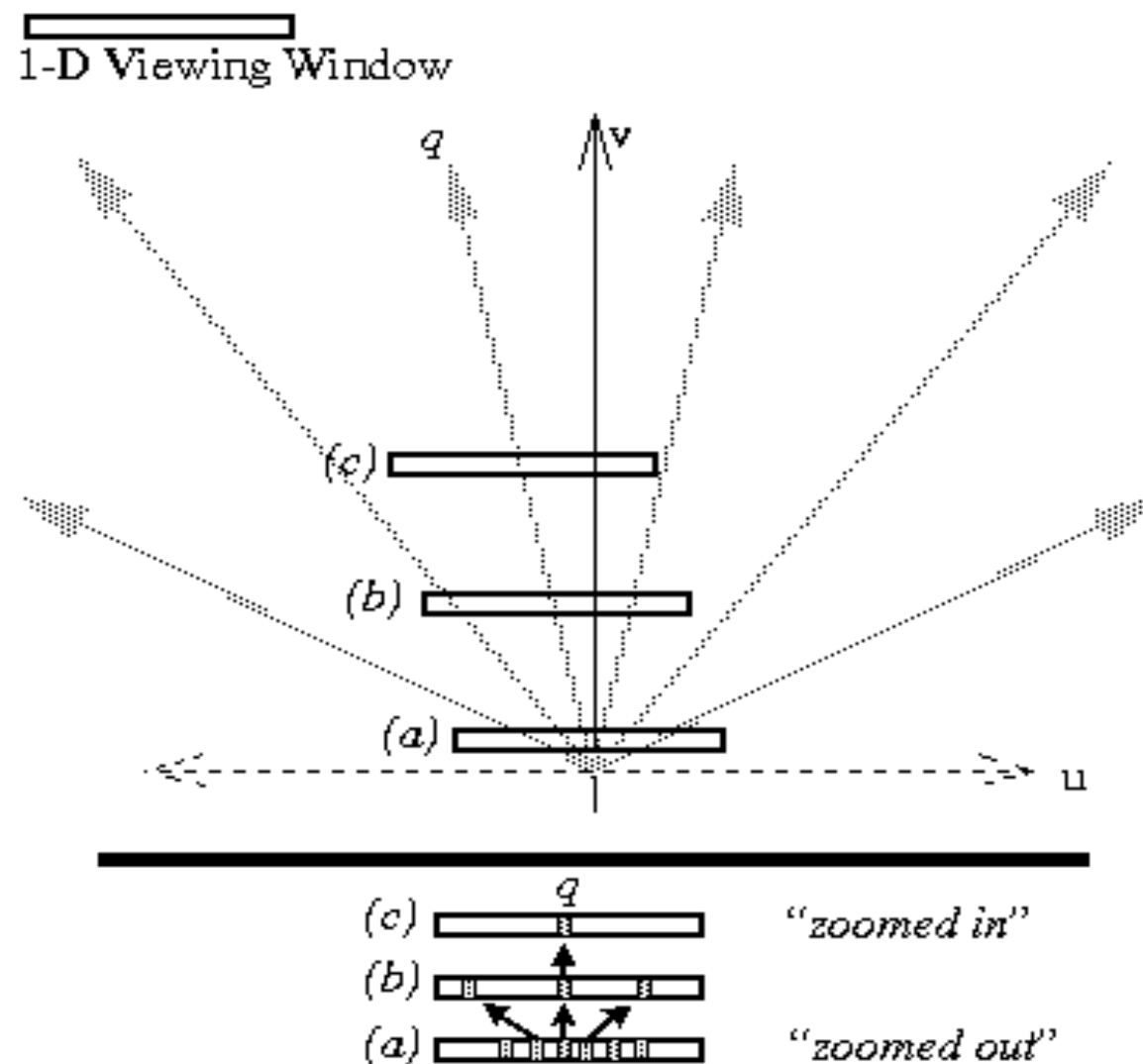


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# Space-Scale Diagrams

(Furnas & Bederson 95)

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

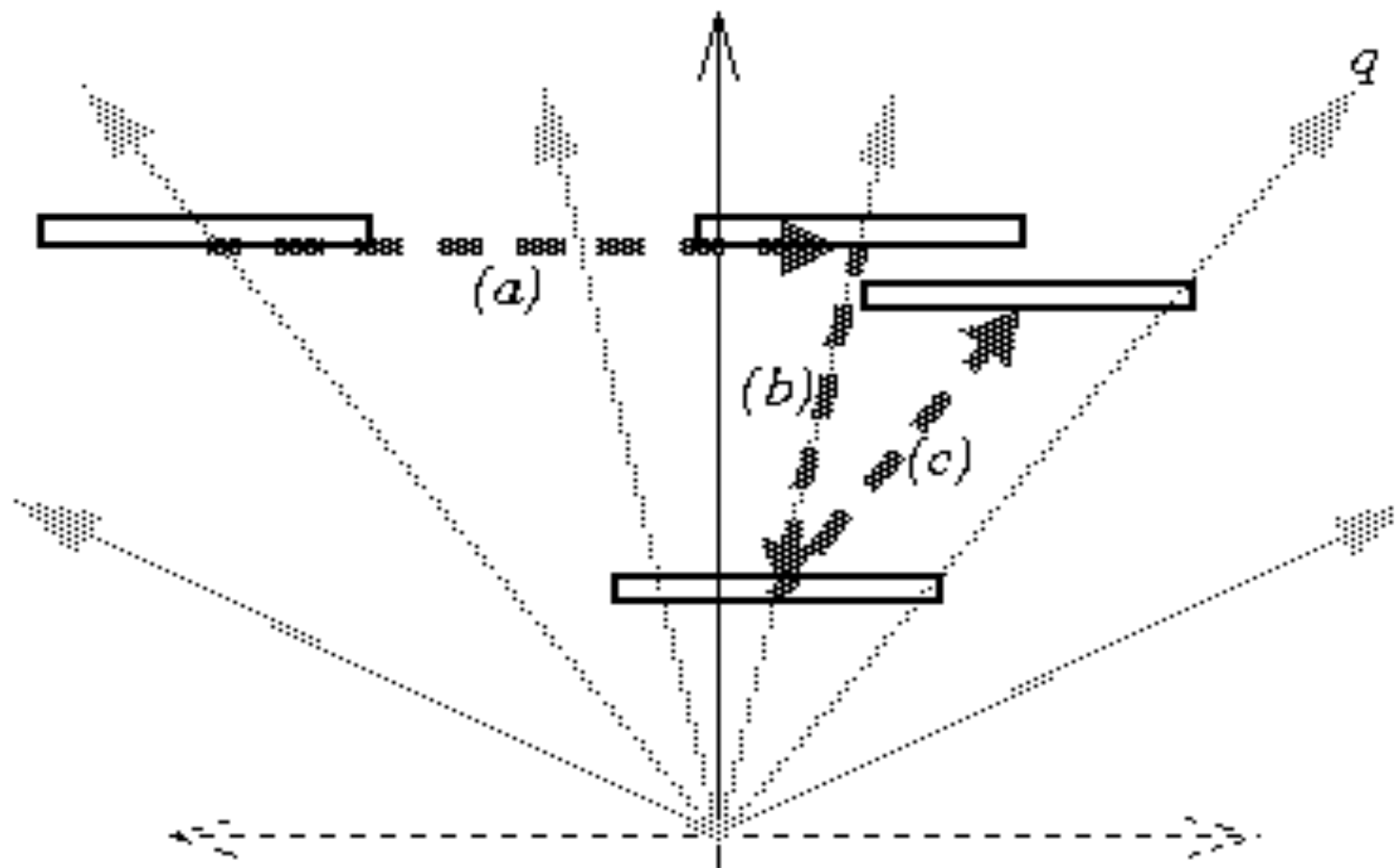


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# Space-Scale Diagrams (Furnas & Bederson 95)

- 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.

# Semantic Zoom in MedioVis

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

MedioVis 0.70m (Jean-Luc) - demonstrating visual search on IMDb.com example data

animation Find animation 9 hits

Help? MedioVis

Results Basket

Film Content People Involved Year

enter keywords to refine>

**Title:** Kaze no tani no Naushika  
**Tagline:** -  
**Alternative Titles:** Kaze no tani no Naushika; Naushika; Naushika of the Valley of the Winds; Warriors of the ...  
**Length:** 116  
**Year:** 1984  
**Country:** Japan

**Genre:** Animation; Drama; Sci-Fi; Fantasy  
**Rating:** 7.9  
**Plot:** In the far future, man has destroyed the Earth in the "Seven Days of Fire". Now, there are small pockets o...  
**User Comment:** Now t... great talent and he f...  
**Trivia:** Banned from Ea... boycotted in German...  
**Recommendations:** K... shiro Rapyuta, The M... kamikakushi, The Fift...

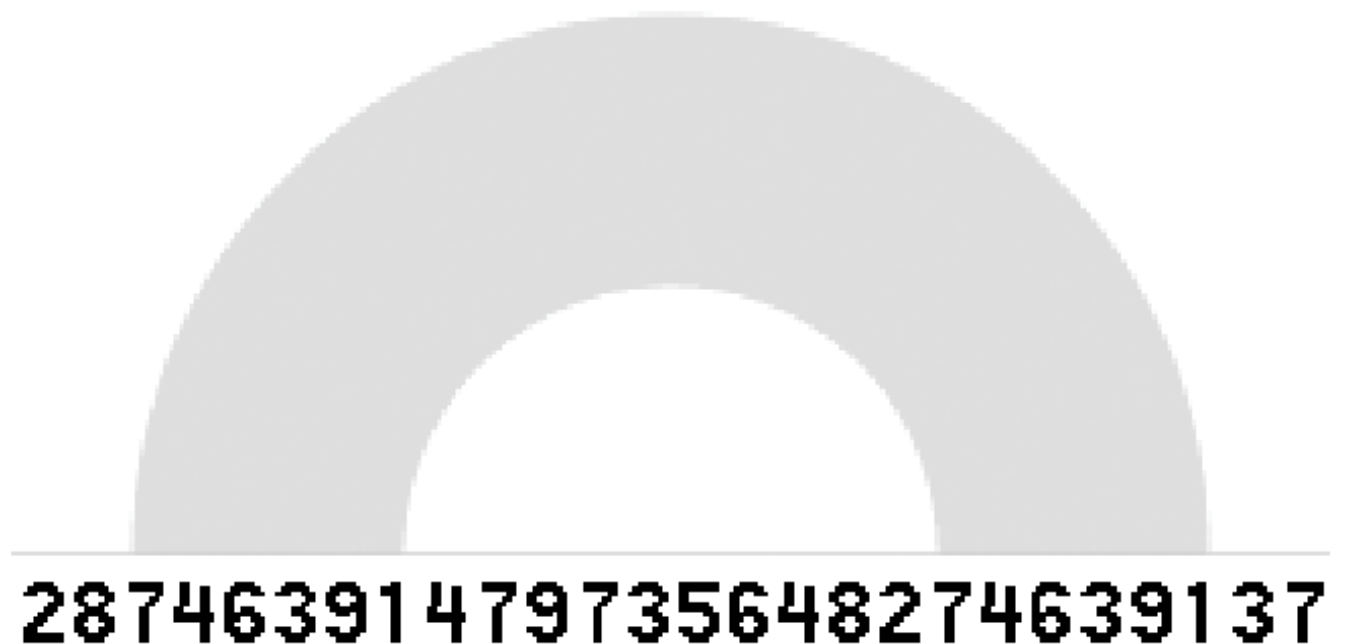
**Hayao Miyazaki**  
**Place of Birth:** Tokyo, Japan

1984

1 2 3 4

# Arc Diagrams

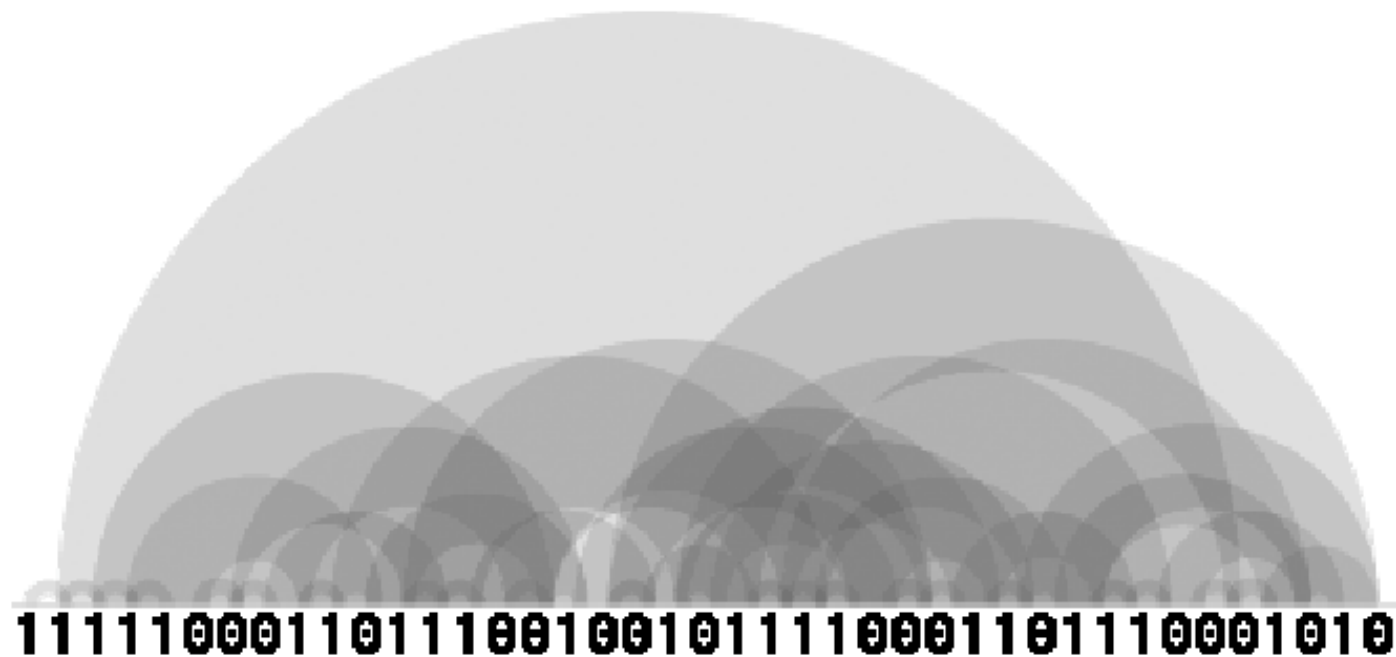
- Visualization method for representing complex patterns of repetition in string data.
  - Arc diagrams scale efficiently for strings that contain many instances of the same subsequence.
  - idea of visualizing only a subset of all possible pairs of matching substrings.
  - highlight just the subsequences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



# Arc Diagrams - Basics

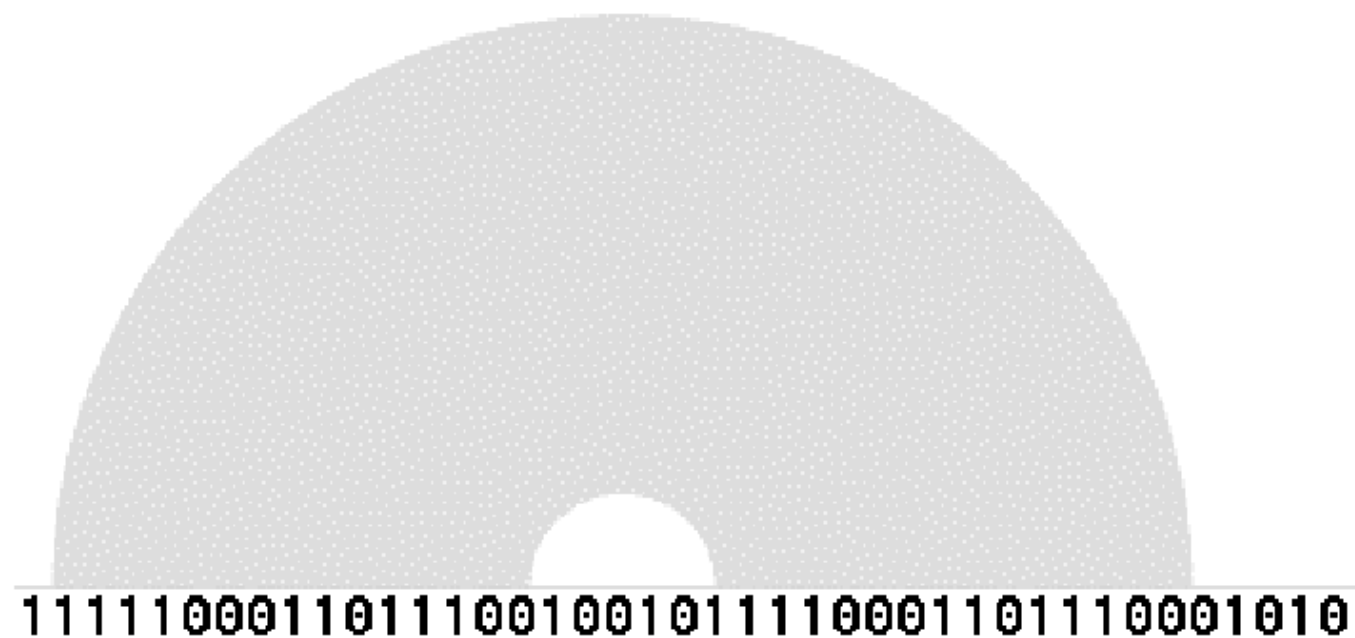


# Arc Diagram – Level of Detail

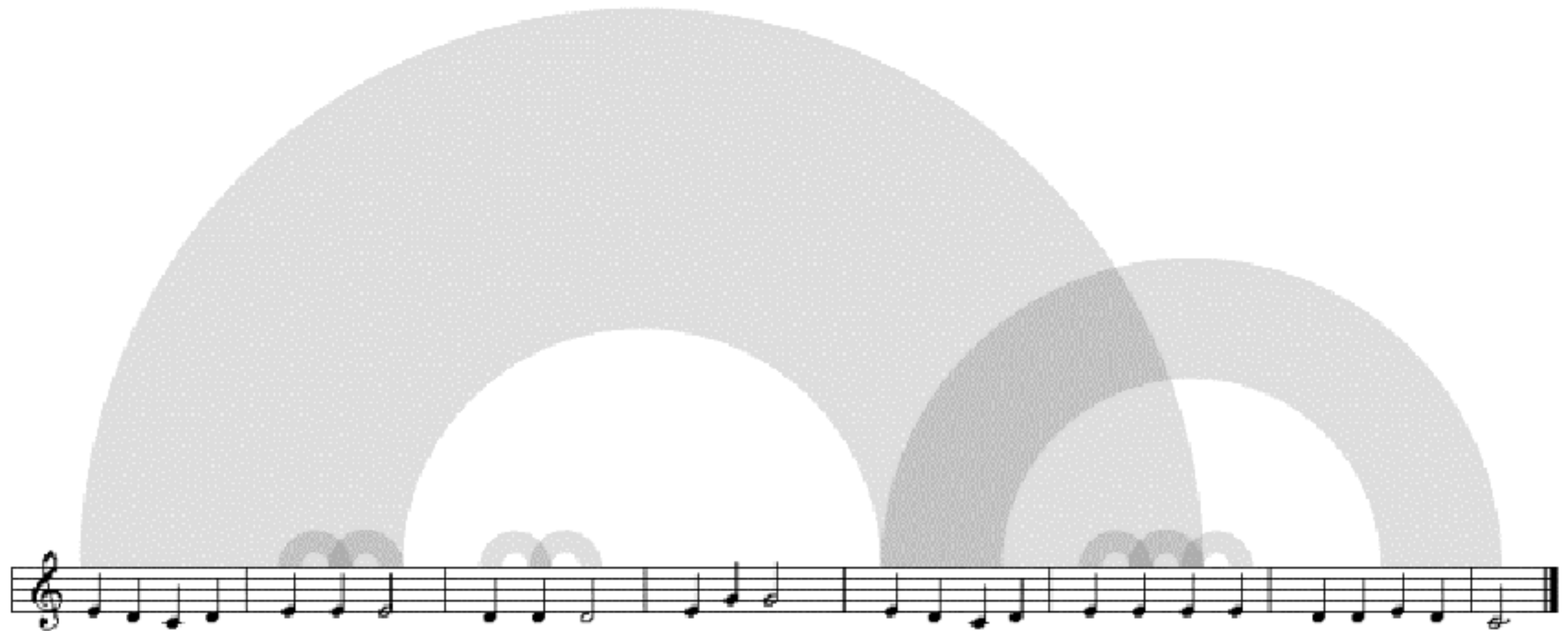


Applied to

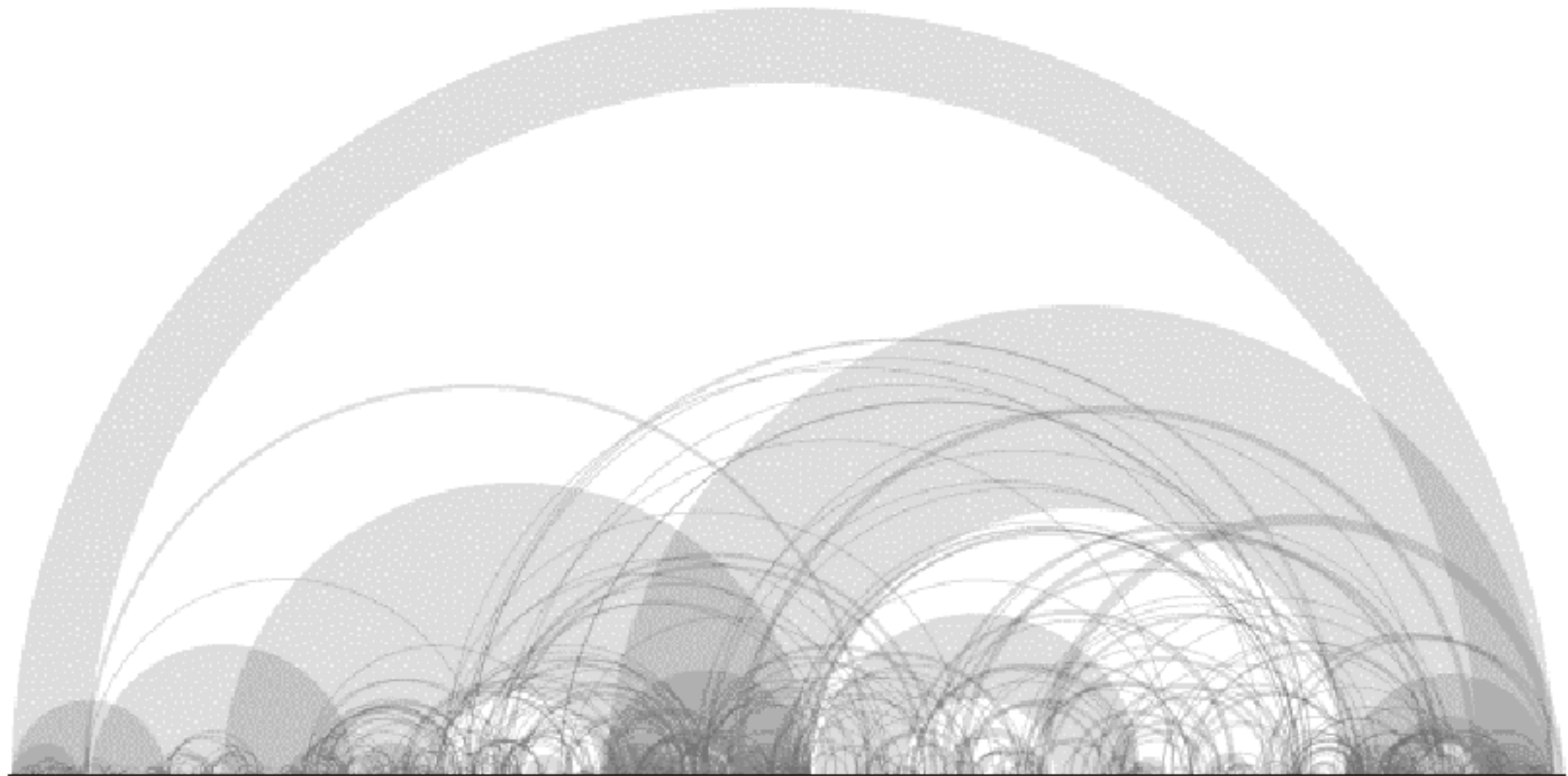
- Music
- DNA
- Web pages
- Byte code



# 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



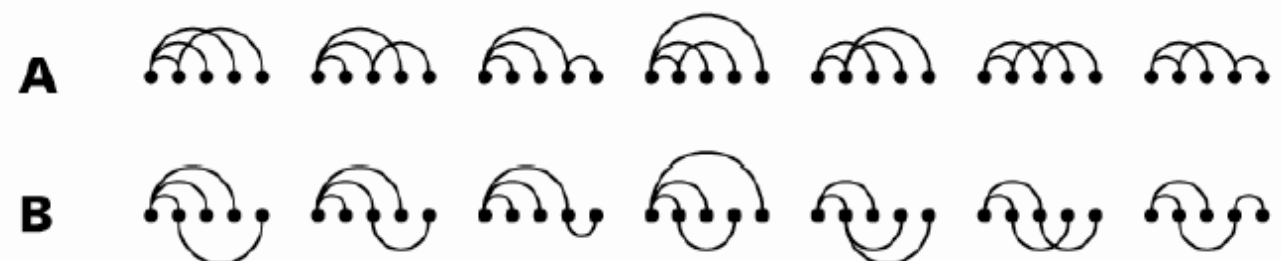
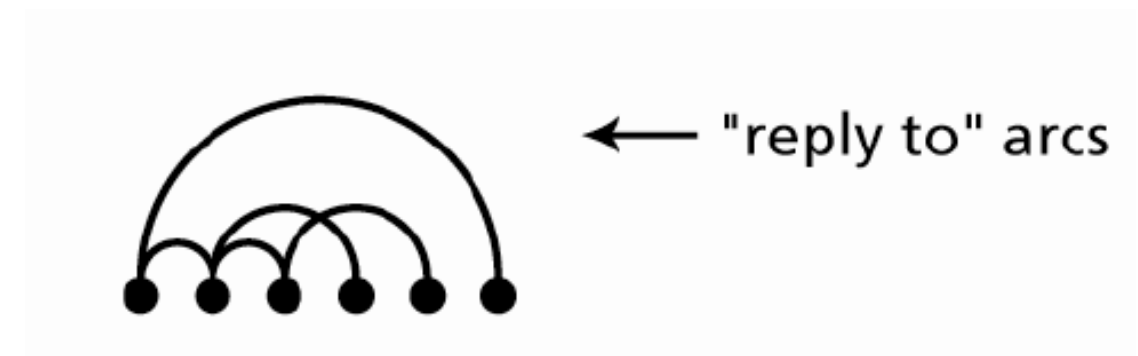
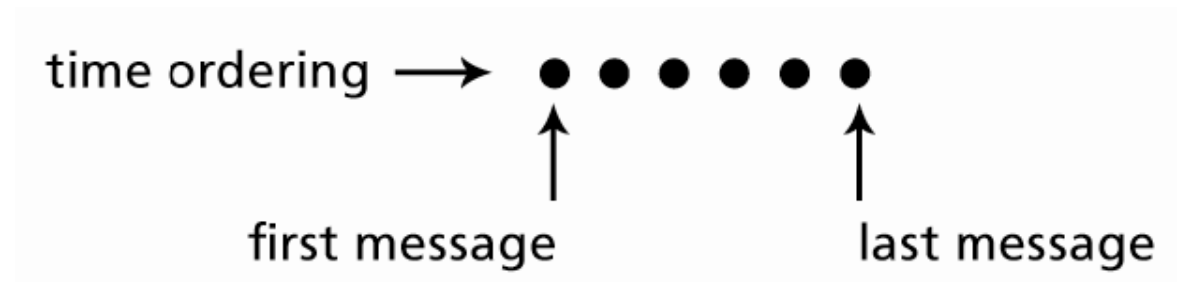
Bernard Kerr, 2003

<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).

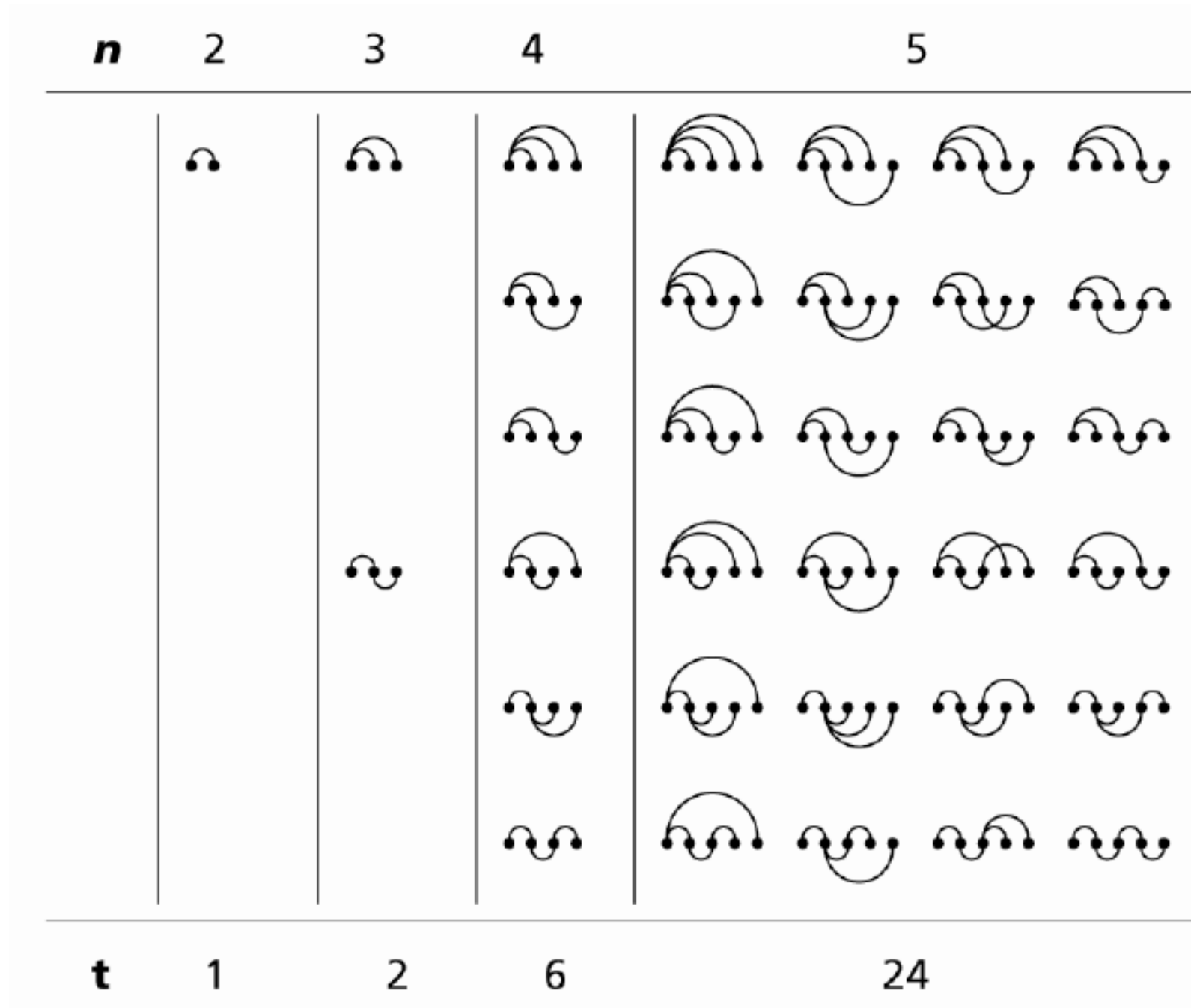
# Pseudo code for drawing a thread arc

## To make a Thread Arc

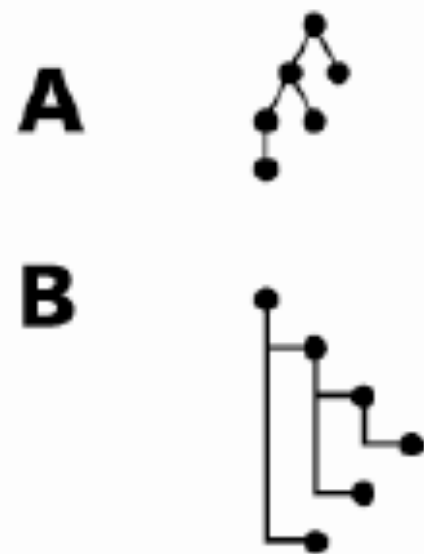
```
sort all messages chronologically
find the generation depth of each message

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



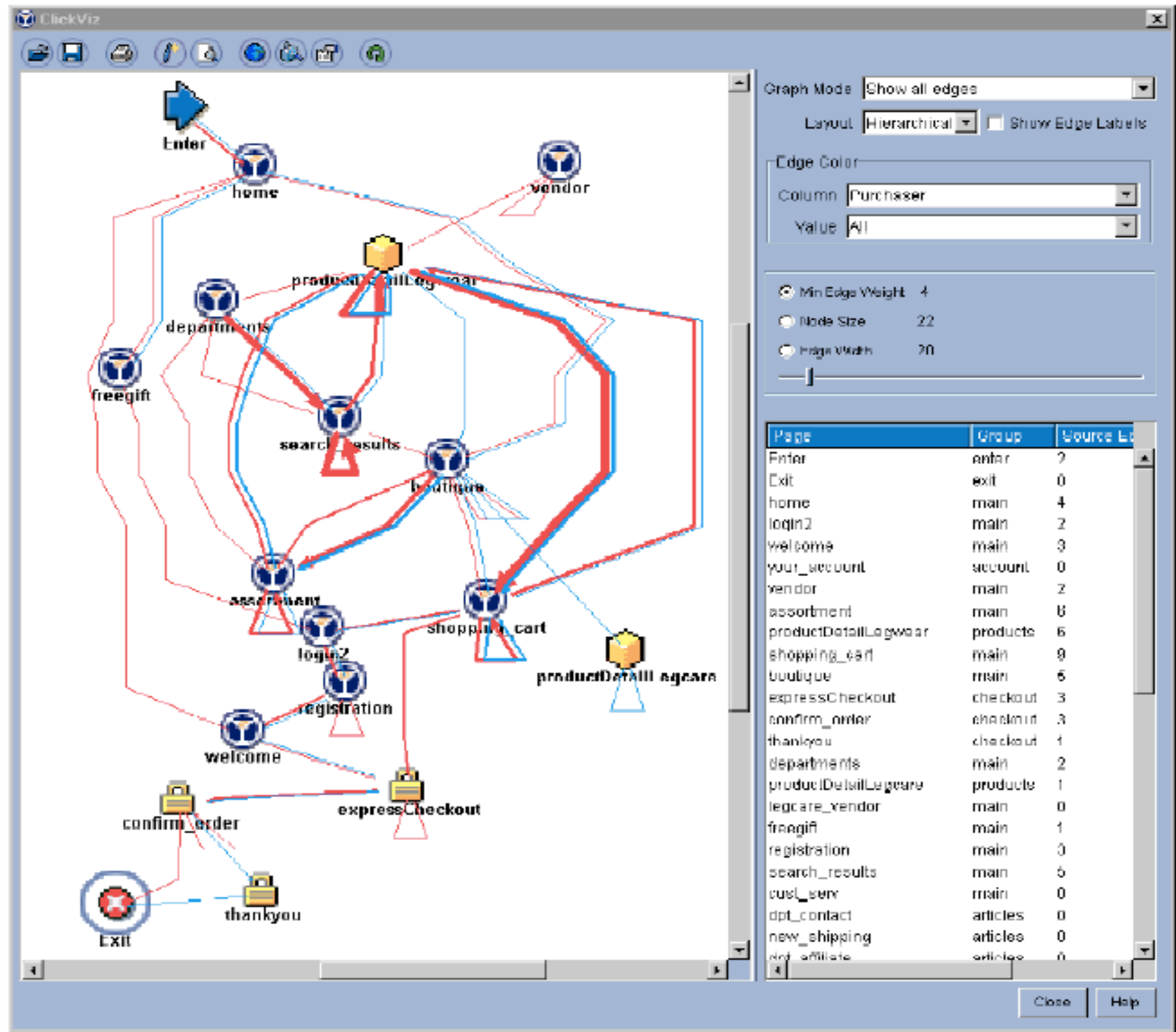
# Example Email Client using Thread Arcs



# 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

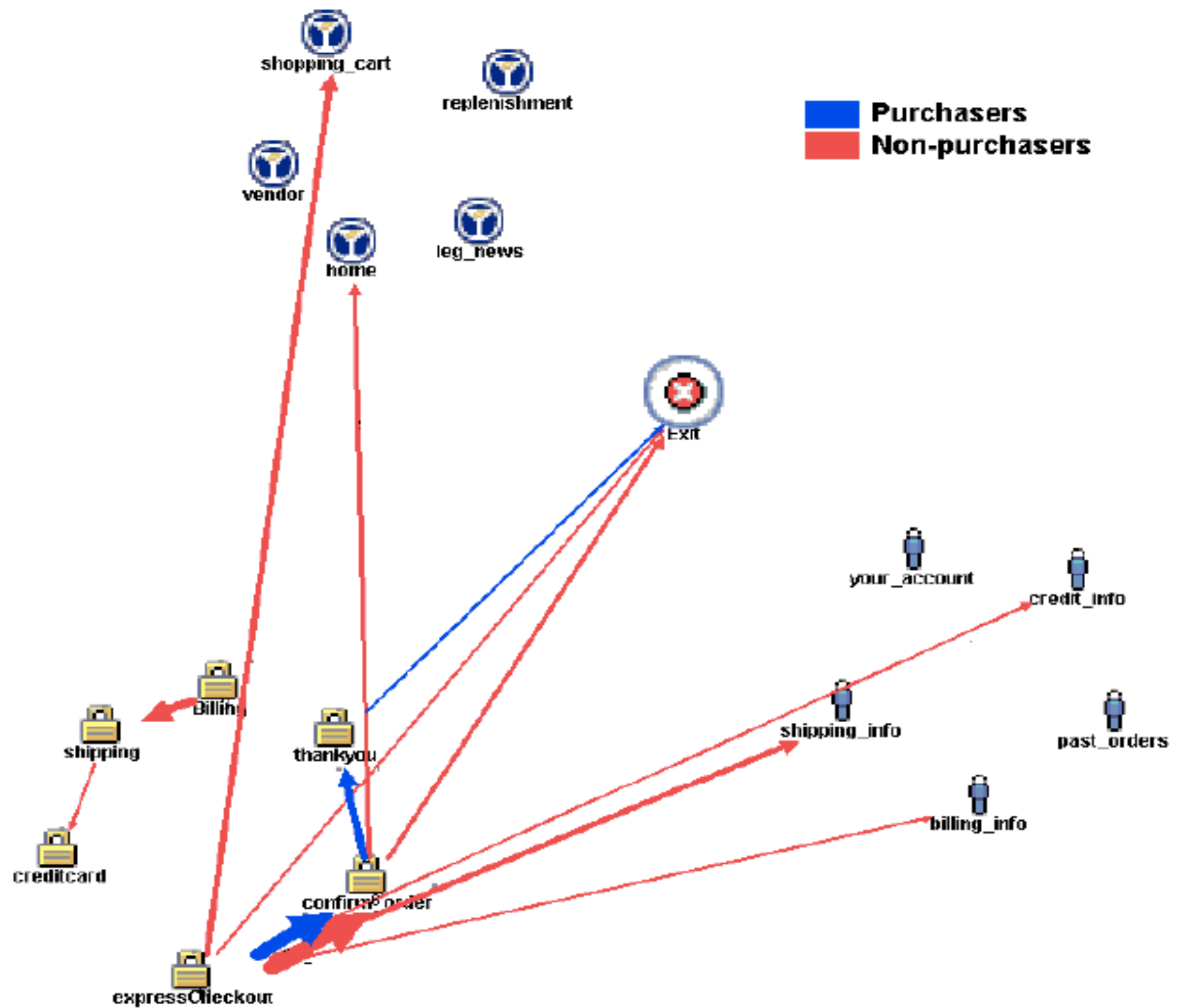


Figure 2. Circular layout. All the checkout pages are grouped (lower left). Red edges that emanate from the checkout pages to other parts of the site represent non-purchasers who are abandoning the checkout process.

- Brainerd et al.

## Click stream Visualization

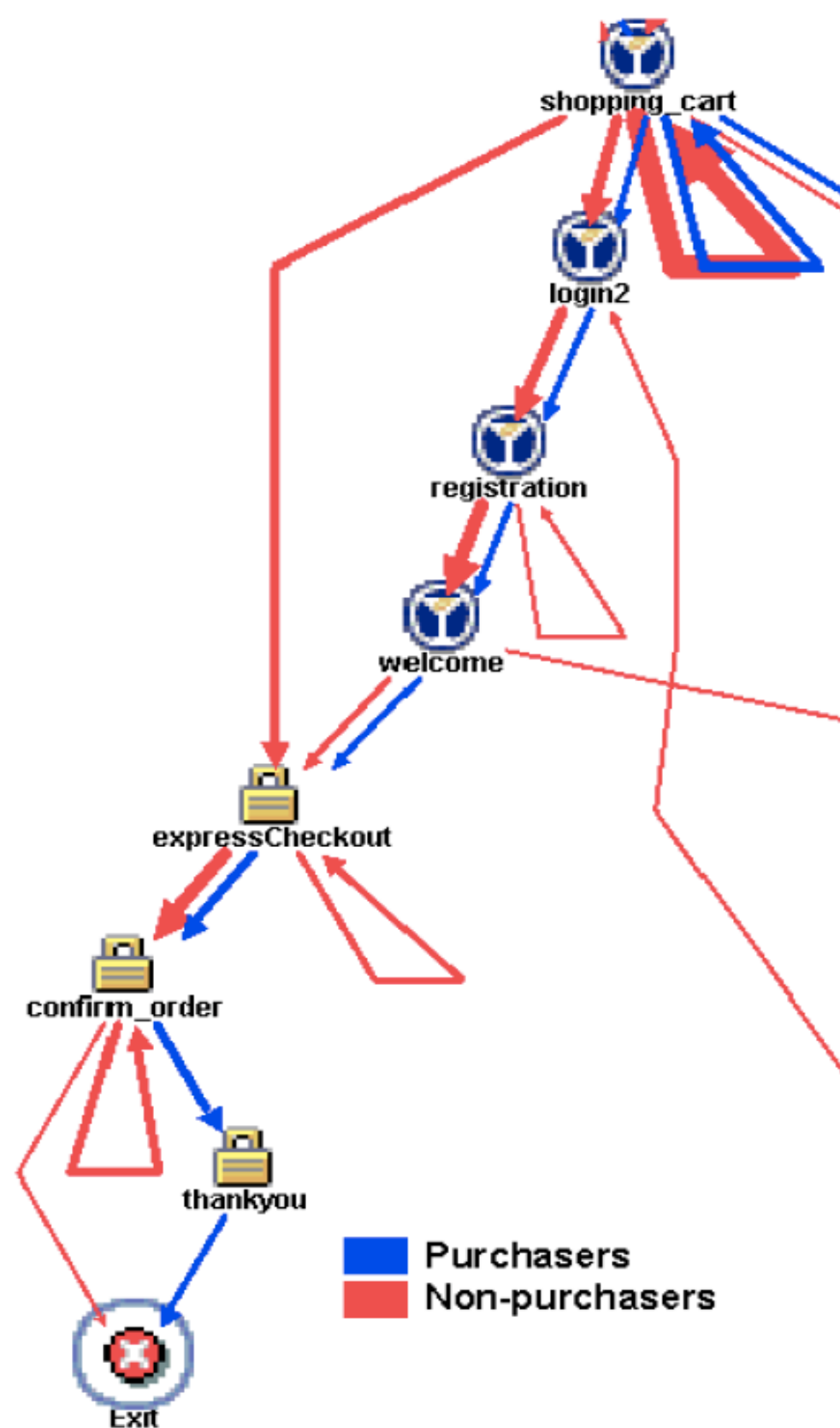


Figure 4. Checkout process. Purchasers take a direct route through the checkout process, whereas non-purchasers show a more haphazard route, including self-edges and early abandonment, possibly indicating a confusing checkout process.

- Brainerd et al.

## Click stream Visualization

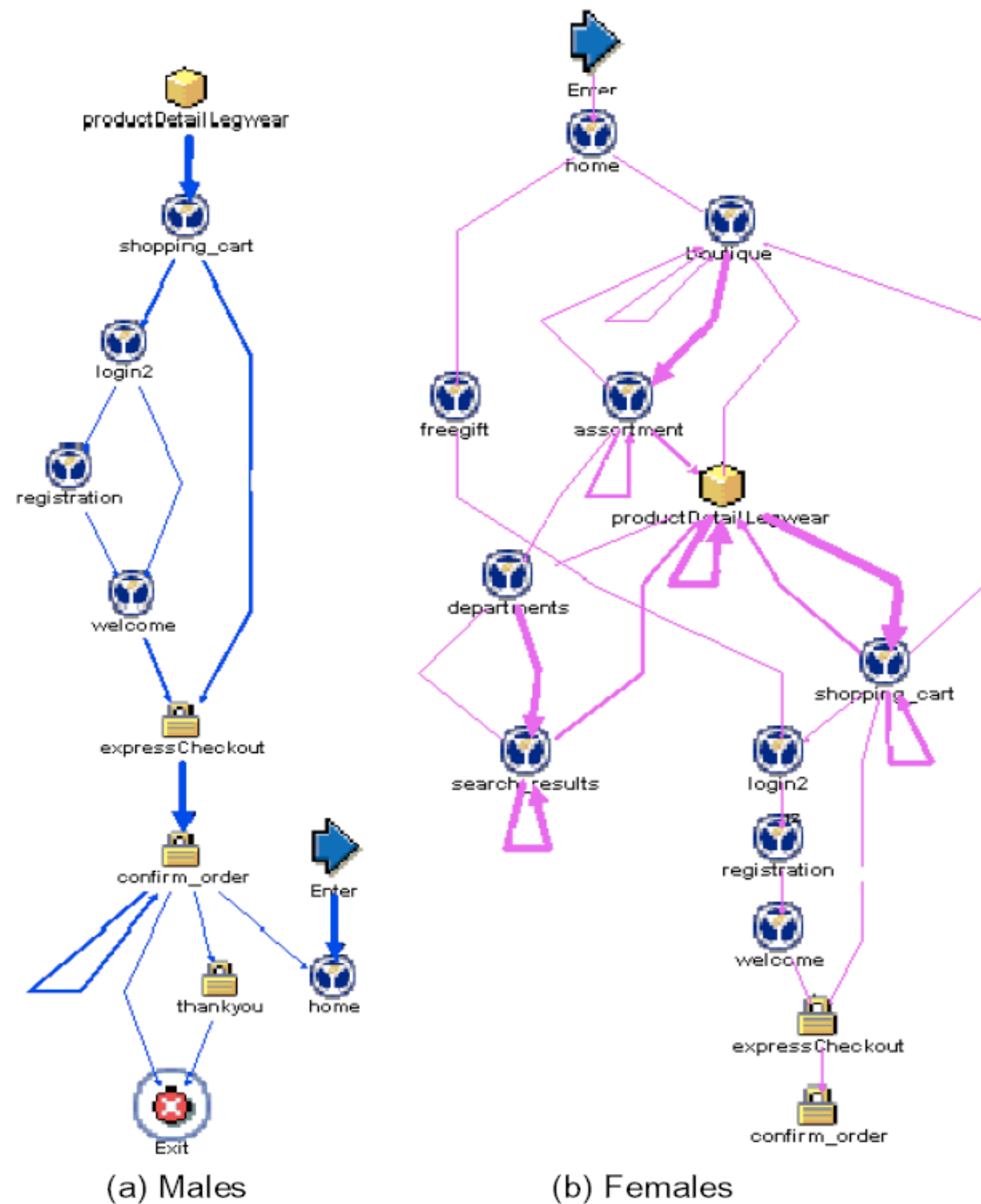


Figure 3. Gender Differences: Males tend to navigate in specific, direct patterns, whereas women's navigation patterns include much more browsing, utilizing much more of the site.

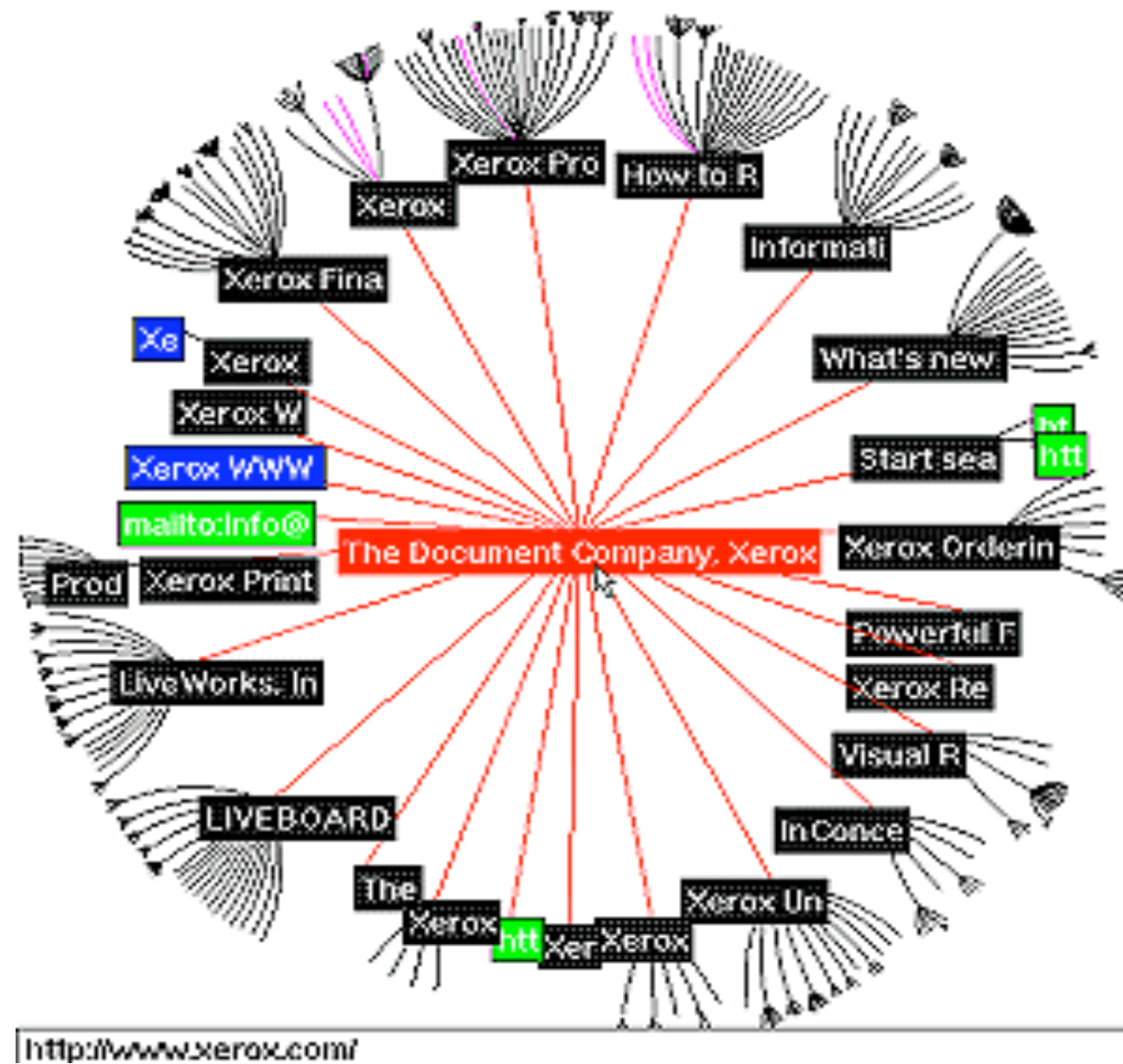
- Brainerd et al.

# Hyperbolic Browser

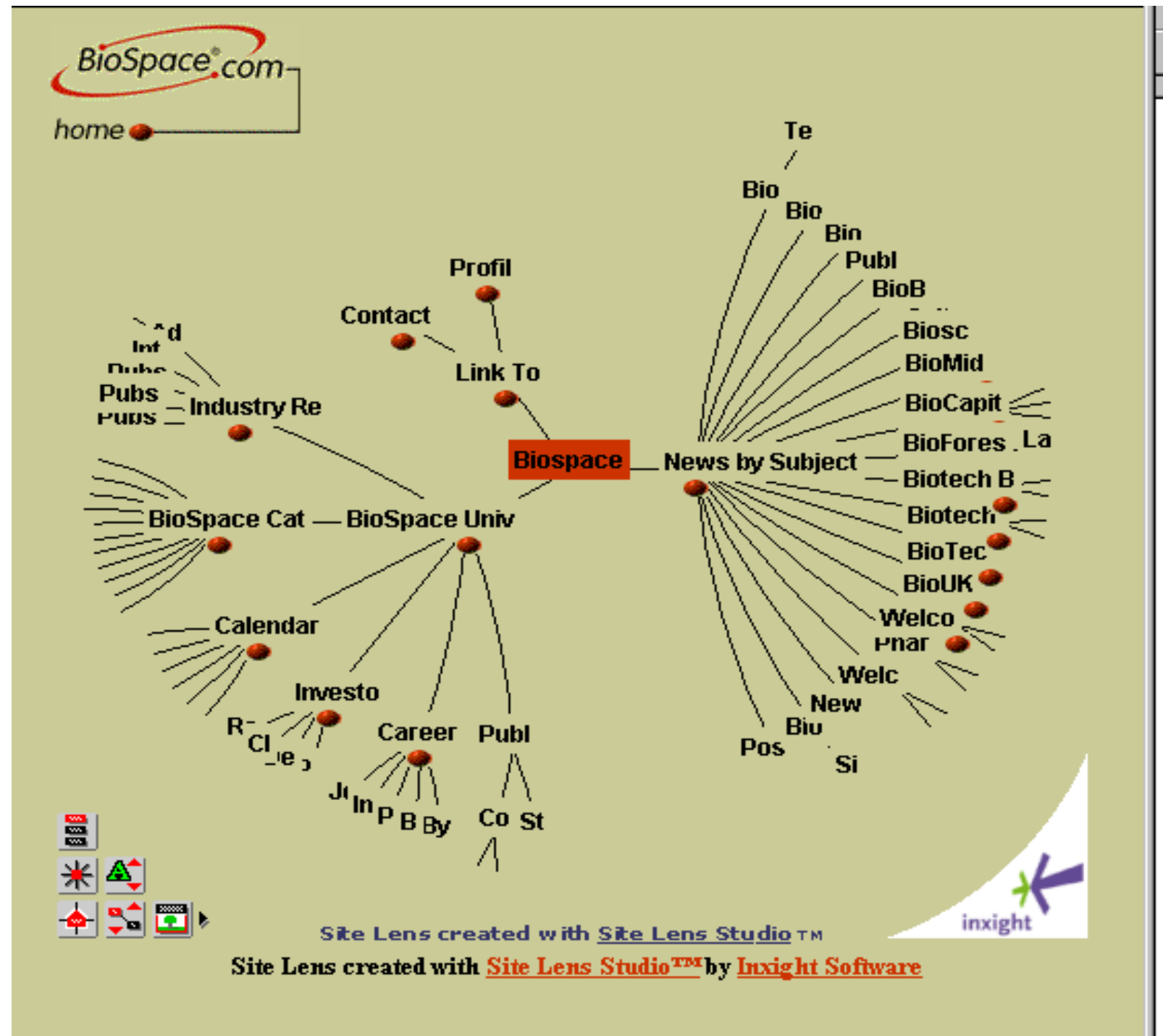
- In the hyperbolic plane, the circumference and area of a circle grow exponentially with its radius
- Allocate each node a wedge of the hyperbolic plane
- The node recursively places all its children within an arc of that wedge
  - at an equal distance from itself
  - far enough out so the children 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](http://www.inxight.com) ..oops, bought by SAP as of 06/2008, demos offline 8(
  - [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

**Contact sales now:**

[LOCATE A SALES PERSON](#)

**Request a demo:**

U.S. & Canada 1 866 681 3435

Europe: 00800 55 11 55 11

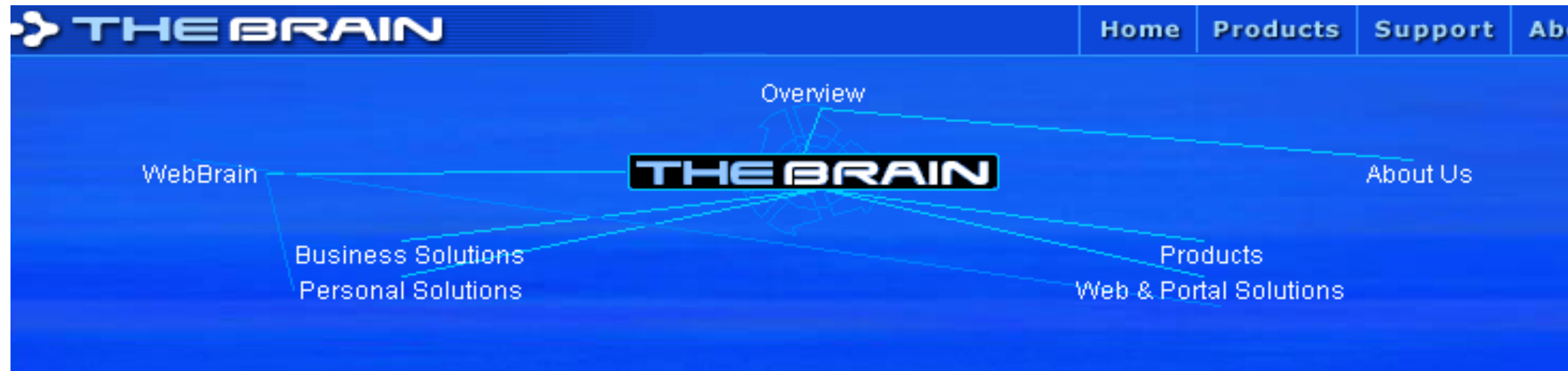
[Global contact list](#)

[Request more information](#)

[Find a reseller](#)



# TheBrain.com





# The Fisheye View Metaphor

The **fish-eye 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](http://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.

December 1986		S	M	T	W	Th	F	S
Dec 16	15	16		17	18	19	20	21
	*CLEAN (leave) *BELLC 4-6pm with Deborah Basil 10t *FINISH (for p)	*JACK SMITH 10pm Talk 11:30 Lunch *LEAVE MCC Pack Office Turn in: Badge, keys *MEET w/RAY ALLARD 3pm (His office) *BANKING Close Austin Accounts *ALLERGY APT. Get Shot & Pick up medicine (pay bill, too)		*Leave Austin 6:30a.m. To North Carolina American Flgt 287 (4 days vacation)	*VACATION North Carolina Coast	*VACATION North Carolina	*VACA North	*N.J. A 2:30p Sue at *FURNI put it
Dec 22	22	23		24	25	26	27	28
	*BROOK Dinne 6:30 *PACK for C	*CLEVELAND Thru 12/27 10:30a.m. United flight 1037		*CHRISTMAS EVE Midnight Church Service	*CHRISTMAS @Parent's House 10AM *TOM'S BIRTHDAY Get him a present After Lunch *DINNER w/DAVE Coming over at 6:50 *NUTCRACKER BALLET 8:30pm		*RETUR Iv 1:1 Unite Arr	*HOLD Aunt 7:30 Bro
Dec 29	29	30		31	1	2	3	4
		*MOVERS Furniture Arrives Find out time... *START ARRANGING FURNITURE --only 3 days to get settled			*NEW YEARS (Hooray!!) *PARTY at Tom&Lynn's 8pm...	*BACK TO WO *MARIA'S FIRS At Bellcore		
Jan 6	6	6		7	8	9	10	11
				*MCC PTAC Starts	*MCC PTAC continues	*MCC PTAC continues	*MCC ends	
Jan 12	12	13		14	15	16	17	18

# The Fisheye View Theory

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

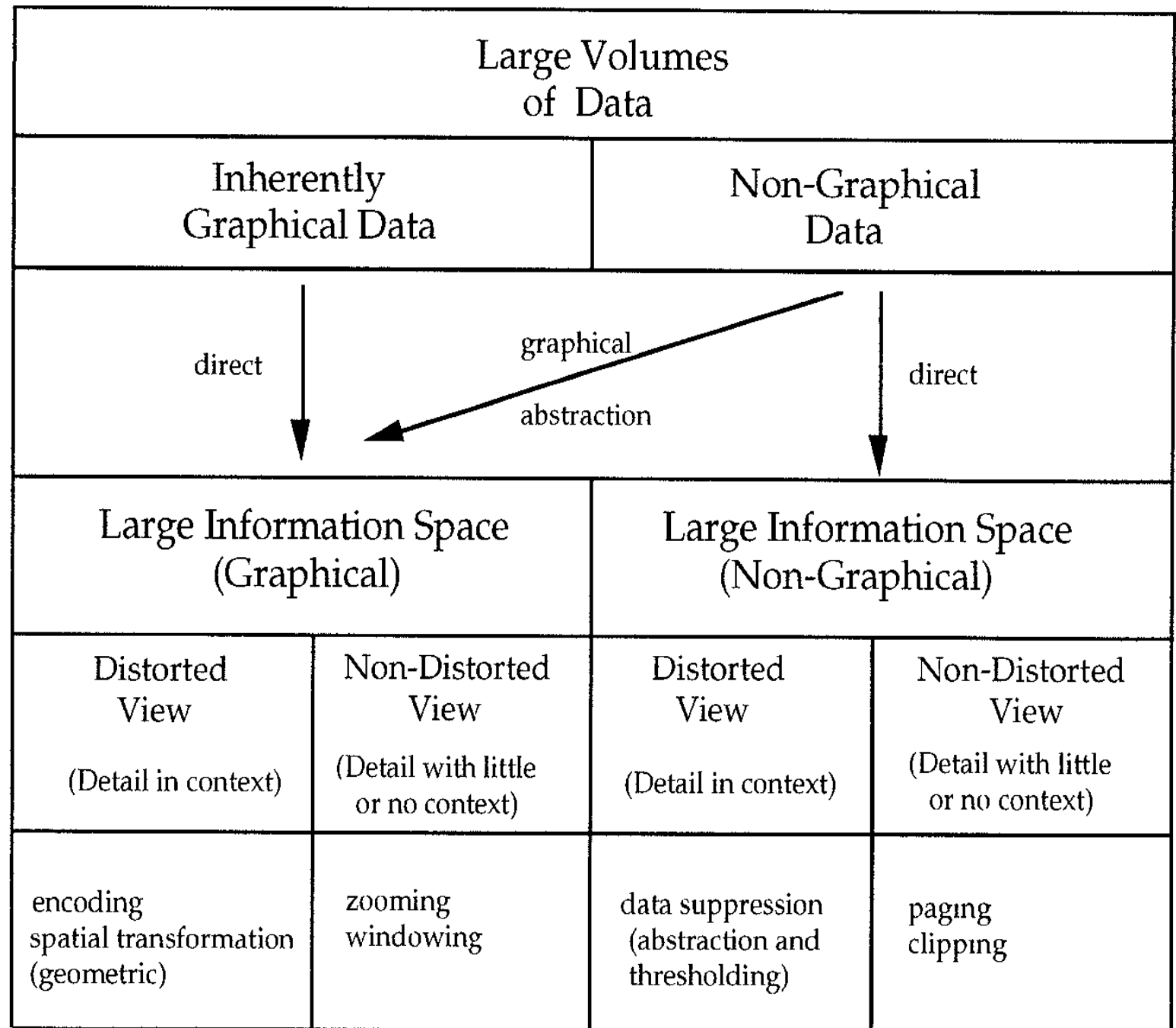
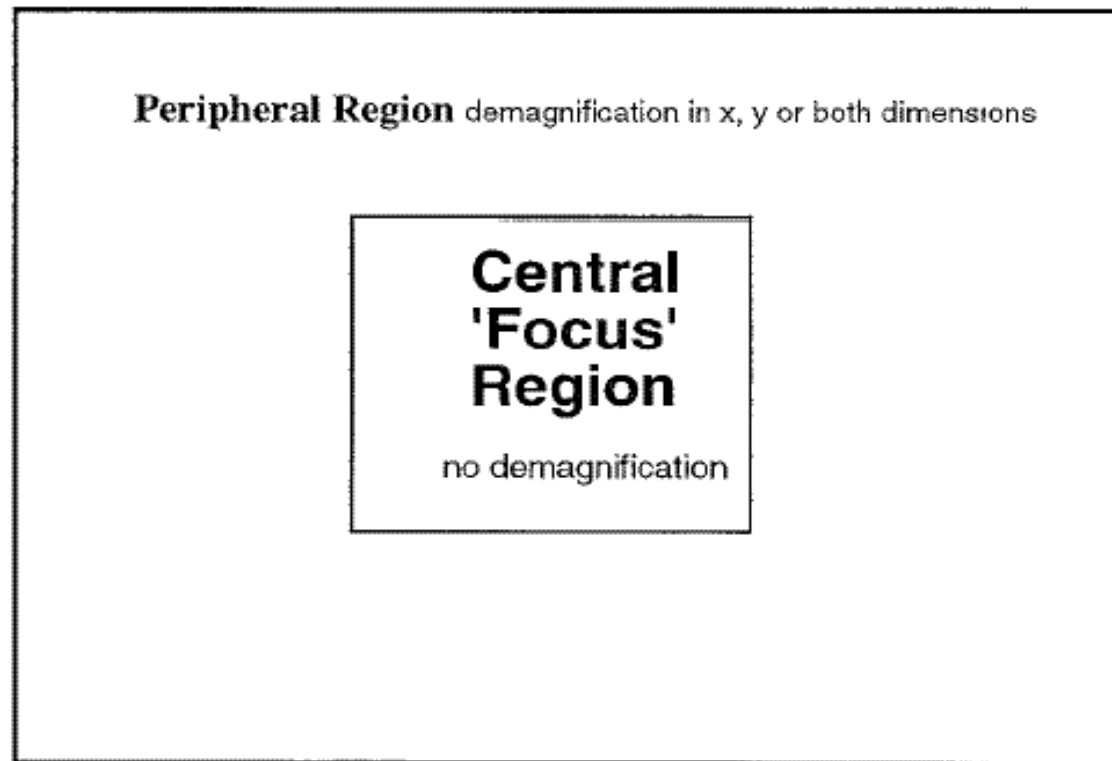


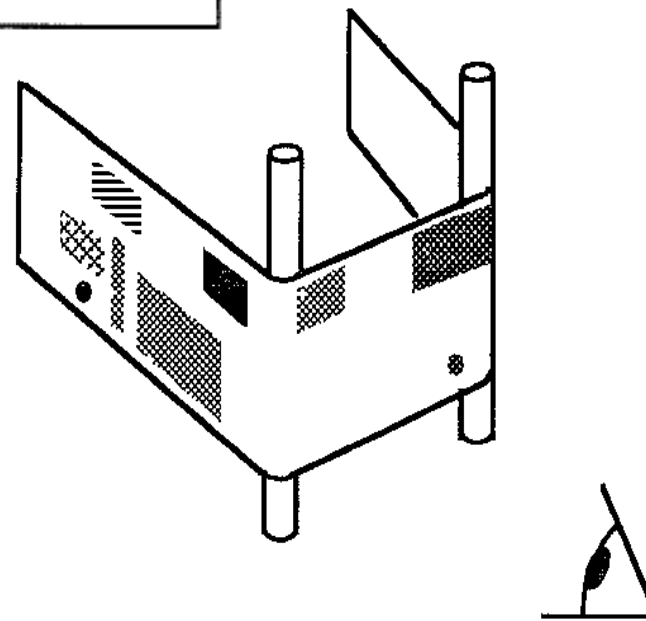
Fig. 1. A taxonomy of presentation techniques for large graphical data spaces.

# The Fisheye View Theory

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



Metaphor of a  
perspective wall

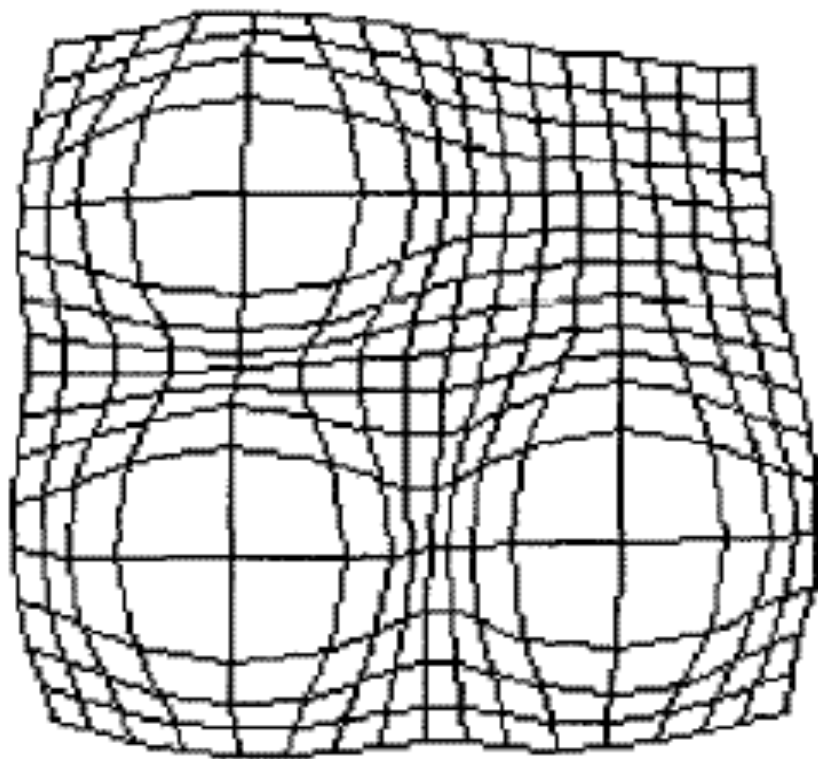


# The Fisheye View Theory

Unified theory of distortion techniques

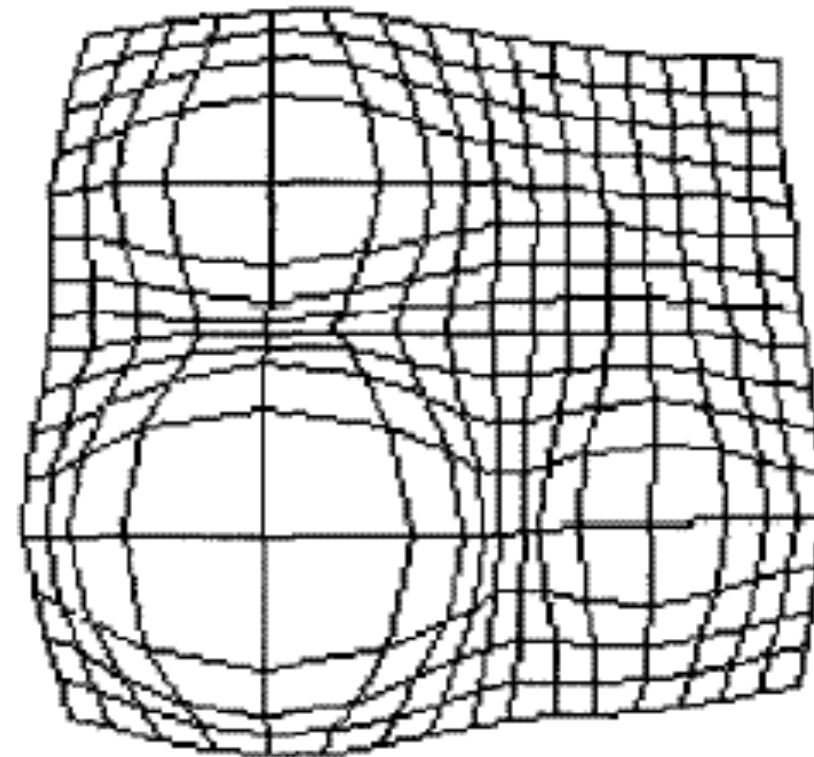
- “...stretchable rubber sheet mounted on a rigid frame”
- Stretching = Magnification
- Stretching one part must equal shrinkage in other areas

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



(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

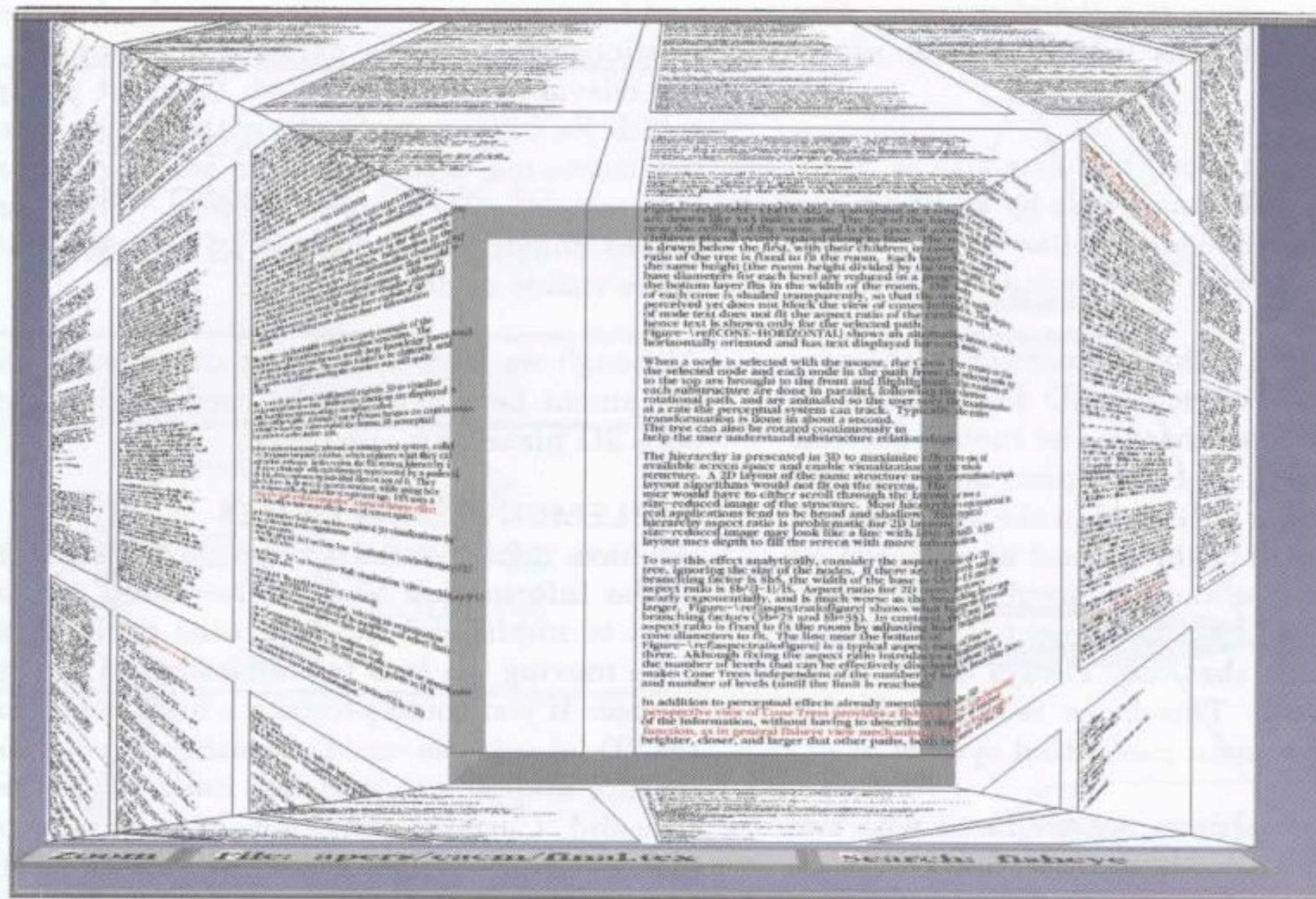
Unit	State	County	Output	Problems	Health
Unit38	Arizona	J	40	0	9
Unit39	Arizona	J	30	2	9
Unit40	Arizona	K	23	0	9
Unit41	Arizona	K	24	1	9
Unit42	Arizona	K	25	0	9
Unit43	Arizona	K	25	0	9
Unit44	Arizona	L	50	1	9
Unit45	Arizona	L	50	0	9
Unit46	Arizona	L	50	0	9
Unit47	Nebraska	V	90	2	9
Unit48	Nebraska	V	90	1	9
Unit49	Nebraska	V	50	2	8
Unit50	Nebraska	F	50	3	7
<b>Unit51</b>	<b>Nebraska</b>	<b>F</b>	<b>70</b>	<b>0</b>	<b>9</b>
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
Unit62	Mississippi	S	60	1	9
Unit63	Mississippi	S	50	1	9
Unit64	Mississippi	S	80	1	9
Unit65	Mississippi	S	80	1	9



# 2-dimensional Fisheye

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

## Document Lens

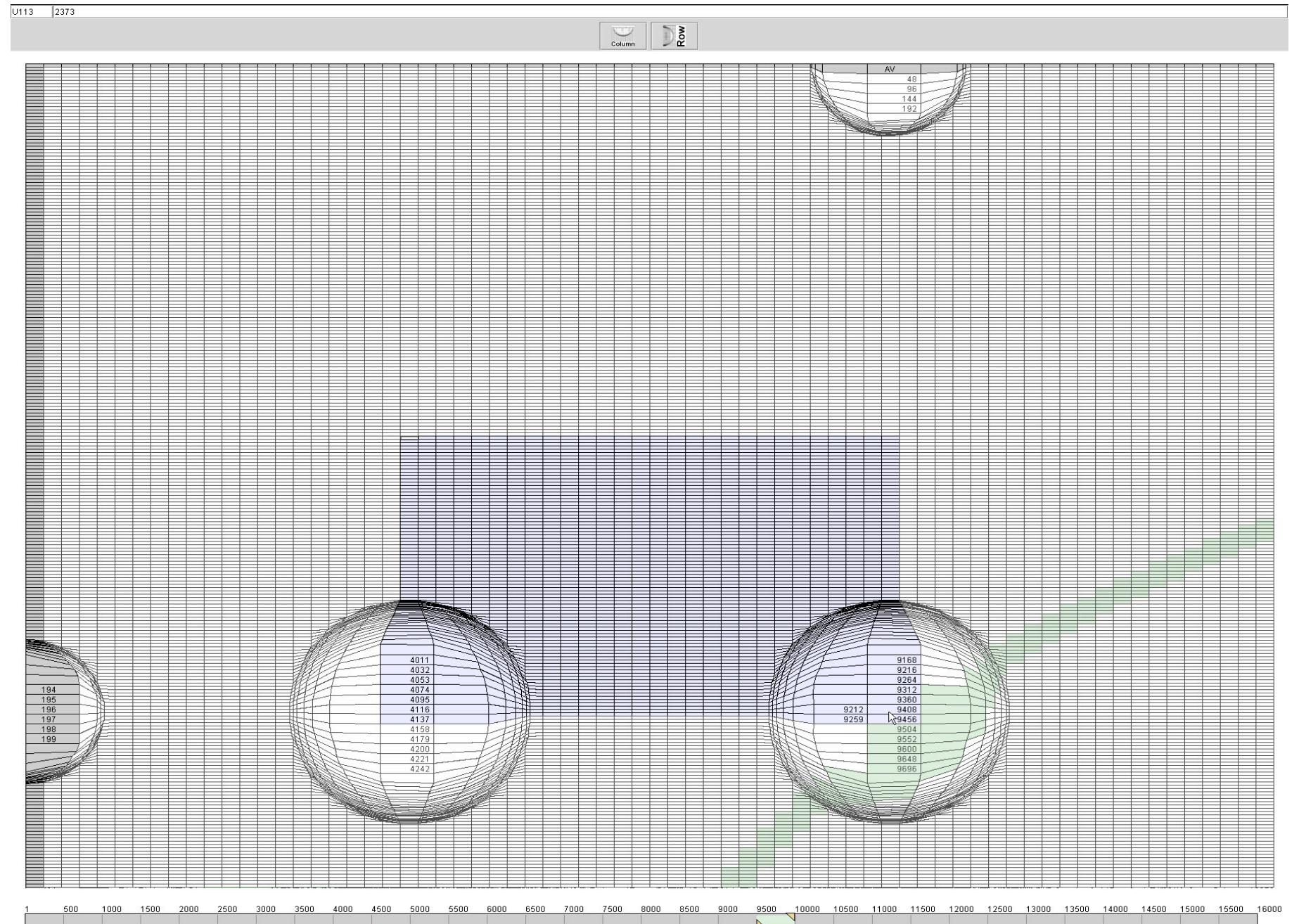




# 2-dimensional Fisheye

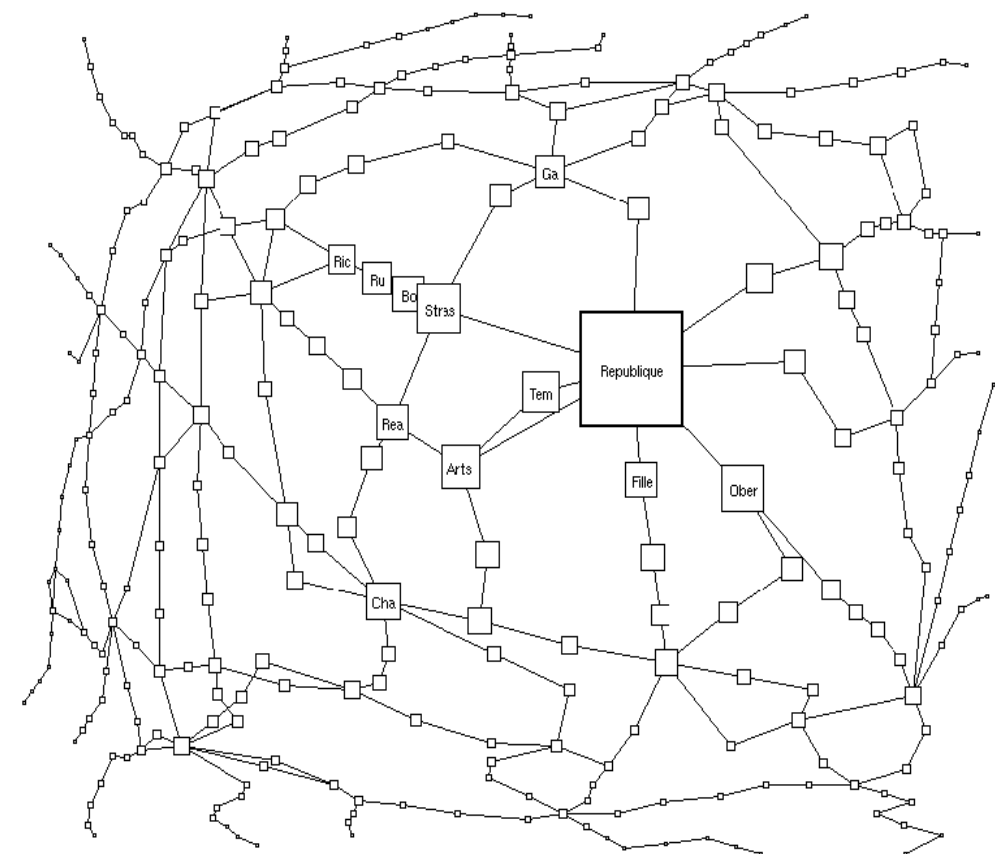
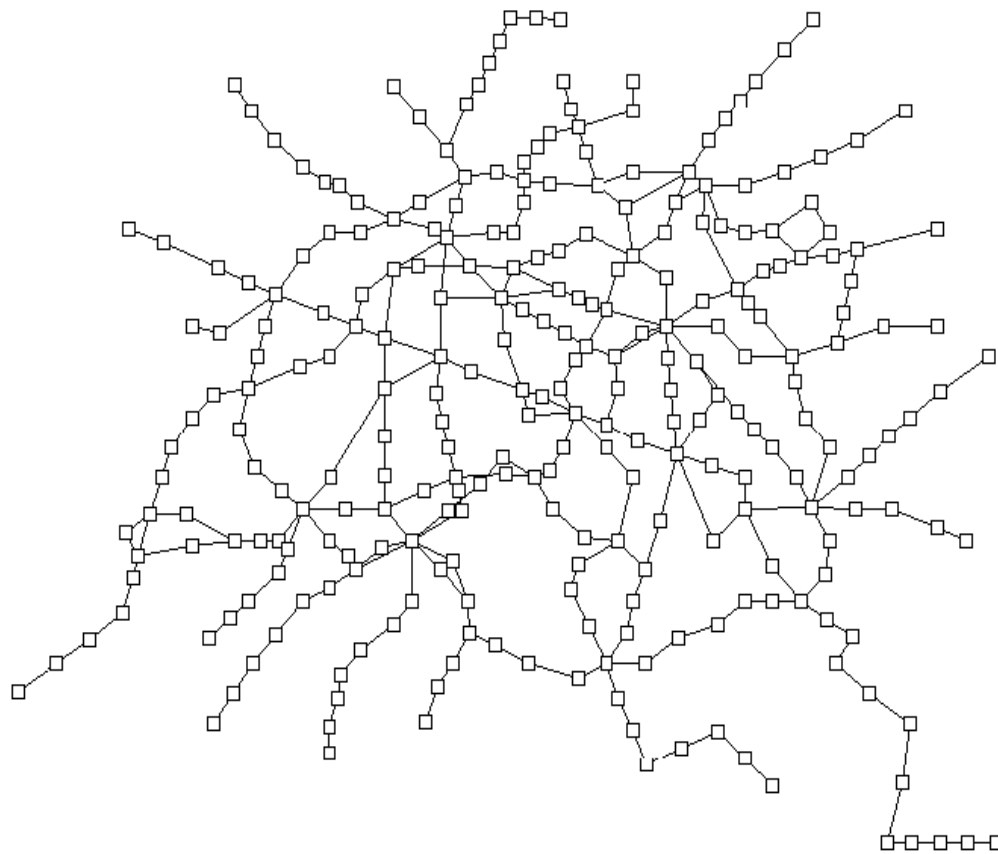
## FiCell Project

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



# 2-dimensional Fisheye

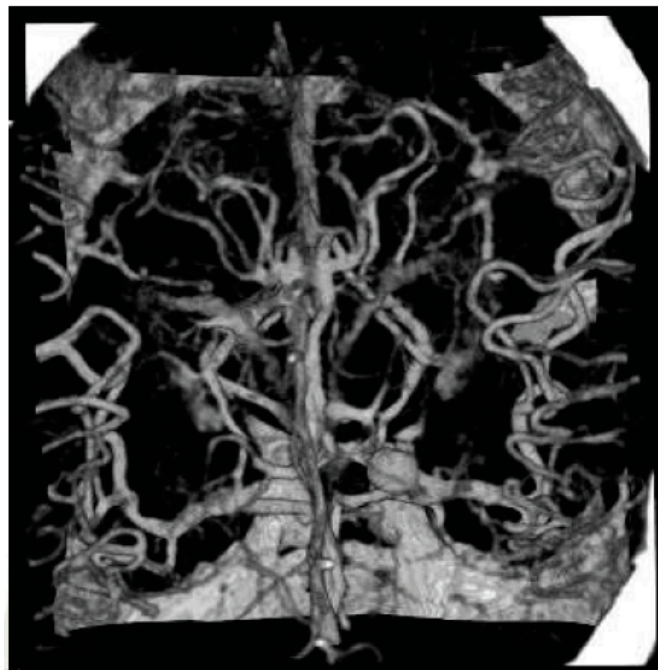
Fisheyes applied to networks



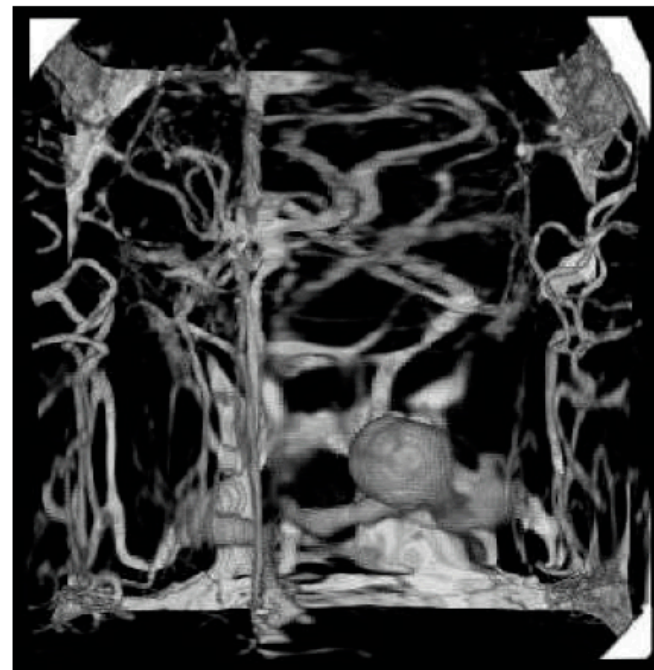
Manojit Sarkar and Marc H. Brown 1992

# 3-dimensional Fisheye

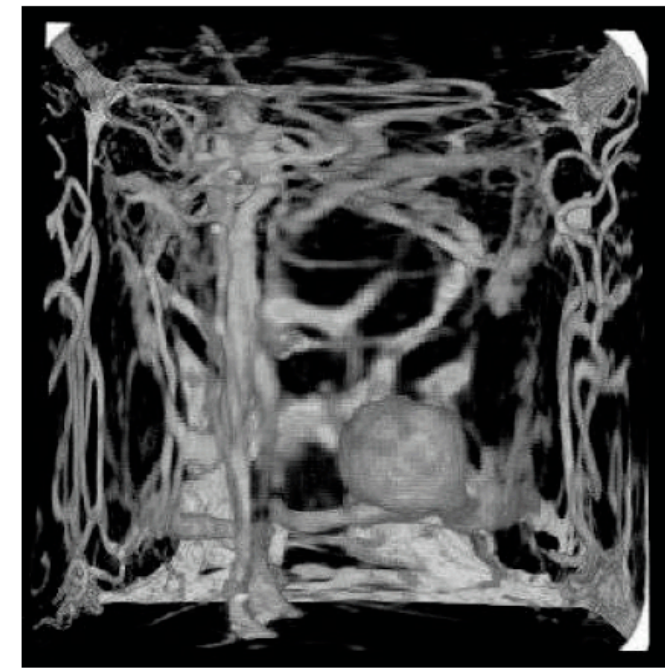
Marcelo Cohen, Ken Brodlie,  
Focus and Context for Volume Visualization,



No distortion



3D cartesian bifocal



3D cartesian fisheye

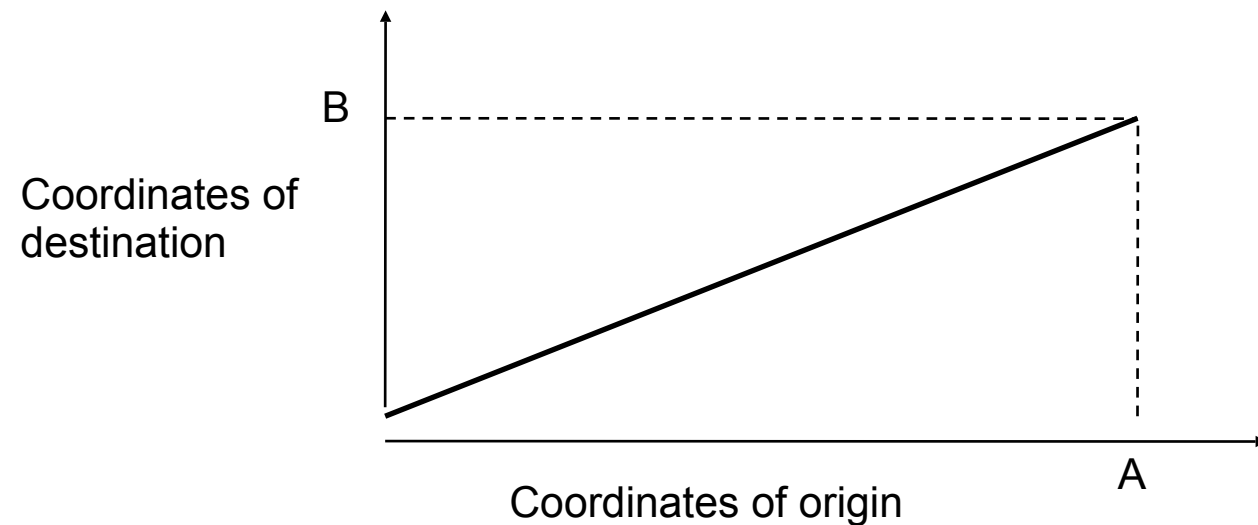
# 1-dimensional Fisheye

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

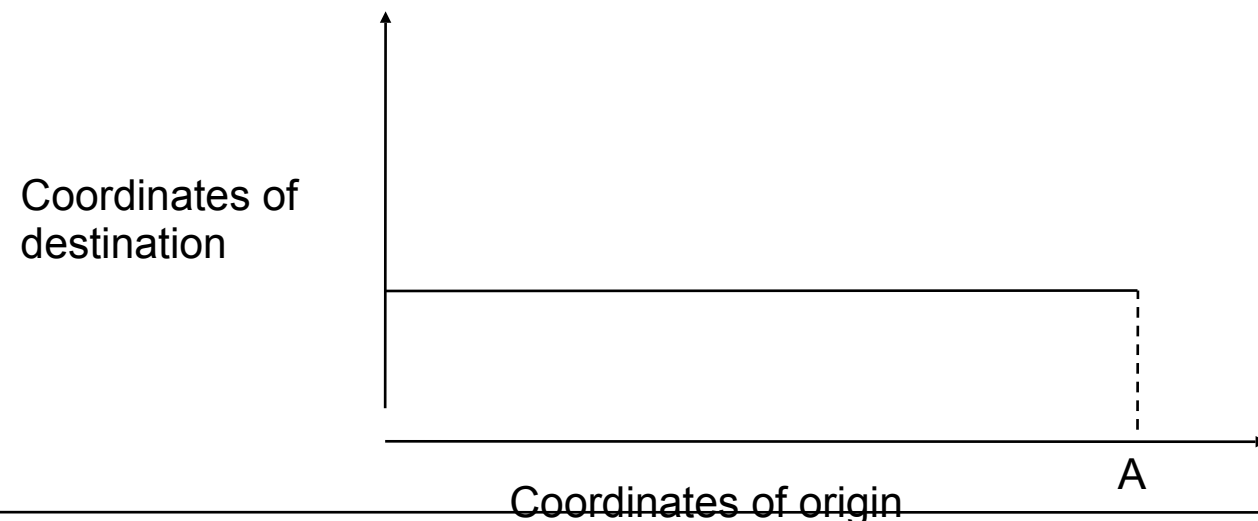
The magnifier function is the first derivative of the transfer function

The transfer function is the integral of the magnifier function

**Transfer function  $T(X)$**



**Magnifier function  $M(X)$**



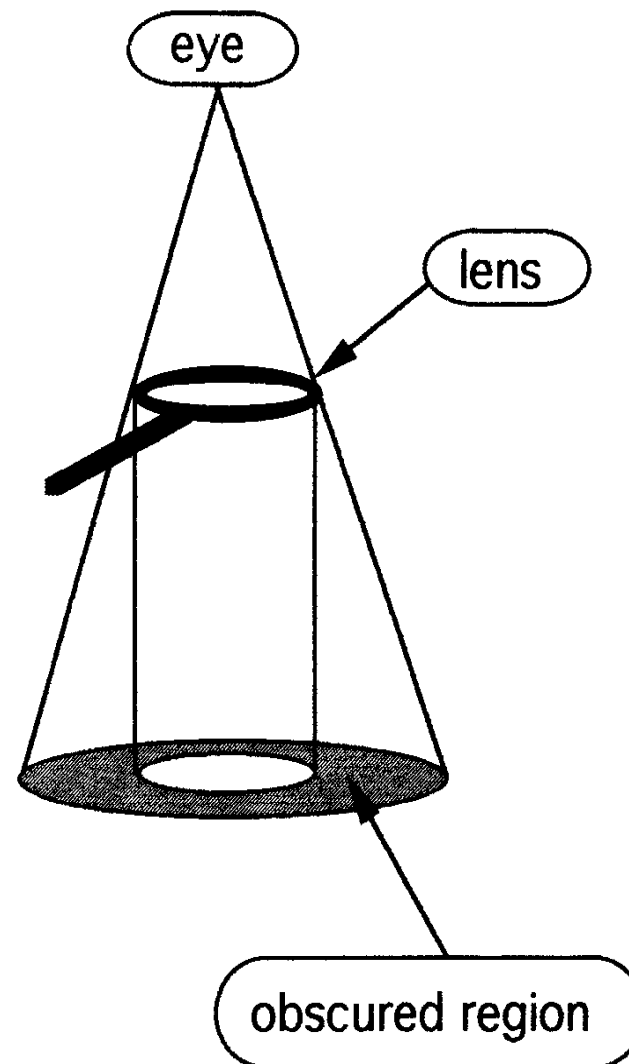
# 1-dimensional Fisheye

The problem with the magnifier:

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

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

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





# 1-dimensional Fisheye

The problem with the magnifier:

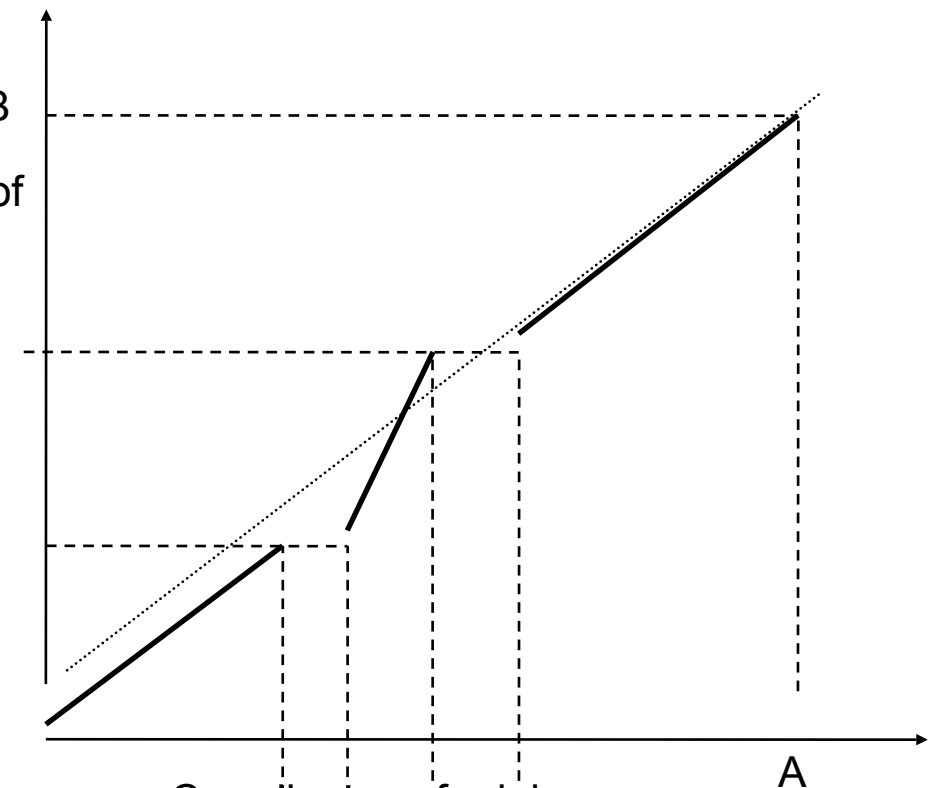
Parts of the origin will not appear at the destination.

In the picture below the Central Station is visible, but not Marienplatz



Transfer function  $T(X)$

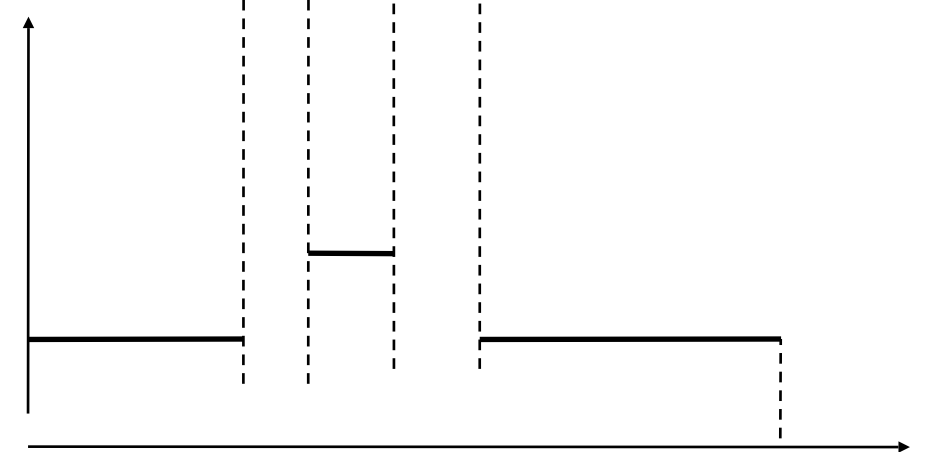
Coordinates of destination



Coordinates of origin

Magnifier function  $M(X)$

Magnifying factor

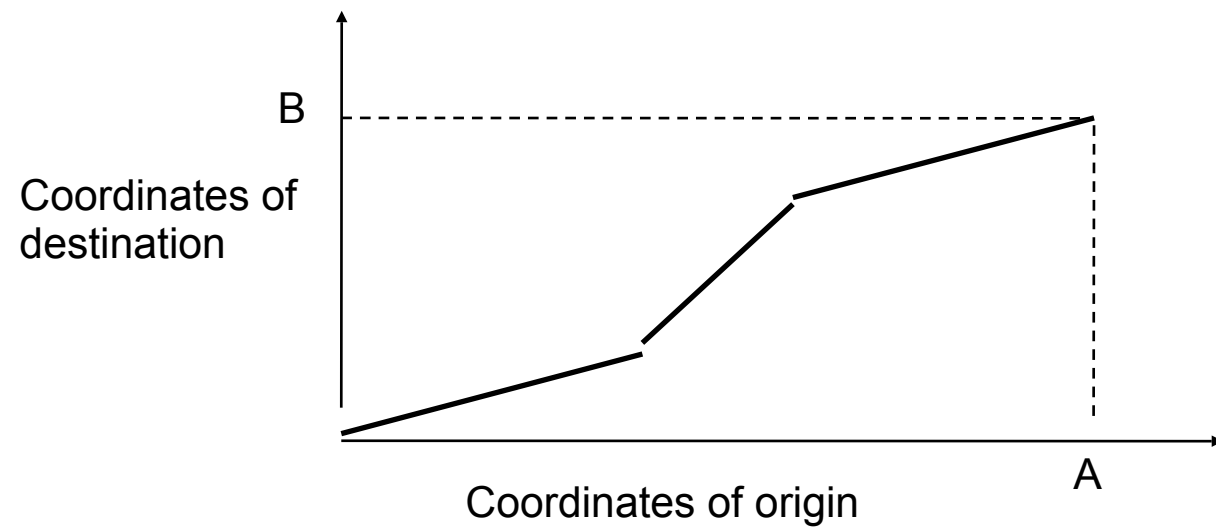


Coordinates of origin

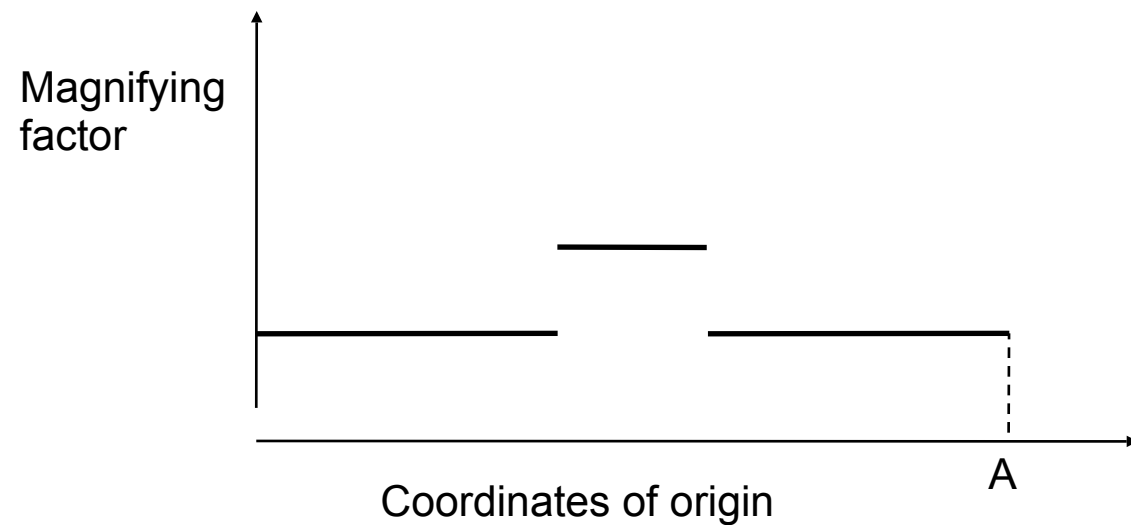
# 1-dimensional Fisheye

Bifocal:

**Transfer function  $T(X)$**

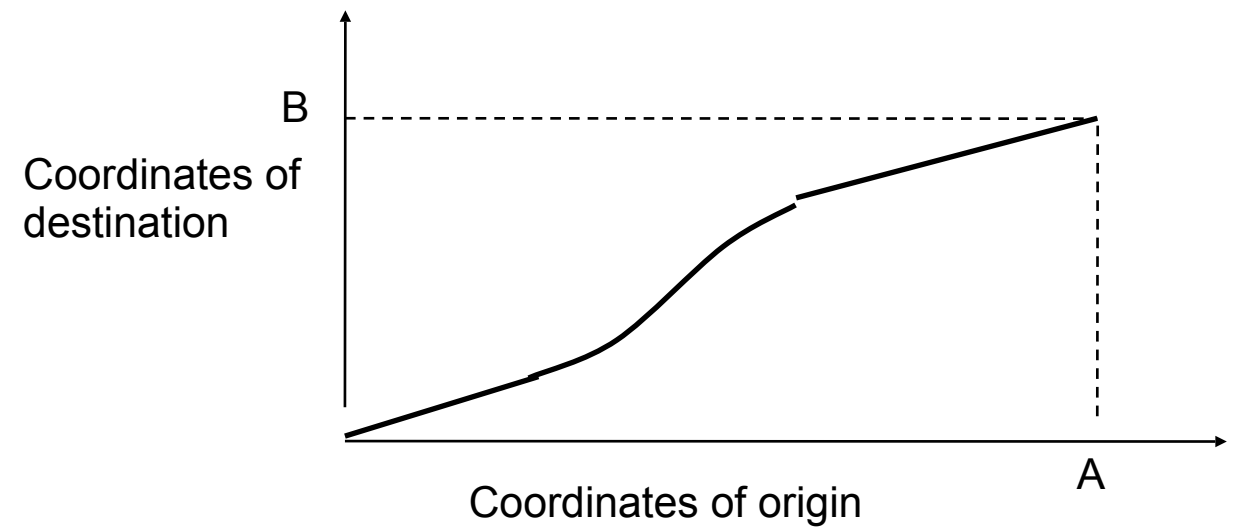


**Magnifier function  $M(X)$**

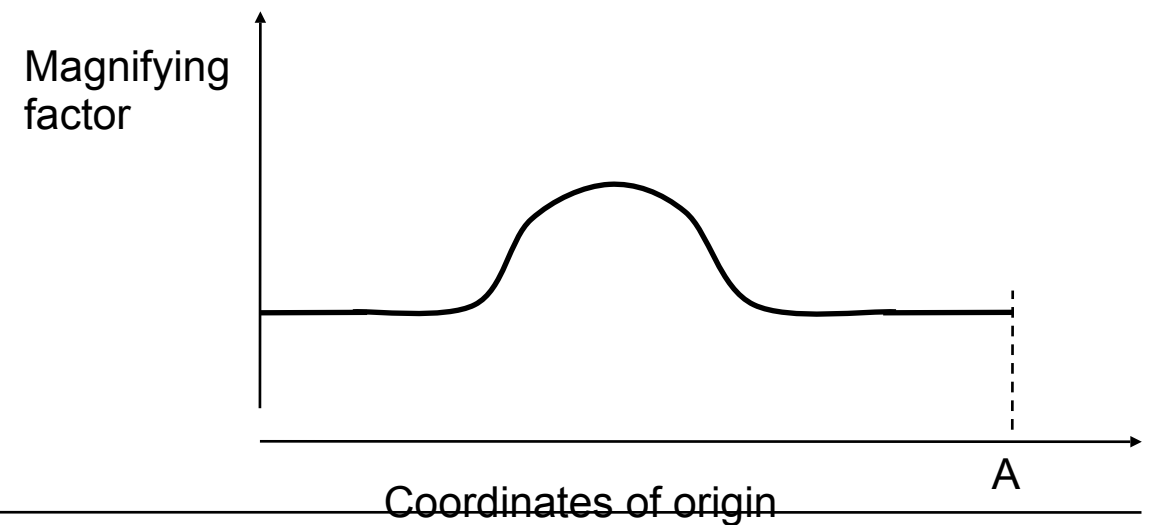


Continuous:

**Transfer function  $T(X)$**



**Magnifier function  $M(X)$**

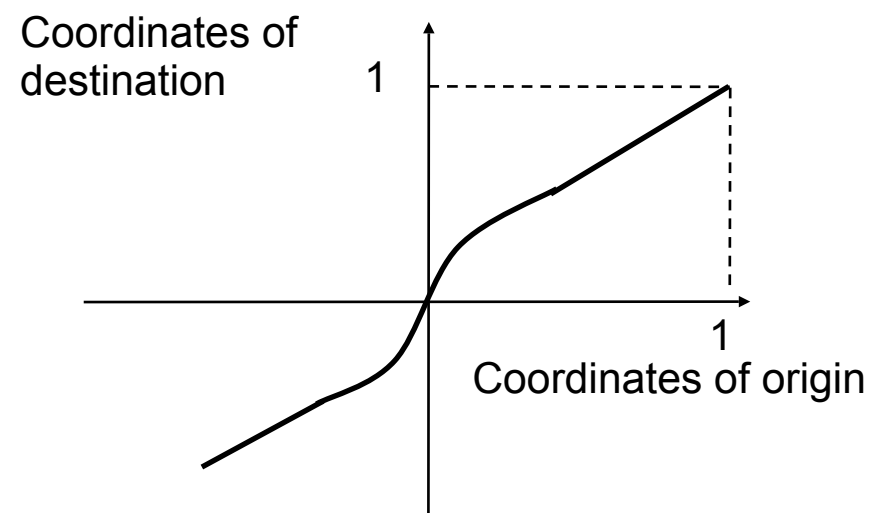




# 1-dimensional Fisheye

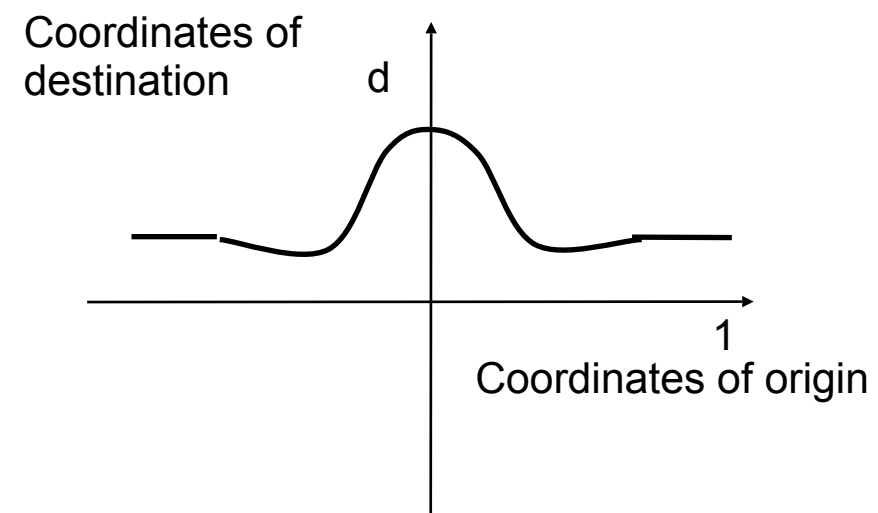
To have transfer function independent of window sizes and resolutions it is common to work with normalized coordinates, i.e. working with intervals from -1 to 1.

## Transfer function $T(x)$



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

## Magnifier function $M(x)$



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

# 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”)

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

Examples:

$$W(Y) = Y$$

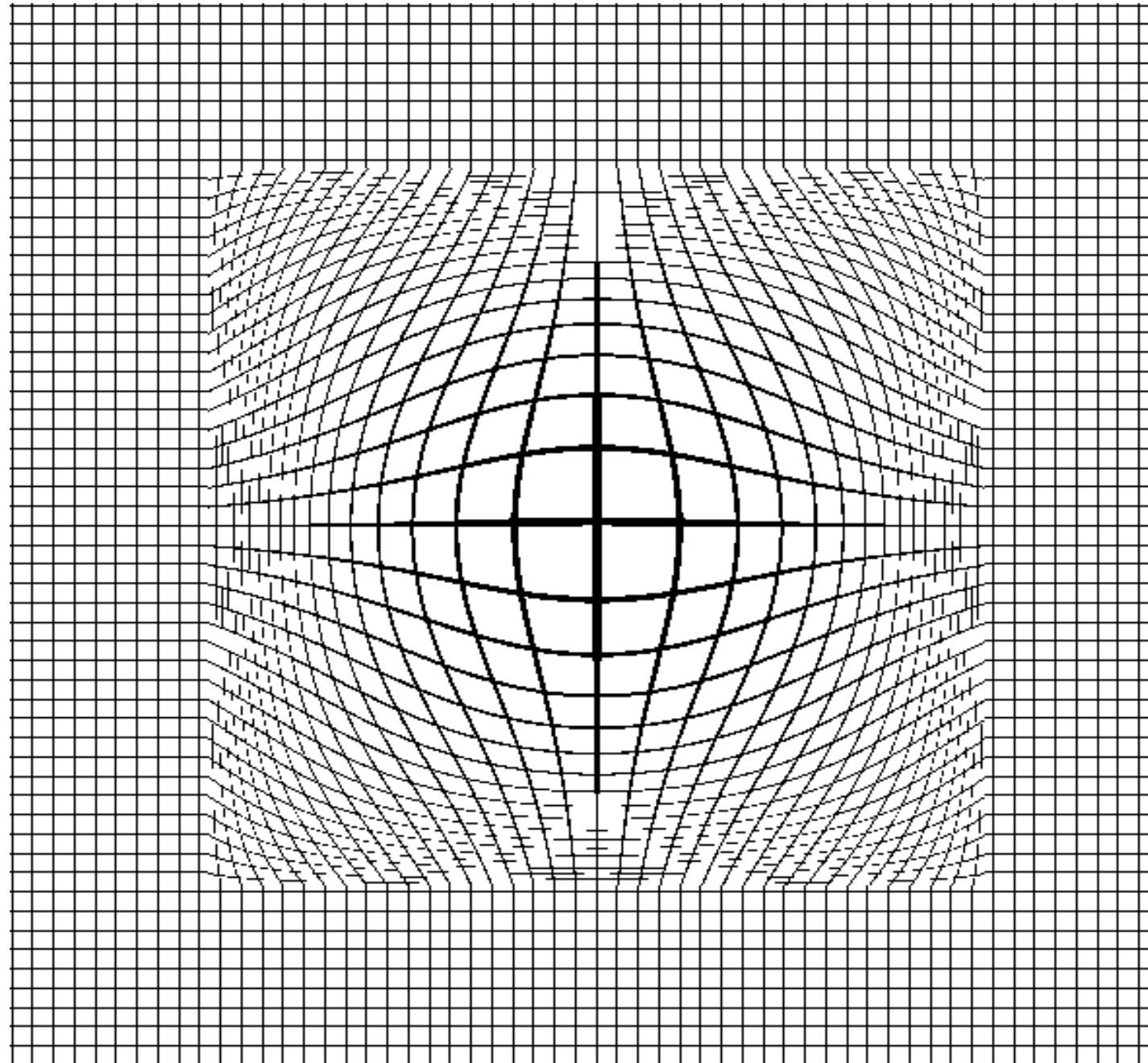
$$W(Y) = Y^2$$

# 2-dimensional Fisheye

Continuous  
transfer  
function

using  
Cartesian  
coordinates

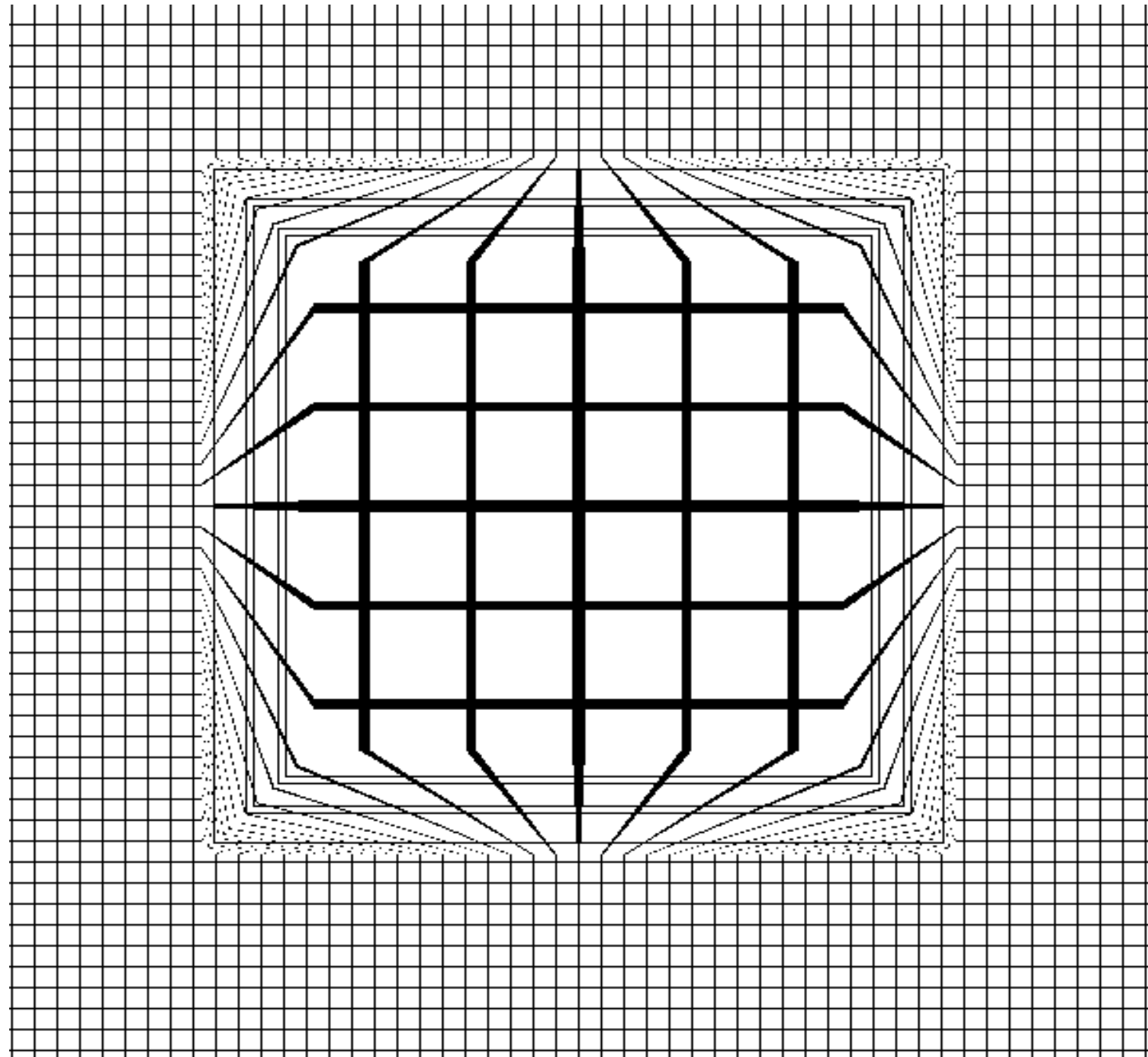
The visualization of the fisheye visualization



# 2-dimensional Fisheye

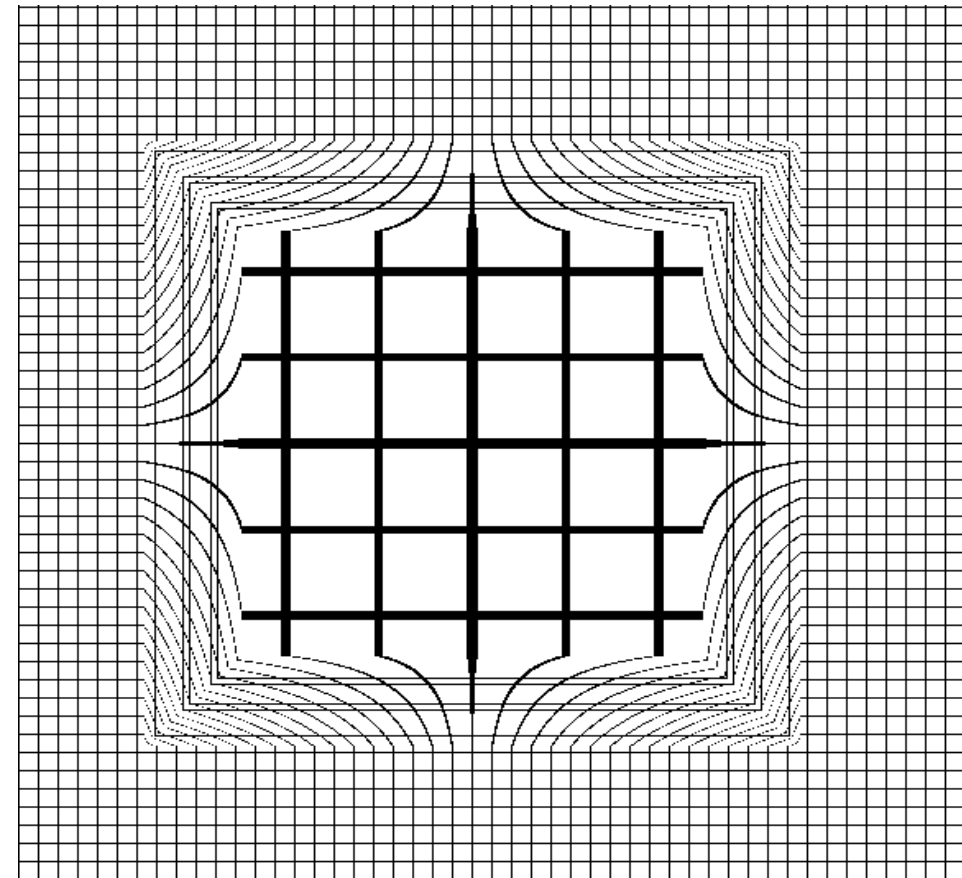
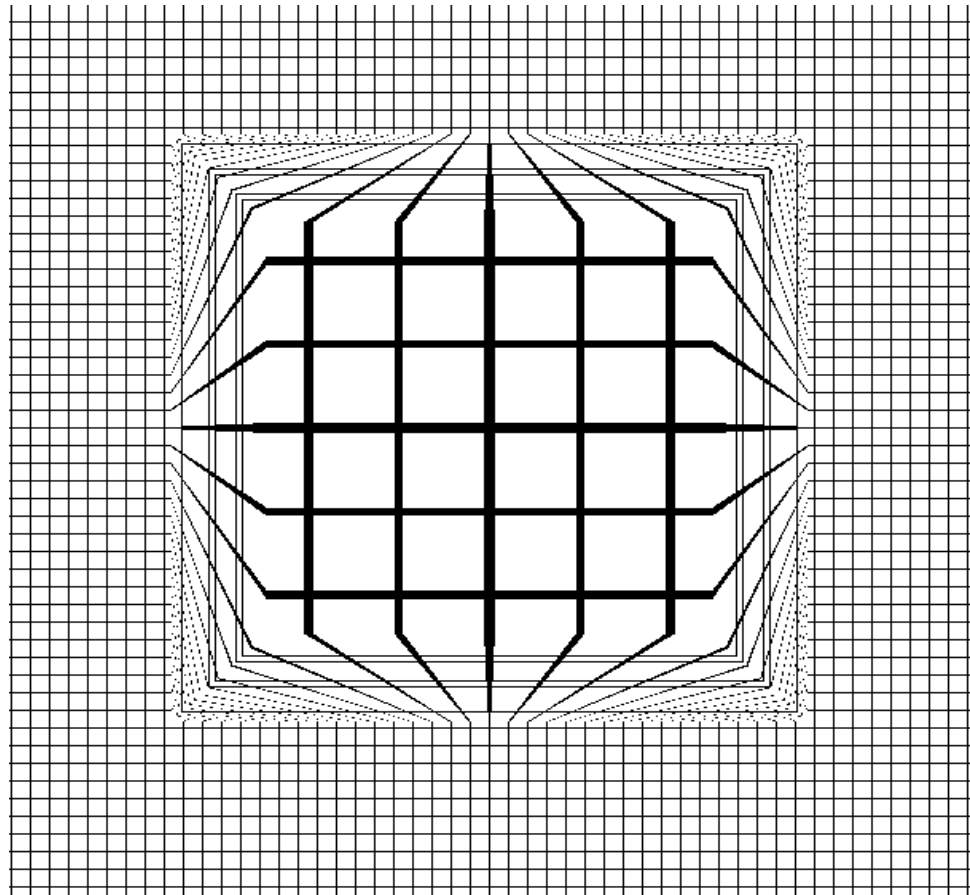
Bifocal  
transfer  
function

using  
Cartesian  
coordinates





# 2-dimensional Fisheye



What is the difference?

# 2-dimensional Fisheye

Using polar coordinates

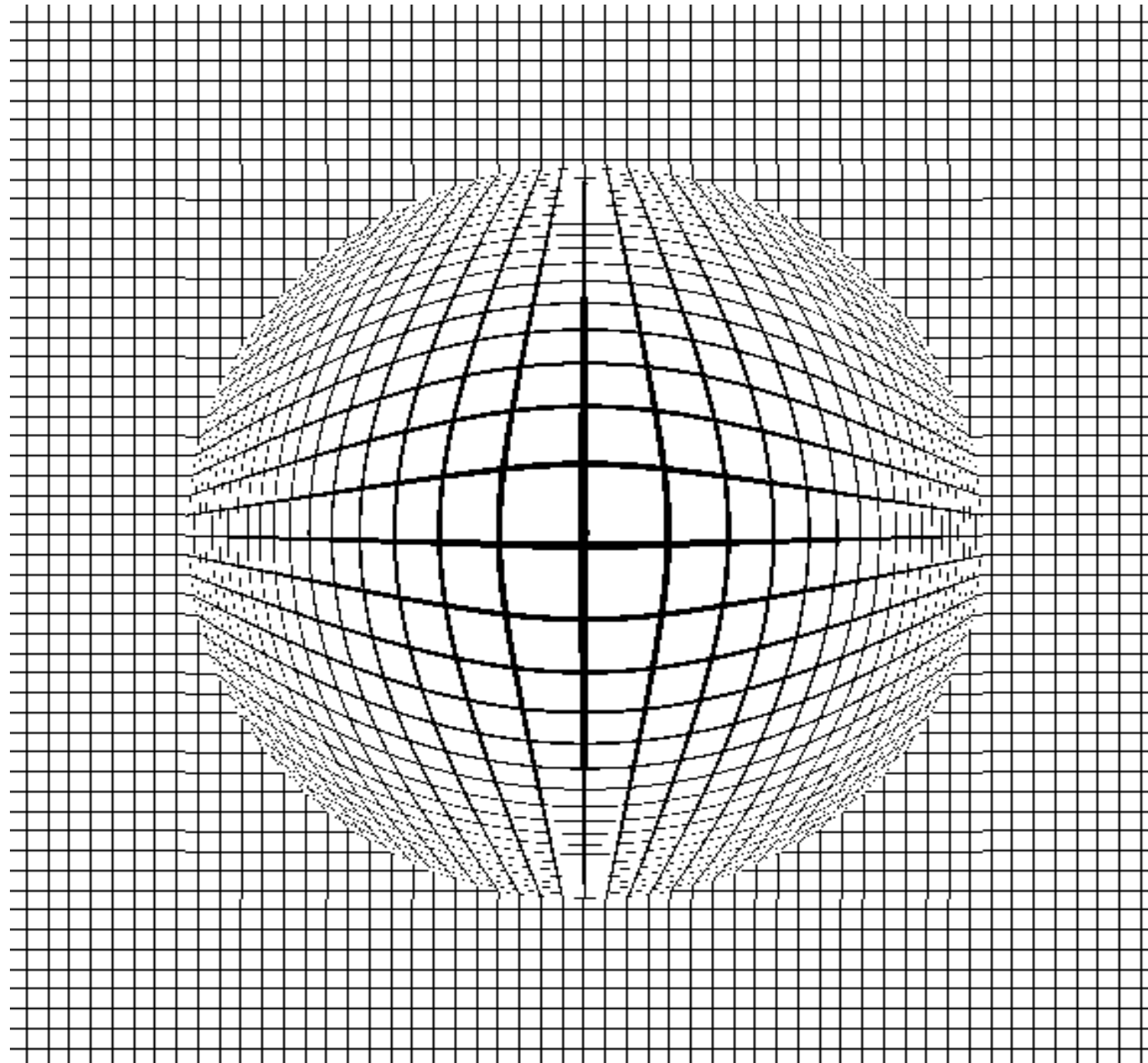
Because a fish eye should not twist the picture, the transfer function does not depend on the angular coordinate. So the transfer function for the 1-dim. case can be used for the radial coordinate.

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

# 2-dimensional Fisheye

Continuous  
transfer  
function

using polar  
coordinates

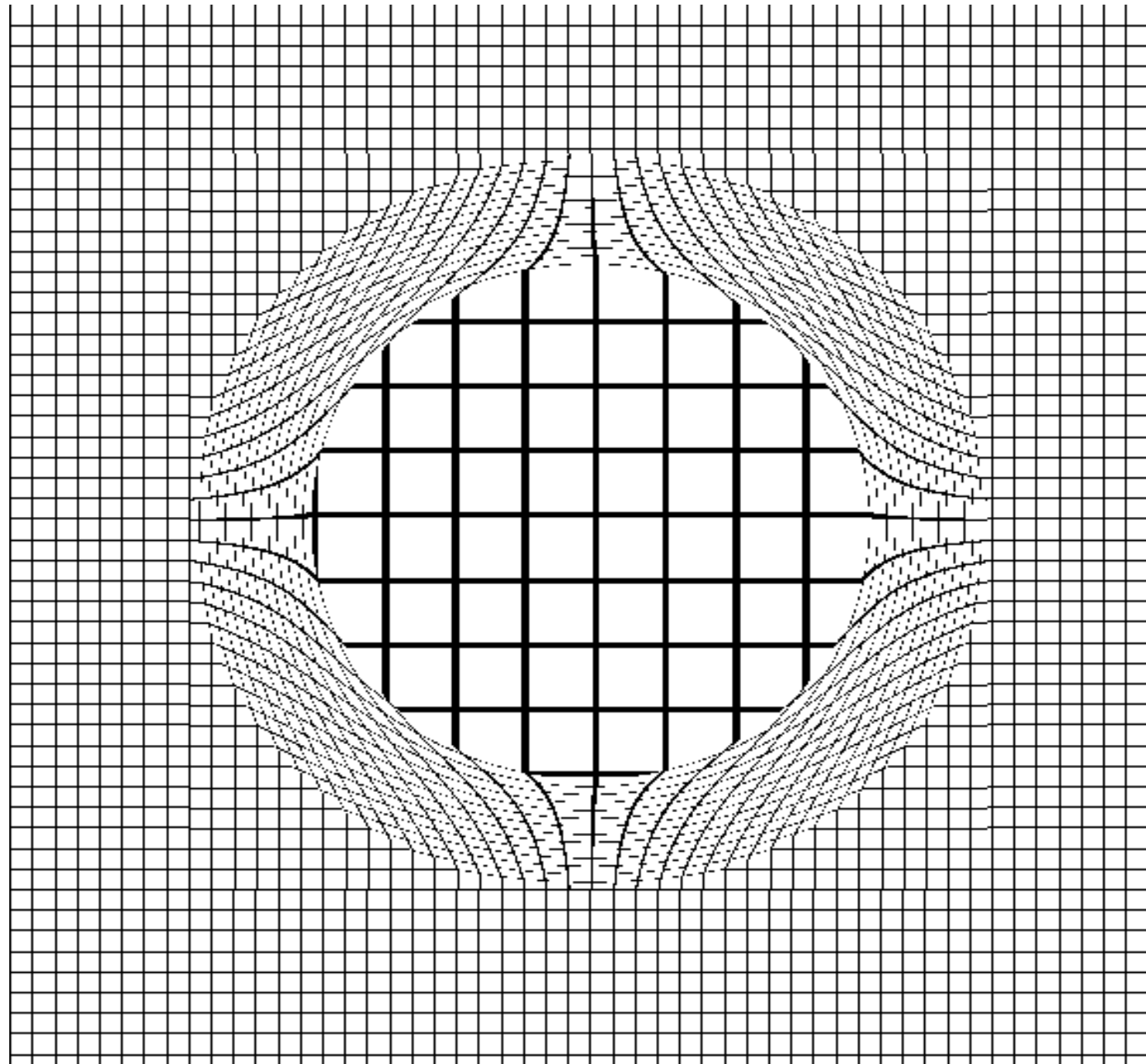




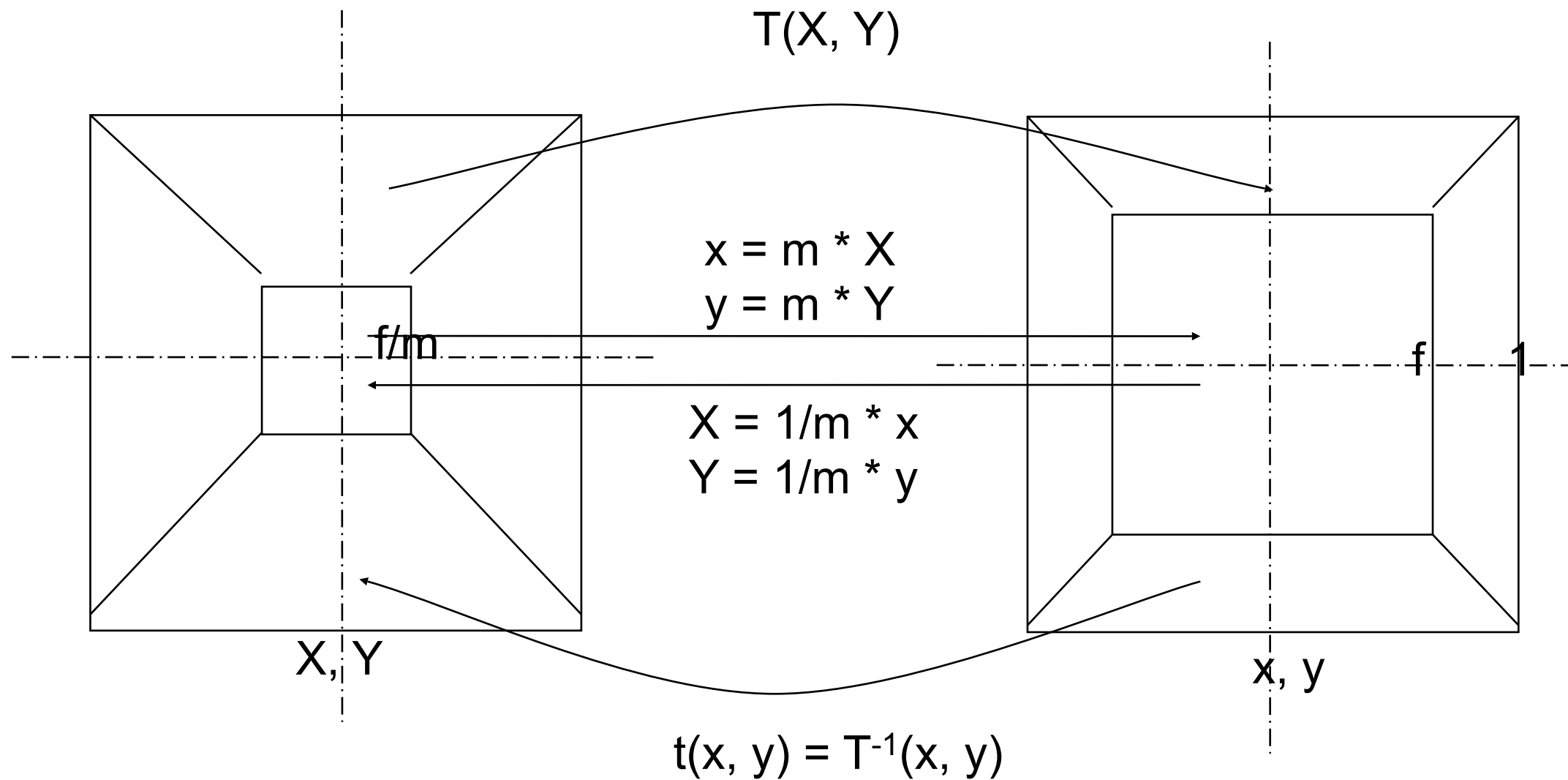
# 2-dimensional Fisheye

Bifocal  
transfer  
function

using polar  
coordinates



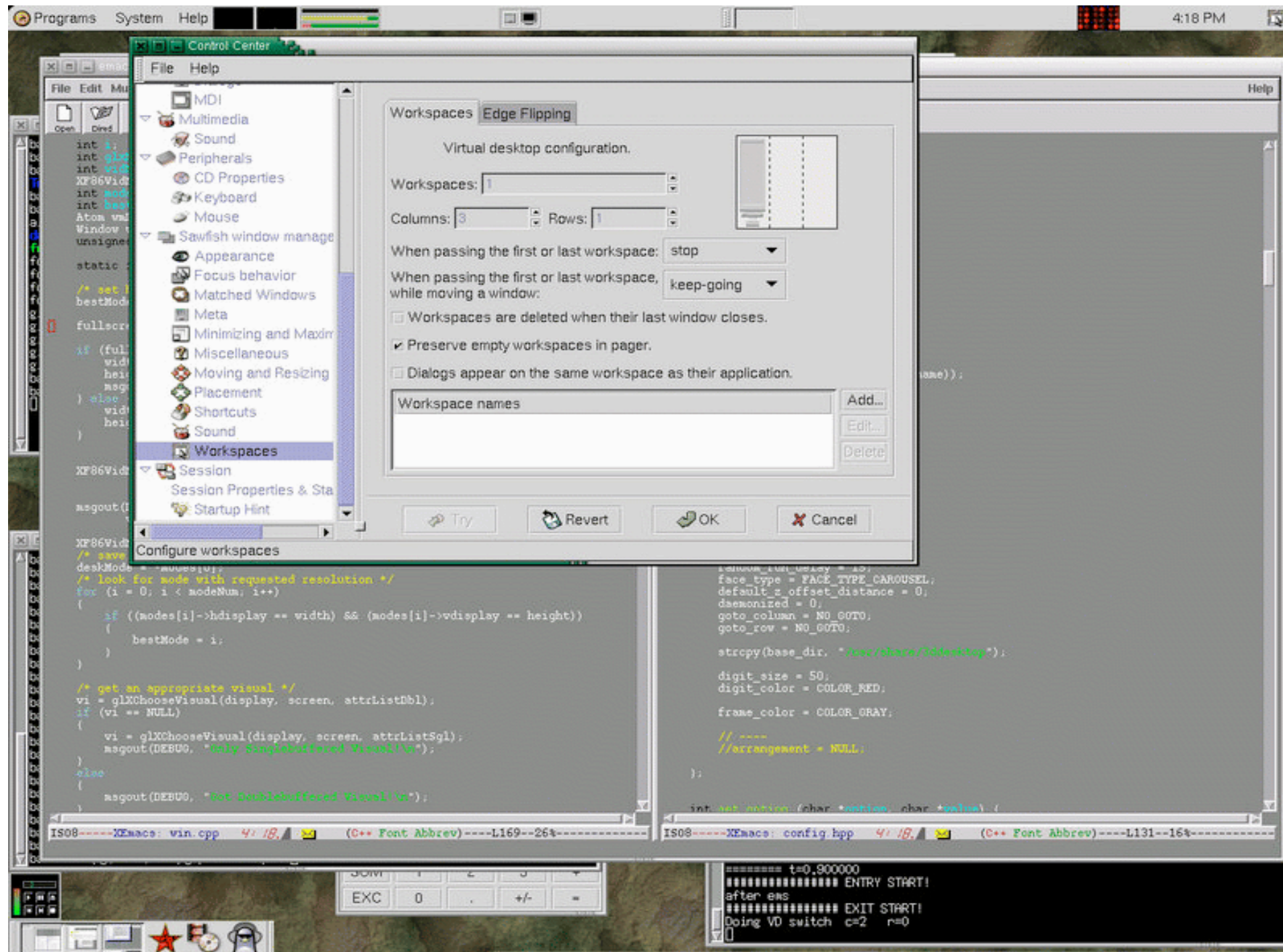
# 2-dimensional Fisheye



# Hints for Programming

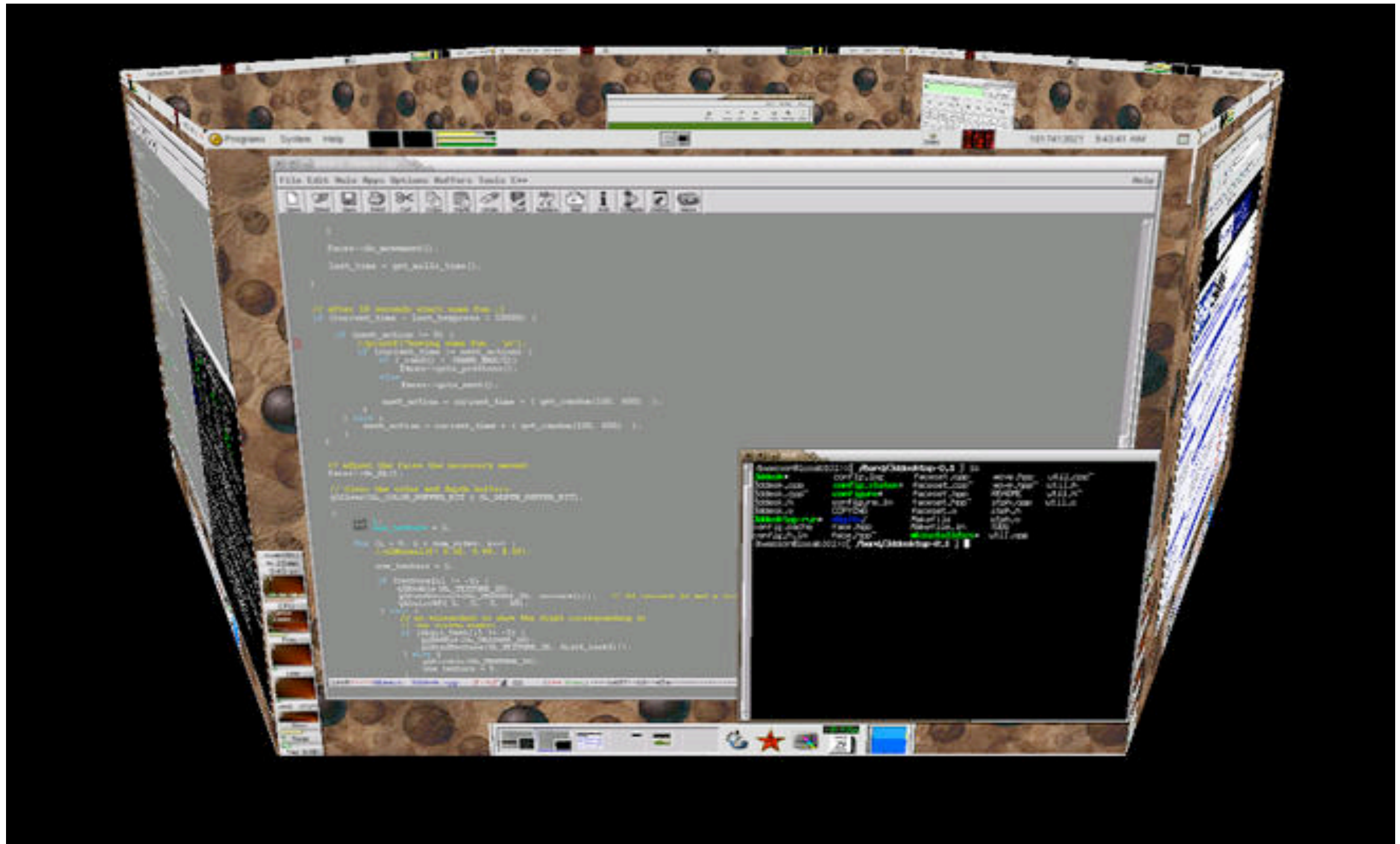
- For bitmaps iterate over the pixel of the destination bitmap using the inverse transfer function  $(X, Y) = T^{-1}(x, y)$ 
  - No pixels are left out
  - The number of pixel are less
- The multiplication of integers and floats may have unexpected results!

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

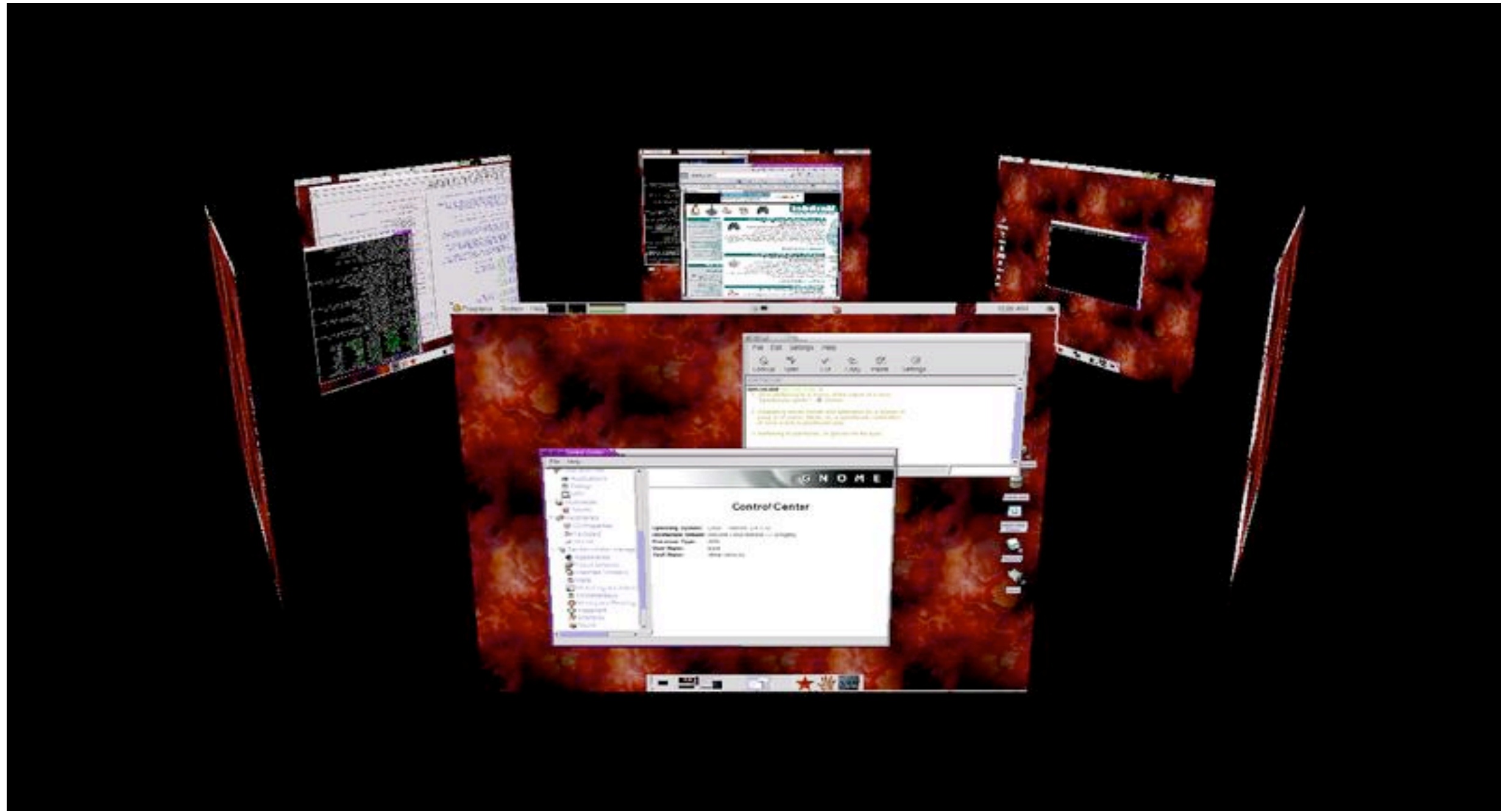




# 3D Desktop - <http://desk3d.sourceforge.net/> switching virtual desktops in 3D



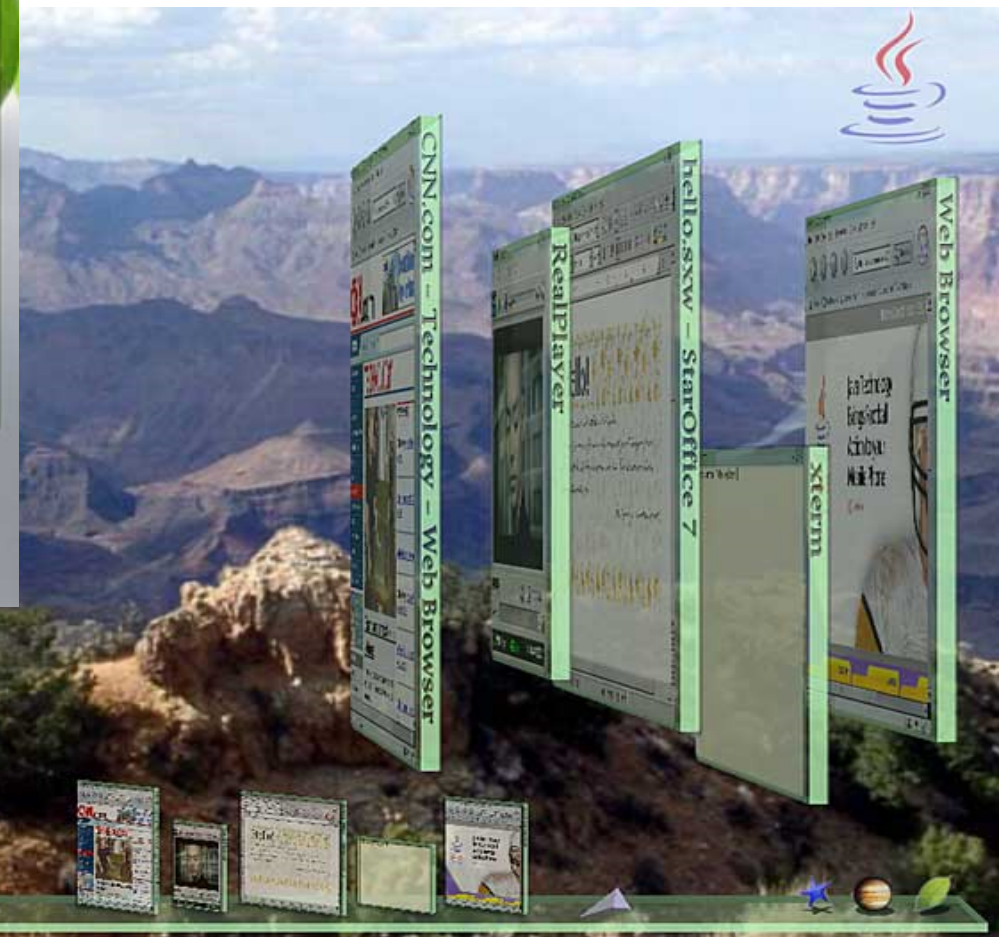
# 3D Desktop - <http://desk3d.sourceforge.net/> switching virtual desktops in 3D





# Sun: Project Looking Glass functional 3D-Desktop

Video ~ 6min



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

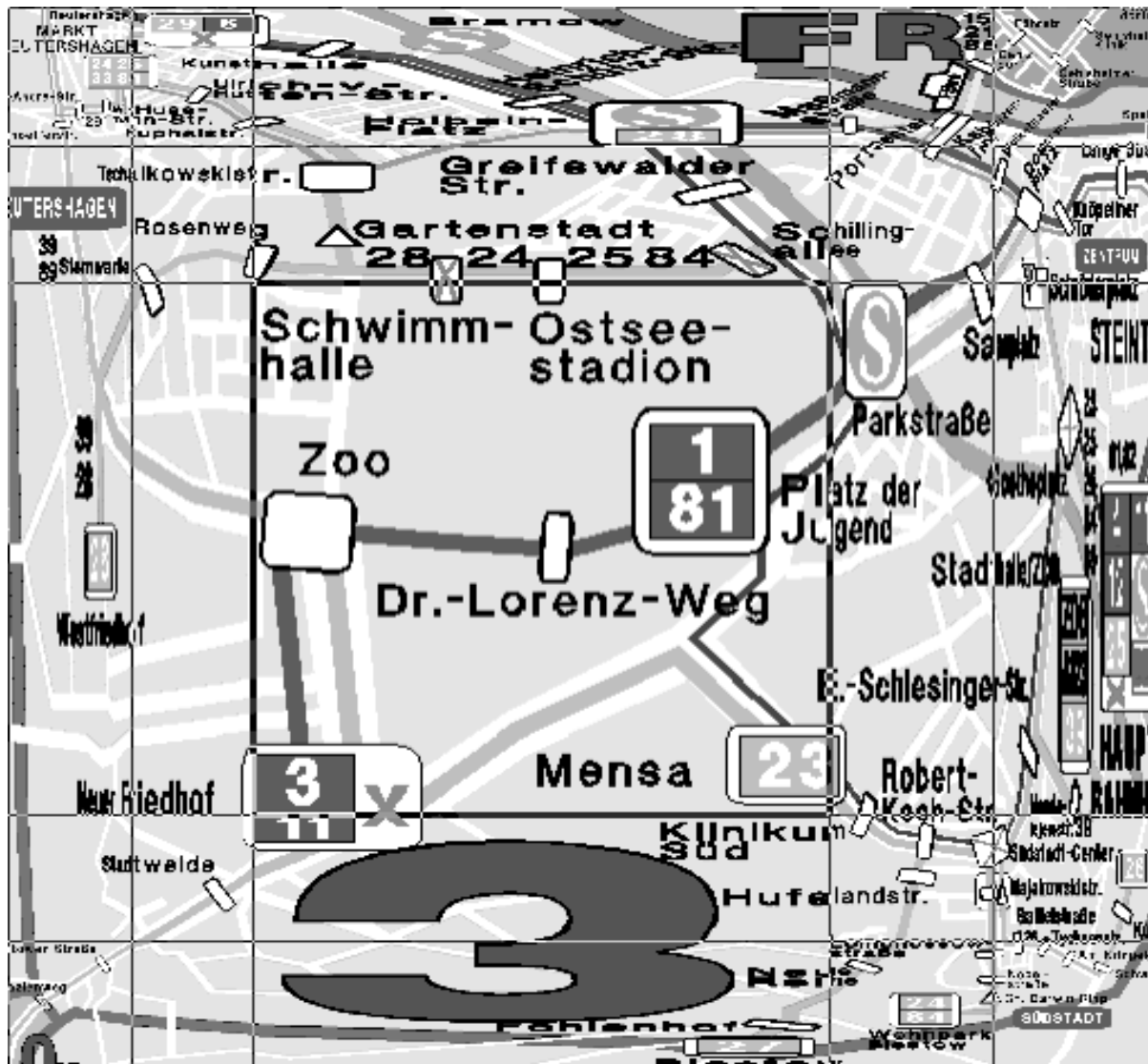
# Visualization on Mobile Devices

- 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://www.icg.informatik.uni-rostock.de/Projekte/MoVi/Publications/ICIP99/>

# Rectangular Fish Eye View saving bandwidth in transmission



Figure 3: Rectangular fish eye view example

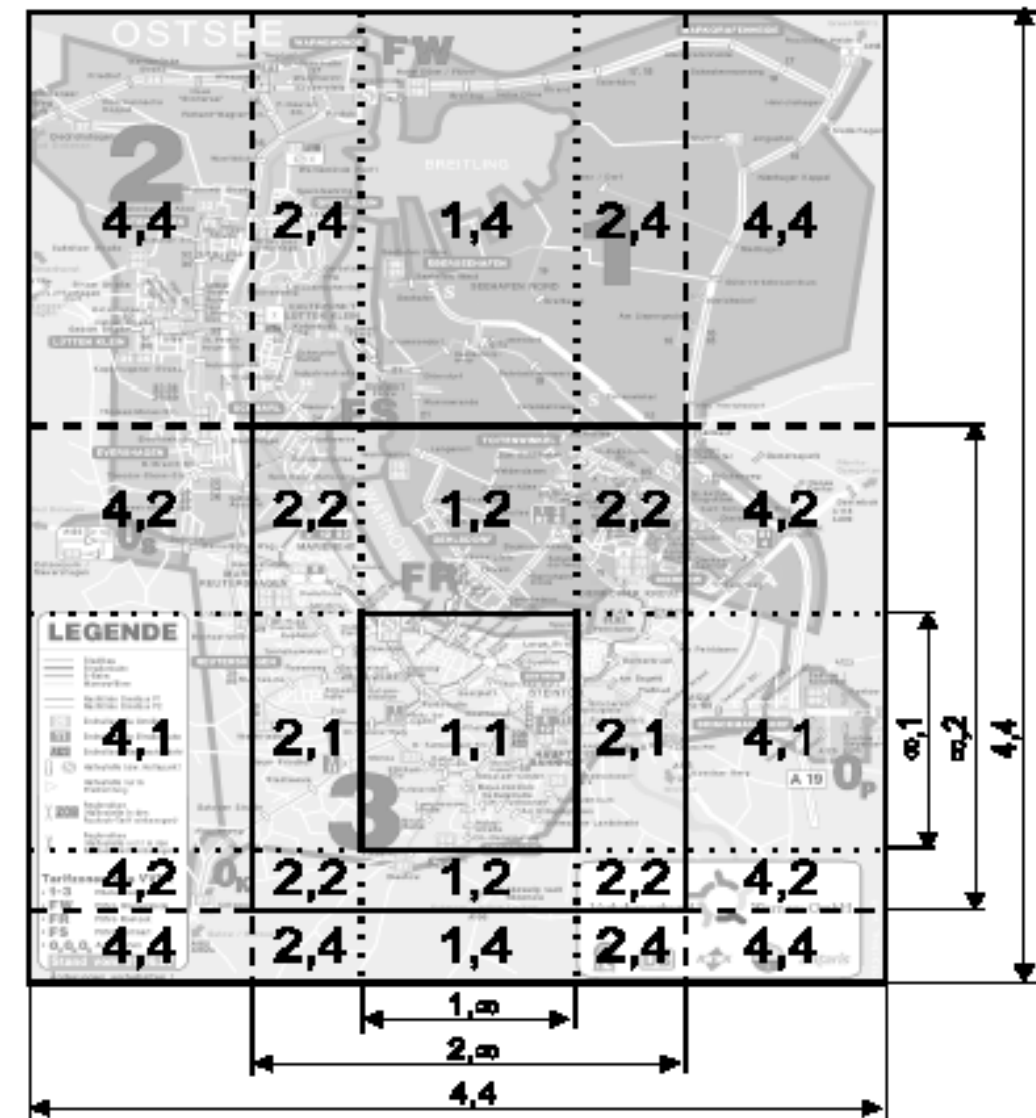


Figure 4: Generating Rol grid

# 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

