

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

Ludwig-Maximilians-Universität München  
LFE Medieninformatik  
Heinrich Hußmann & Albrecht Schmidt  
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<http://www.medien.informatik.uni-muenchen.de/>

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## Chapter 2: Information Visualization

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# Fisheye Views

Principles, Applications and  
Programming

Heiko Drewes

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## 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.rolfwiegst.com](http://www.rolfwiegst.com)

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

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## The Fisheye View Metaphor

In many contexts, humans often represent their own "neighborhood" in great detail, yet only major landmarks further away.

(George W. Furnas - CHI 1986)

The fisheye metaphor is more than a distortion of an image to display. It can be applied to many fields – networks, hierarchical structures.

All you need is a metric/context/distance function, that means something that tells whether another object is far or near.

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## The Fisheye View Theory

(George W. Furnas - CHI 1986)

**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.

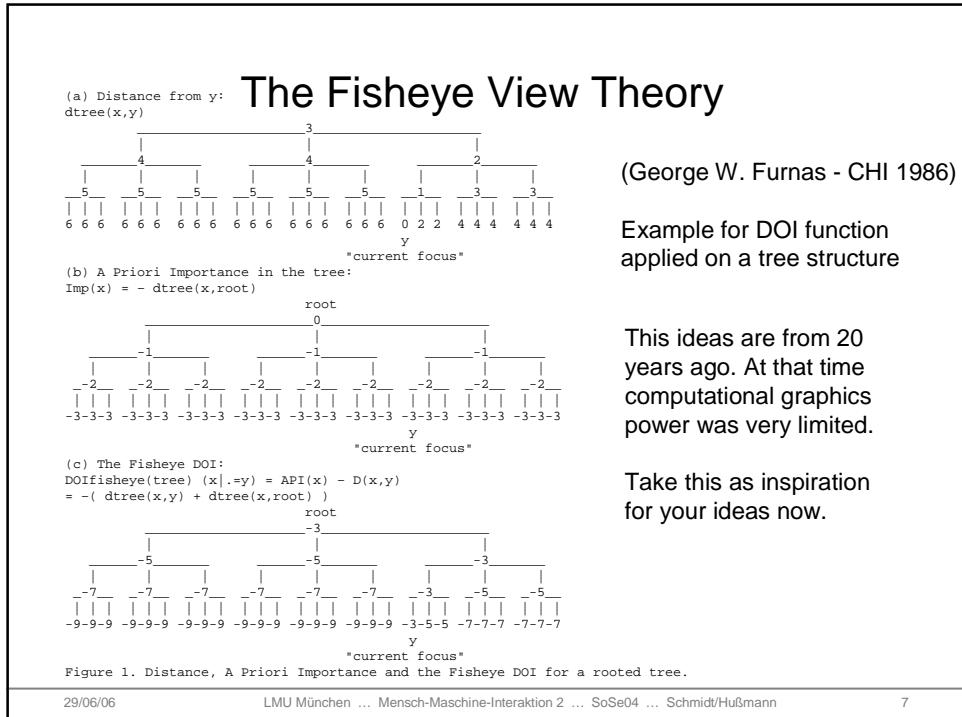
API(a): static global a priori importance measure.

D(a,b): distance between a and b.

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(George W. Furnas - CHI 1986)

Example for DOI function applied on a tree structure

This ideas are from 20 years ago. At that time computational graphics power was very limited.

Take this as inspiration for your ideas now.

**The Fisheye View Theory**

(George W. Furnas  
-CHI 1986)

A Fisheye Calendar.

S	M	T	W	Th	F	S
Dec 18	19	20	21	22	23	24
Dec 19	20	21	22	23	24	25
Dec 20	21	22	23	24	25	26
Dec 21	22	23	24	25	26	27
Dec 22	23	24	25	26	27	28
Dec 23	24	25	26	27	28	29
Dec 24	25	26	27	28	29	30
Dec 25	26	27	28	29	30	31

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## The Fisheye View Theory

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

Large Volumes of Data	
Inherently Graphical Data	Non-Graphical Data
direct	graphical abstraction
Large Information Space (Graphical)	Large Information Space (Non-Graphical)
Distorted View (Detail in context)	Non-Distorted View (Detail with little or no context)
encoding spatial transformation (geometric)	zooming windowing
data suppression (abstraction and thresholding)	paging clipping

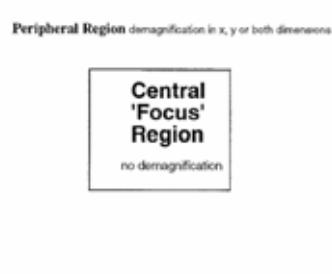
Fig. 1. A taxonomy of presentation techniques for large graphical data spaces.

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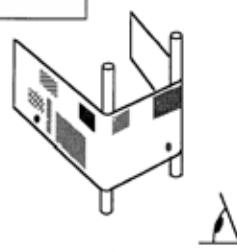
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## The Fisheye View Theory

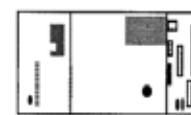


(Y. K. Leung,  
M. D. Apperley 1994)

Metaphor of a perspective wall



(a)



(b)

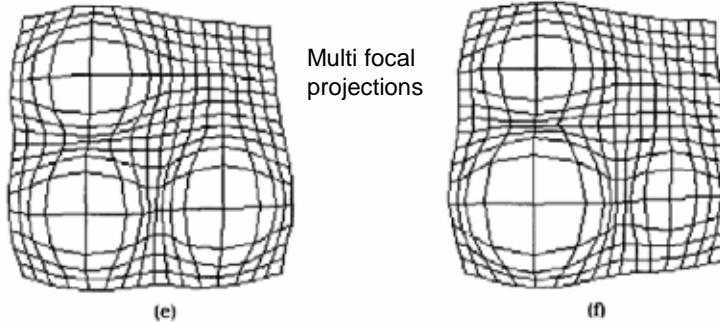
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## The Fisheye View Theory

- Unified theory of distortion techniques (Y. K. Leung,  
M. D. Apperley 1994)
- "...stretchable rubber sheet mounted on a rigid frame"
  - Stretching = Magnification
  - Stretching one part must equal shrinkage in other areas



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## Fisheye Views Applications

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

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# 1-dimensional Fisheye

- Time axis
  - historical calendar
  - story line
- Menus

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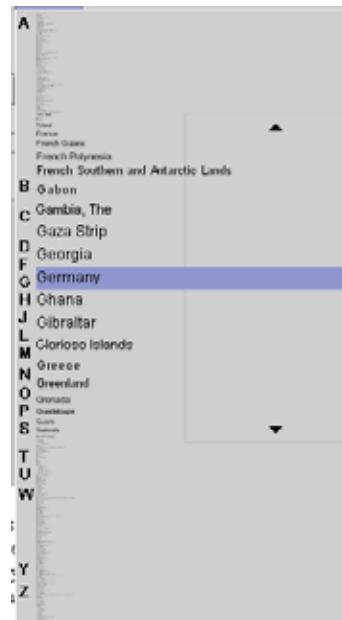
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# 1-dimensional Fisheye

## Example: Fisheye Menu

Benjamin B. Bederson.  
Fisheye Menus. UIST'00

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



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# 1-dimensional Fishey

Fishey Table

Unit	State	County	Output	Problems	Health
Unit1	Arizona	A	10	1	9
Unit2	Arizona	B	15	1	9
Unit3	Arizona	C	20	1	9
Unit4	Arizona	D	25	0	9
Unit5	Arizona	E	30	1	9
Unit6	Arizona	F	50	0	9
Unit7	Arizona	G	50	0	9
Unit8	Nebraska	V	90	2	9
Unit9	Nebraska	V	90	1	9
Unit10	Nebraska	V	90	2	8
Unit11	Nebraska	F	50	3	7
Unit12	Nebraska	P	70	0	9
Unit13	Nebraska	P	60	1	9
Unit14	Nebraska	P	50	1	8
Unit15	Nebraska	P	90	0	9
Unit16	Nebraska	P	90	0	9
Unit17	Nebraska	Q	90	0	9
Unit18	Nebraska	Q	90	1	9
Unit19	Nebraska	Q	90	1	9
Unit20	Nebraska	S	50	0	9
Unit21	Nebraska	S	50	0	9
Unit22	Nebraska	S	50	0	9
Unit23	Nebraska	S	50	0	9
Unit24	Nebraska	S	50	0	9
Unit25	Nebraska	S	50	0	9
Unit26	Nebraska	S	50	0	9
Unit27	Nebraska	S	50	0	9
Unit28	Nebraska	S	50	0	9
Unit29	Nebraska	S	50	0	9
Unit30	Nebraska	S	50	0	9
Unit31	Nebraska	S	50	0	9
Unit32	Nebraska	S	50	0	9
Unit33	Nebraska	S	50	0	9
Unit34	Nebraska	S	50	0	9
Unit35	Nebraska	S	50	0	9
Unit36	Nebraska	S	50	0	9
Unit37	Nebraska	S	50	0	9
Unit38	Nebraska	S	50	0	9
Unit39	Nebraska	S	50	0	9
Unit40	Nebraska	S	50	0	9
Unit41	Nebraska	S	50	0	9
Unit42	Nebraska	S	50	0	9
Unit43	Nebraska	S	50	0	9
Unit44	Nebraska	S	50	0	9
Unit45	Nebraska	S	50	0	9
Unit46	Nebraska	S	50	0	9
Unit47	Nebraska	S	50	0	9
Unit48	Nebraska	S	50	0	9
Unit49	Nebraska	S	50	0	9
Unit50	Nebraska	S	50	0	9
Unit51	Nebraska	P	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	Nebraska	S	50	0	9
Unit61	Nebraska	S	50	0	9
Unit62	Nebraska	S	50	0	9
Unit63	Nebraska	S	50	0	9
Unit64	Nebraska	S	50	0	9
Unit65	Nebraska	S	50	0	9
Unit66	Nebraska	S	50	0	9
Unit67	Nebraska	S	50	0	9
Unit68	Nebraska	S	50	0	9
Unit69	Nebraska	S	50	0	9
Unit70	Nebraska	S	50	0	9
Unit71	Nebraska	S	50	0	9
Unit72	Nebraska	S	50	0	9
Unit73	Nebraska	S	50	0	9
Unit74	Nebraska	S	50	0	9
Unit75	Nebraska	S	50	0	9
Unit76	Nebraska	S	50	0	9
Unit77	Nebraska	S	50	0	9
Unit78	Nebraska	S	50	0	9
Unit79	Nebraska	S	50	0	9
Unit80	Nebraska	S	50	0	9
Unit81	Nebraska	S	50	0	9
Unit82	Nebraska	S	50	0	9
Unit83	Nebraska	S	50	0	9
Unit84	Nebraska	S	50	0	9
Unit85	Nebraska	S	50	0	9
Unit86	Nebraska	S	50	0	9
Unit87	Nebraska	S	50	0	9
Unit88	Nebraska	S	50	0	9
Unit89	Nebraska	S	50	0	9
Unit90	Nebraska	S	50	0	9
Unit91	Nebraska	S	50	0	9
Unit92	Nebraska	S	50	0	9
Unit93	Nebraska	S	50	0	9
Unit94	Nebraska	S	50	0	9
Unit95	Nebraska	S	50	0	9
Unit96	Nebraska	S	50	0	9
Unit97	Nebraska	S	50	0	9
Unit98	Nebraska	S	50	0	9
Unit99	Nebraska	S	50	0	9
Unit100	Nebraska	S	50	0	9

# 2-dimensional Fishey

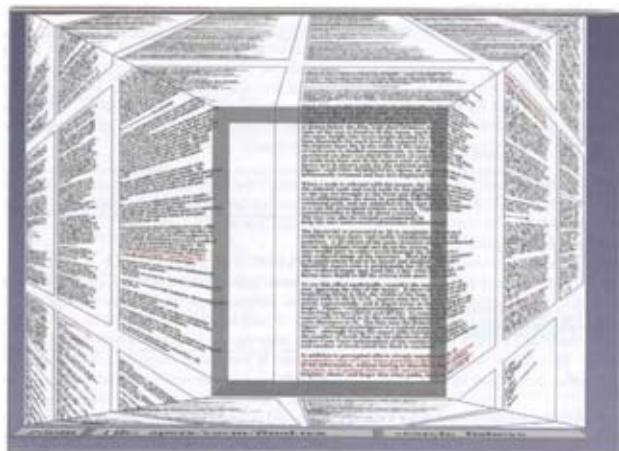
- Typically surfaces
  - geographical/topological data i.e. maps
  - desktop

Fishey views controlled with the mouse avoid the scrolling interactions but also speeds up the mouse velocity.  
(Think about a fisheye view for Google Earth)

## 2-dimensional Fisheye

Document Lens

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



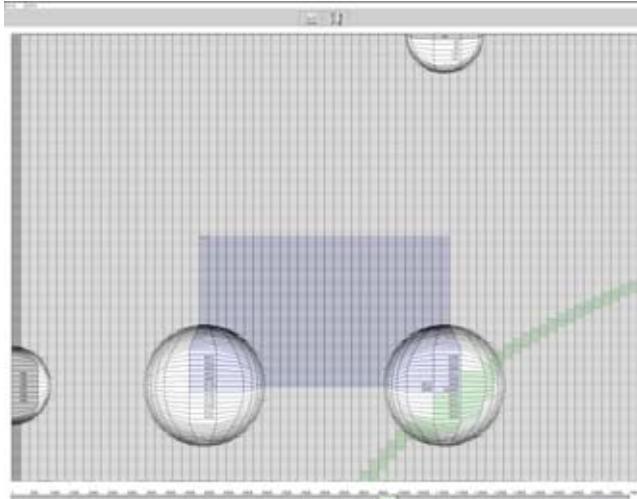
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## 2-dimensional Fisheye

**FiCell Project**  
[http://iigm.imag.  
fr/vernier/](http://iigm.imag.fr/vernier/)



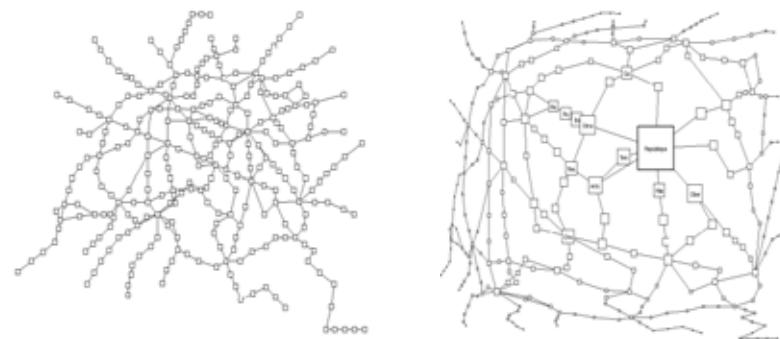
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## 2-dimensional Fisheye

Fisheyes applied to networks



Manojit Sarkar and Marc H. Brown 1992

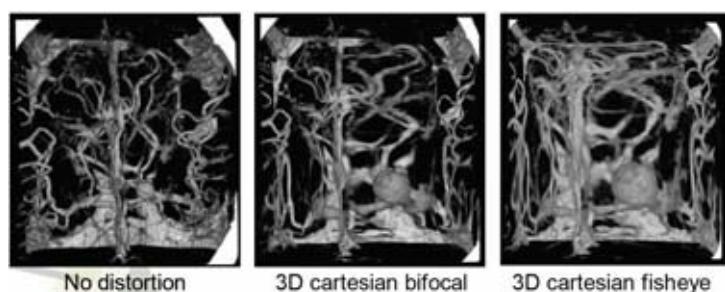
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## 3-dimensional Fisheye

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



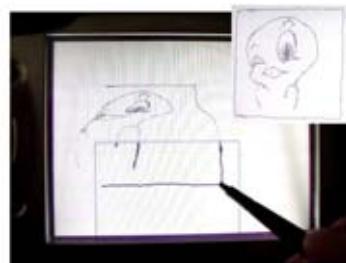
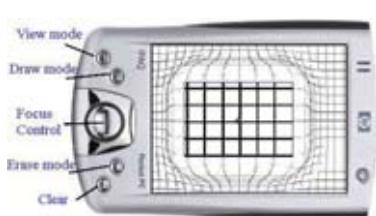
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# Fisheye for input

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



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# Fisheye for input

Paper/Video from Mitsubishi

Forlines, C.; Balakrishnan, R.; Beardsley, P.; van Baar, J.; Raskar, R.,  
"Zoom-and-Pick: Facilitating Visual Zooming and Precision Pointing with  
Interactive Handheld Projectors", ACM Symposium on User Interface  
Software and Technology (UIST), ISBN: 1-59593-271-2, pp. 73-82,  
October 2005 (ACM Press)

[http://www.merl.com/people/forlines/papers/2005\\_forlines\\_zoom\\_and\\_pick.pdf](http://www.merl.com/people/forlines/papers/2005_forlines_zoom_and_pick.pdf)  
[http://www.merl.com/people/forlines/videos/MERL\\_ZoomAndPick\\_highRes.mov](http://www.merl.com/people/forlines/videos/MERL_ZoomAndPick_highRes.mov)

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# How to program

## Fisheyes

for bitmaps

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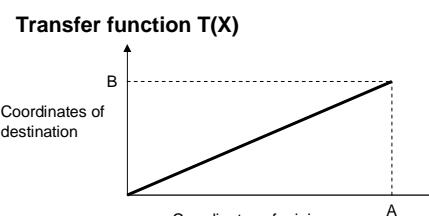
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## 1-dimensional Fisheye

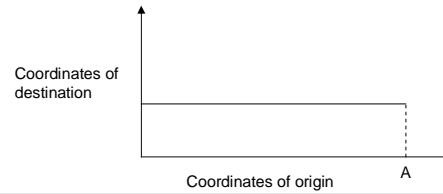
Normal scaling: Display an object of size A on a window of width B

The magnifier function is  
the first derivate of the  
transfer function

The transfer function is the  
integral of the magnifier  
function



**Magnifier function M(X)**



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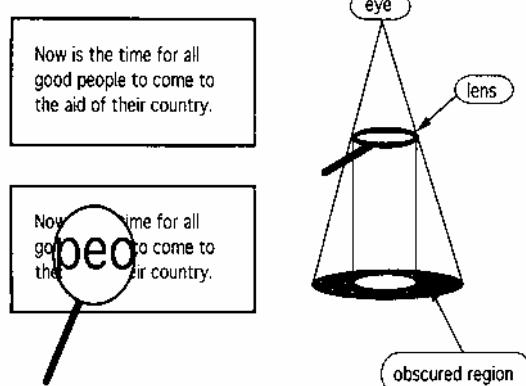
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# 1-dimensional Fisheye

The problem with the magnifier:

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



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# 1-dimensional Fisheye

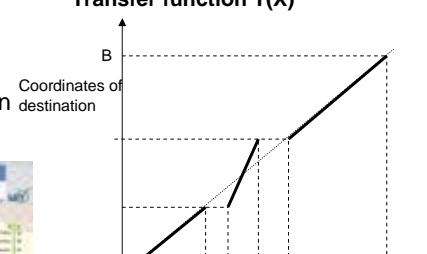
The problem with the magnifier:

Parts of the origin will not appear at the destination.

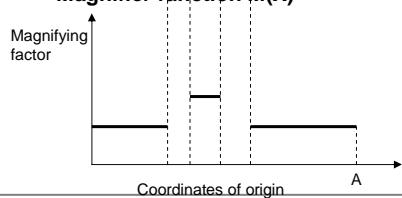
In the picture below the Central Station is visible, but not Marienplatz



Transfer function  $T(X)$



Magnifier function  $M(X)$



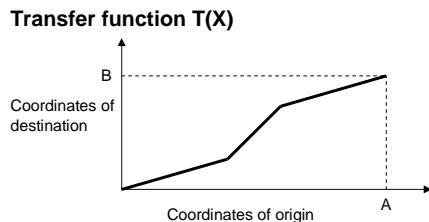
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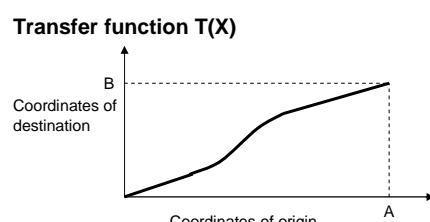
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# 1-dimensional Fisheye

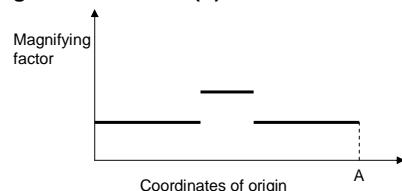
Bifocal:



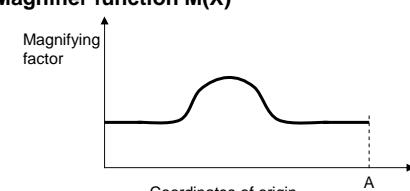
Continuous:



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



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



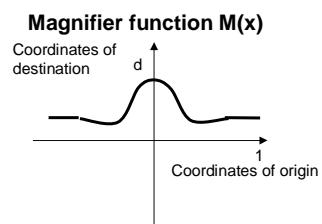
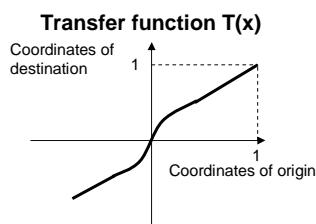
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# 1-dimensional Fisheye

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.



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

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

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# 1-dimensional Fisheye

Transfer functions from  
Y.K.Leung and M.D.Apperley

Table A.II. A Summary of Transformation and Magnification Functions

	Transformation Function T(x)	Magnification Function M(x)	Perspective Wall
Polyfocal Projection	$x + \frac{A.x}{(1+C.x^2)}$	$\frac{1+A.(1-C.x^2)}{(1+C.x^2)^2}$	for $x \leq a$ , $\frac{b}{a}$
			for $x > a$ , $\frac{[b+(x-a)\cos\theta]}{1-\frac{[(1-b)-\cos\theta](x-a)}{(1-a)}} = \frac{b.k+(1-b)\cos\theta}{[(k-\cos\theta).x+(a.\cos\theta-a.k-1)]^2}$ note: $k = \frac{(1-b)}{(1-a)}$
Fisheye View	$\frac{(1+d).x}{(d.x+1)}$	$\frac{d+1}{(d.x+1)^2}$	Bifocal Display
			for $x \leq a$ , $\frac{b}{a}$
			for $x > a$ , $b+(x-a)\frac{(1-b)}{(1-a)} = \frac{(1-b)}{(1-a)}$

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# 2-dimensional Fisheye

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



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## 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:

$$W(Y) = Y$$

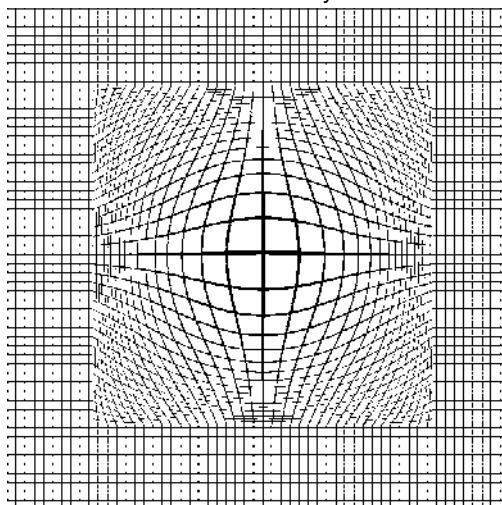
$$W(Y) = Y^2$$

## 2-dimensional Fisheye

Continuous  
transfer  
function

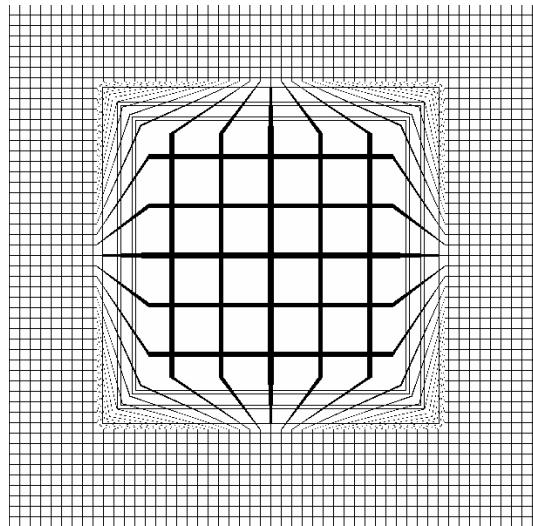
using  
Cartesian  
coordinates

The visualization of the fisheye visualization



## 2-dimensional Fisheye

Bifocal  
transfer  
function  
  
using  
Cartesian  
coordinates

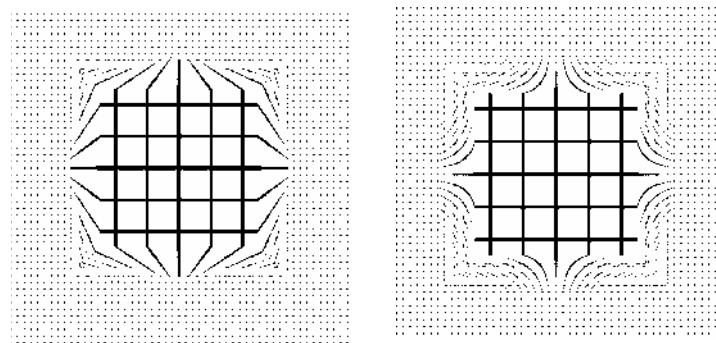


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## 2-dimensional Fisheye



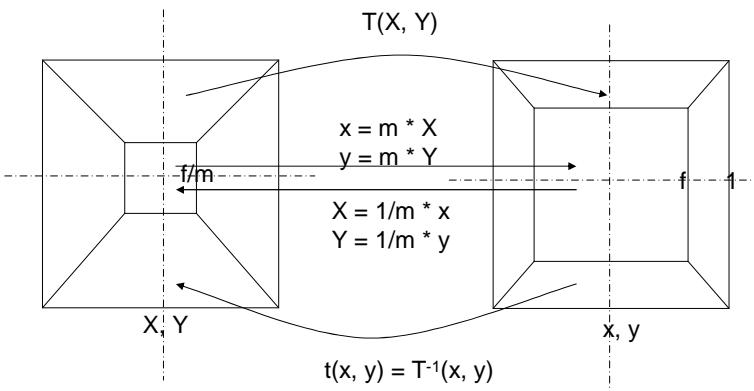
What is the difference?

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## 2-dimensional Fisheye



This is one part of the exercise

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## 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.

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

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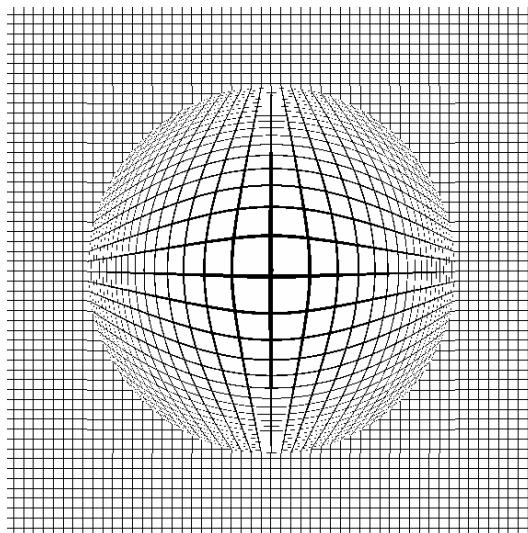
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## 2-dimensional Fisheye

Continuous  
transfer  
function

using polar  
coordinates



This is the  
other part of  
the exercise

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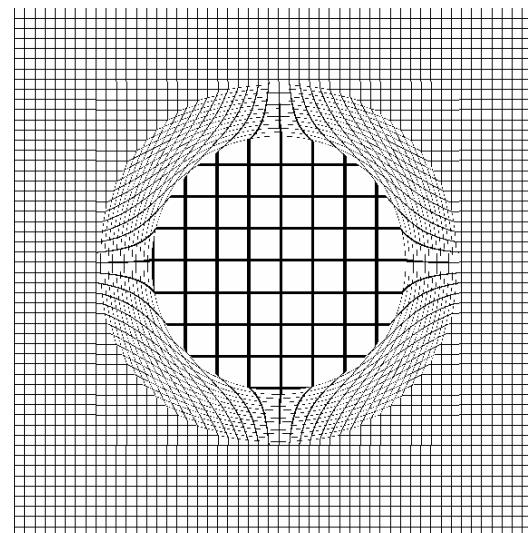
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## 2-dimensional Fisheye

Bifocal  
transfer  
function

using polar  
coordinates



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## 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 pixels are less
- The multiplication of integers and floats may have unexpected results!
- Use well chosen names for variables

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## Chapter 3: Mobile HCI

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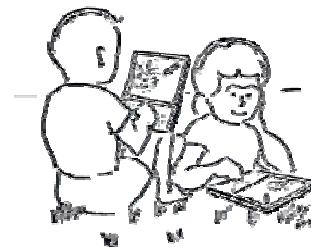
- Input & Output Devices
- Input & Output Techniques
- Guidelines
- System Architectures for Mobile UIs
- Example: Applications for Mobile Phones

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## Dynabook Vision



- Handheld,
- wireless connectivity,
- multimedia capabilities
- support for programming

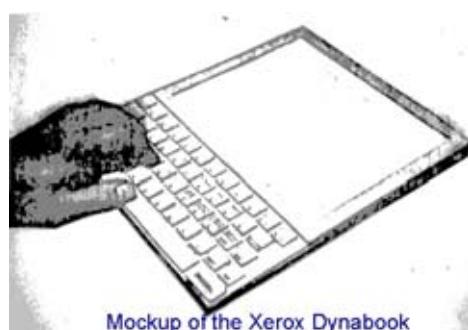
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## Mobile Computing / mobile UIs 1972 Xerox Dynabook

- Alan Kay's group at Xerox PARC
- First description of “mobile computing” with a focus on the UI?
- a portable interactive personal computer, as accessible as a book
- a computer for children (learning aid)
- Big problem: software that facilitates dynamic interactions between the computer and its user



Mockup of the Xerox Dynabook

<http://www.honco.net/os/kay.html>

The Dynabook Revisited - A Conversation with Alan Kay

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# Mobile User Interfaces

- “Beyond the laptop...”
- Devices are used while the user is mobile
  - Handhelds & PDAs
  - Phones
  - Wearable Computer
  - Tablet Computers
  - Car Infotainment system

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## Apple Newton Commercial Handheld Computer

- Recognition Architecture
  - Recognizes handwriting--printed, cursive, or a mixture of the two--with the assistance of a 93,000-word, built-in word list
  - Lets you add up to 1,000 words
  - Includes four pop-up keyboards: typewriter, numeric, phone, and time/date
  - Recognizes graphics and symmetrical objects
- 320 by 240 pixels Display
- Sold from 1993



<http://www.oldschool.net/newton/papers/index130.html>

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# Itsy Pocket Computer



- Research platform
- Gesture and speech interaction
- *tilt-to-scroll* and *Rock 'n' Scroll* to include the use of gestures to issue commands.
  
- <http://research.compaq.com/wrl/projects/itsy/itsy.html>
- <http://research.compaq.com/wrl/projects/itsy/movies.html>

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## Input to Mobile Devices What to input?

- Commands
- Text
- Drawings/sketches
- Images
- Audio
- Movies

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# Input to Mobile Devices

## How to input?

- Keyboards
  - Full-size
  - Miniature
  - Chord-keyboard
  - On-screen
- Stylus
  - Point and click
  - Handwriting recognition
- hard buttons / wheels
  - Scroll wheels
  - Joypad-style navigation
- Capture
  - Camera
  - microphone
- Future devices
  - Tilt scrolling
  - Virtual workspaces

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# Input Technologies for Mobile Devices

- Soft Keyboards
- Screen Keyboards



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# Input Technologies for Mobile Devices

- Keyboards



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# Input Technologies for Mobile Devices

- Virtual Keyboards
- Projection Keyboards



<http://www.alpern.org/weblog/stories/2003/01/09/projectionKeyboards.html>

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## Input Technologies for Mobile Devices

- Chord Keyboard
- One-handed Keyboards
- Example Twiddler
  - Combines keyboard and Mouse
  - keypad designed for "chord" keying  
This means you press one or more keys at a time. Each key combination generates a unique character or command.
  - 12 finger keys and 6 thumb keys, the twiddler can emulate the 101 keys on the standard keyboard



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## Yoyo Input Device designed for artic environments



Figure 5. The Yo-Yo user interface.

- Smart Clothing for the Arctic Environment by J. Rantanen et al. in proceedings of the int. Symposium on Wearable Computing 2000 (ISWC2000)

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