Chapter 2: Information Visualization
Fisheye Views

Principles, Applications and Programming

Heiko Drewes

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 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.

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.
The Fisheye View Theory

(a) Distance from y:
\[ \text{dist}(x,y) \]

(b) A Priori Importance in the tree:
\[ \text{Imp}(x) = -\text{dist}(x, \text{root}) \]

(c) The Fisheye DOI:
\[ \text{DOI}_{\text{fisheye}}(x|.=y) = \text{API}(x) - \text{D}(x,y) \]
\[ = -(\text{dist}(x,y) + \text{dist}(x, \text{root})) \]

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.

A Fisheye Calendar.
The Fisheye View Theory

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 (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

Fisheye Views Applications

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

- Time axis
  - historical calendar
  - story line
- Menus

Example: Fisheye Menu

Benjamin B. Bederson.
Fisheye Menus. UIST’00

1-dimensional Fisheye

Fisheye Table

<table>
<thead>
<tr>
<th>Unit</th>
<th>State</th>
<th>County</th>
<th>Output</th>
<th>Problems</th>
<th>Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1</td>
<td>K</td>
<td>K</td>
<td>K</td>
<td>K</td>
<td>K</td>
</tr>
<tr>
<td>K2</td>
<td>K</td>
<td>K</td>
<td>K</td>
<td>K</td>
<td>K</td>
</tr>
<tr>
<td>K3</td>
<td>K</td>
<td>K</td>
<td>K</td>
<td>K</td>
<td>K</td>
</tr>
<tr>
<td>K4</td>
<td>K</td>
<td>K</td>
<td>K</td>
<td>K</td>
<td>K</td>
</tr>
</tbody>
</table>

2-dimensional Fisheye

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

Fisheye 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)

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,
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.,

http://www.merl.com/people/forlines/videos/MERL_ZoomAndPick_highRes.mov
How to program

Fisheyes

for bitmaps

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 $T(X)$

Coordinates of origin

Coordinates of destination

Magnifier function $M(X)$

Coordinates of origin

Coordinates of destination

$B$

$A$
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.
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 \(1\).

\[
T(X) = \frac{(1 + d) \cdot X}{(d + X + 1)} \\
M(X) = \frac{(d + 1)}{(d + X + 1)^2}
\]
1-dimensional Fisheye

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

<table>
<thead>
<tr>
<th>Physical Projection</th>
<th>Magnification Function Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish Eye View</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transformation Function f(x)</th>
<th>Magnification Function Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>x \rightarrow \frac{Ax}{(1 + Cx^2)}</td>
<td>1 \rightarrow \frac{A(B - Cx^2)}{(1 + Cx^2)^2}</td>
</tr>
</tbody>
</table>

| x \rightarrow \frac{(d + b) x}{(d + x)^2} | y \rightarrow \frac{a}{(d + x)^2} |

2-dimensional Fisheye

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

<table>
<thead>
<tr>
<th>Perspective Wall</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>for x \leq a, x \rightarrow \frac{b}{a}</td>
<td></td>
</tr>
<tr>
<td>for x &gt; a, \frac{b}{1 + \cos d} \rightarrow \frac{b k - (1 - k) \cos \theta}{1 - \cos d}</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visual Display</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>for x \leq a, x \rightarrow \frac{b}{a}</td>
<td></td>
</tr>
<tr>
<td>for x &gt; a, x \rightarrow \frac{b}{1 + \cos d}</td>
<td></td>
</tr>
</tbody>
</table>

| for x \leq a, y \rightarrow \frac{b}{a} | |
| for x > a, y \rightarrow \frac{b}{1 + \cos d} | |
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 fisheye 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")

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

Examples:

$W(Y) = Y$
$W(Y) = Y^2$
2-dimensional Fisheye

Bifocal transfer function using Cartesian coordinates

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.

\[ T(r, \phi) = (T_{1\text{dim}}(r), \phi) \]
2-dimensional Fisheye

Continuous transfer function using polar coordinates

This is the other part of the exercise

2-dimensional Fisheye

Bifocal transfer function using polar coordinates
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!
- Use well chosen names for variables

Chapter 3: Mobile HCI

Table of Content

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

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

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

http://www.honco.net/os/kay.html
The Dynabook Revisited - A Conversation with Alan Kay
Mobile User Interfaces

- “Beyond the laptop…”

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

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
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.


Input to Mobile Devices
What to input?

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

Input Technologies for Mobile Devices

- **Soft Keyboards**
- **Screen Keyboards**
Input Technologies for Mobile Devices

- Keyboards

Input Technologies for Mobile Devices

- Virtual Keyboards
- Projection Keyboards

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

Yoyo Input Device
designed for artic environments

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