11. Presentation Approaches II
Dealing with the presentation problem

Vorlesung „Informationsvisualisierung”
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Outline

• Introduction focus&context
• Generalized fisheye view
• Graphical fisheye
  – Early examples
  – Graph fisheye
  – Multiple foci
  – Speed-Coupled Flattening
  – Symbolic Representation of Context
• Use-case: mobile devices
• Designing mobile scatterplot displays
Focus+Context

- Recap presentation problem: information space is too large to be displayed on a single screen
- Approaches in previous lecture
  - Zoomable user interface: scale and translate a single view of the information space
  - Overview+detail: use multiple views with different scale / detail granularity
- Focus+Context (f+c) means a presentation technique where both focus and context information are integrated into a single view by employing distortion
  - Local detail for interaction
  - Context for orientation
- No need to zoom out to regain context as in ZUIs
- No need to switch and relate between multiple separate views as in overview+detail interfaces
- Focus+context is commonly known as fisheye views
Generalized Fisheye Views

• Furnas 1986
• Idea: trade-off of detail with distance
• Naturally occurring, e.g.
  – Employees being asked about the management structure: they know local department heads, but only the Vice president of remote divisions
  – Regional newspaper contain local news stories and only more distant ones that are compensatingly of greater importance (e.g. war in a remote country)
• Formalization
  – Presentation problem: interface can only display $n$ items of a structure that has a number of items $> n$
  – Degree-of-interest function: assign importance value to each item in structure - only display the $n$ most important items
Degree-of-Interest

- DOI\textsubscript{fisheye} (x|y) = API(x) - D(x,y)
  - DOI\textsubscript{fisheye} : the users‘ degree of interest in point x, given the focus point y
  - API(x) : Global a priori importance of point x
  - D(x,y) : distance between x and focus point y
- Can be applied to any structure for which the components can be defined

- Example: rooted tree structure of programming code
- Components definition
  - D(x,y) = d\textsubscript{tree}(x,y) = path length between node x and node y in the tree
  - API(x) = –d\textsubscript{tree}(x,root) = distance of node x from the root node (nodes closer to the root are generally more important than nodes further away)
- DOI\textsubscript{fisheye(tree)} (x|y) = API(x) - D(x,y) = –(d\textsubscript{tree}(x,y) + d\textsubscript{tree}(x,root))
Fisheye Tree

(a) Distance from $y$:
\[ d_{fisheye}(x, y) \]

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

(c) The Fisheye DOI:
\[ \text{DOI}_{fisheye}(x, y) = \text{API}(x) - d(x, y) \]
\[ = -(d_{fisheye}(x, y) + d_{fisheye}(x, \text{root})) \]

An arithmetically larger number means that the node is more interesting for interactions focused on $y$.
Fisheye Tree

• To obtain fisheye views of different sizes, set a DOI threshold $k$ with $\text{DOI}(x) > k$

$k = -3; \text{ direct ancestral lineage}$

(a) Zero-order tree fisheye:

$k = -5; \text{ siblings are added}$

(b) First-order tree fisheye:

$k = -7; \text{ cousins are added}$

(c) Second-order tree fisheye:
Fisheye Tree Applied

- Full view of the program
  - Box: lines in default view
  - Underlines: lines in fisheye view

```c
#include <stdio.h>

main()
{
    int c, i, x[DIG/4], t[DIG/4], k = DIG/4, noprint = 0;

    while((c = getchar()) != EOF){
        if(c >= '0' && c <= '9') {  
            x[0] = 10 * x[0] + (c - '0');
            for(i=1;i<k;i++){
                x[i] = 10 * x[i]
                + x[i-1]/10000;
                x[i-1] %= 10000;
            }
            t[k-1] %= 10000;
            break;
        }
    }

    switch(c){
    case '+':
        t[0] = t[0] + x[0];
        for(i=1;i<k;i++){
            t[i] = t[i] + x[i]
            + t[i-1]/10000;
            t[i-1] %= 10000;
        }
        t[k-1] %= 10000;
        break;
    case '-':
        t[0] = (t[0] + 10000)
        - x[0];
        for(i=1;i<k;i++){
            t[i] = (t[i] + 10000)
            - x[i]
            - (1 - t[i-1]/10000);
            t[i-1] %= 10000;
        }
        t[k-1] %= 10000;
        break;
    case 'e':
        for(i=0;i<k;i++) t[i] = x[i];
        break;
    case 'q':
        exit(0);
    default:
        noprint = 1;
        break;
    }

    if(!noprint){
        for(i=k-1;i>=0;i--){
            printf("%d", t[i]);
        }
    }

    putchar(\n"n");
    for(i=0; i > k; i++) x[i] = 0;
}
```
Fisheye Tree Applied

• Working on line marked with „>>“

```c
#define DIG 40
#include <stdio.h>

int main()
{
    int c, i, x[DIG/4], t[DIG/4], k = DIG/4, noprint = 0;
    while((c = getchar()) != EOF)
    {
        if(c >= '0' && c <= '9'){
            ...16
        } else {
            switch(c){
            ...27
            } case 'e':
            >>39
            for(i=0;i<k;i++) t[i] = x[i];
            break;
            case 'q':
            ...38
            exit(0);
            default:
            ...43
            noprint = 1;
            break;
            } if(!noprint){
            ...57
            for(i=k-1;i>=0;i--){
            printf("%d",t[i]);
            if(i > 0) {
```

Figure 3. Standard ‘flat-window’ view of a C program. Line numbers are in the left margin.

```c
            ...58
            }
            noprint = 0;
```

Figure 4. A fisheye view of the C program. Line numbers are in the left margin. "..." indicates missing lines.
Graphical Fisheye Views

- Applied rather to layouts than to logical structure
- Furnas fisheye: items are either present in full detail or absent from the view
- Objective: continuous distortion of items and item representation
Bifocal Display

- Spence & Apperley 1982
- Office environment of the future
- Virtual workspace showing documents on a horizontal strip
- Centered detail region and two compressed context regions
- Scroll compressed documents in the detail region to decompress
- Distortion increases the amount of information that can be displayed
Perspective Wall

- Robertson et al. 1991
- Same approach as the bifocal lens but using perspective
- Detail information about objects recedes in the distance
Document Lens

- Robertson & MackInlay 1993
Distortion Approaches Used

• Overview of the different distortion techniques

Bifocal display
Perspective wall
Document lens

Magnification
Transfer function
Graph Fisheye

• Sarkar & Brown 1994
• Fisheye lens for viewing and browsing large graphs
• Present focus vertex in high detail but preserve context
• Recap node-link representation
  – Vertex (node)
  – Edges (links)
How did they do that...?

- Focus: viewer’s point of interest
- Coordinates in the initial layout: normal coordinates
- Coordinates in the fisheye view: fisheye coordinates
- Each vertex has
  - A position specified by normal coordinates
  - Size (Length of the square-shaped bounding box)
  - A priori importance (API)
  - Edge
    - Straight line from one vertex to another OR
    - For bended edges: set of intermediate bend points
- Apart from the distortion, the systems calculates for each vertex:
  - Amount of detail (content) to be displayed
  - Visual worth: shall the vertex be displayed? - display threshold
Implementation

• Two step process
  – Apply geometric transformation to the normal view to reposition vertices and magnify / demagnify the bounding boxes
  – Use the API of vertices to determine their final size, detail, and visual worth

• Slides will only present the repositioning of vertices - for the remaining algorithm see the paper!
Cartesian Transformation

- Compute the position of a point $P_{\text{norm}}$ from normal coordinates to fisheye coordinates

$$P_{\text{feye}} = \langle G \left( \frac{D_{\text{norm}x}}{D_{\text{max}x}} \right) D_{\text{max}x} + P_{\text{focus}x},$$

$$G \left( \frac{D_{\text{norm}y}}{D_{\text{max}y}} \right) D_{\text{max}y} + P_{\text{focus}y} \rangle$$

- where

$$G(x) = \frac{(d + 1)x}{dx + 1}$$

- $D_{\text{max}}$: the horizontal / vertical distance between the boundary of the screen and the focus in normal coordinates
- $D_{\text{norm}}$: horizontal / vertical distance between the point being transformed and the focus in normal coordinates
- $d$: distortion factor, see graphs
**Distortion Factor**

- Example: distortion of a nearly symmetric graph
- Focus in the southeast

Undistorted, $d = 0$

$\begin{align*}
\text{d} &= 1.46 \\
\text{d} &= 2.92 \\
\text{d} &= 4.38
\end{align*}$
Polar Transformation

• With cartesian transformation all vertical and horizontal lines remain vertical and horizontal in the fisheye view
• Makes this approach well suited for abstract orthogonal layouts of information spaces (e.g. circuit design, UML diagrams, etc.)
• Problem: does not seem very natural
• Alternative approach: distorting the map onto a hemisphere using polar coordinates (origin = focus)
• Point with normal coordinates \((r_{\text{norm}}, \theta)\) is mapped to fisheye coordinates \((r_{\text{feye}}, \theta)\), where

\[
    r_{\text{feye}} = r_{\text{max}} \frac{(d + 1) r_{\text{norm}}}{d r_{\text{norm}} + 1}
\]

• \(r_{\text{max}}\): maximum possible value of \(r\) in the same direction as \(\theta\)
• Note: \(\theta\) remains unchanged, origin of polar coordinates is the focus
• Distortion forms a pyramid lens
• Users know this effect from lenses and elastic materials in the real world, often find it fascinating
Cartesian vs Polar Transformation

Cartesian

Polar
More Fisheye Lenses

- Gutwin & Fedak 2004

Original pyramid lens (polar transformation, full screen)

Constrained hemispherical lens: constrain polar algorithm to a fixed radius

Constrained flat-hemispherical lens: insert a region of constant magnification
Discussion break

• What do you think of this? Ideas?
Victor Vasarely (1906-1997)
Multiple Foci

• Keahey & Robertson 1996
• Also multiple foci in a single domain are possible
• Interesting question: how to handle overlap?

Clipped  Weighted average  Composition transformation
Problem: Focus Targeting

• Gutwin 2002
• Move the fisheye lens to a target
• Problem: targets appear to move and thus are more difficult to hit directly (same effect as with a simple magnifying lens)
• Movement is in the opposite direction to the motion of the fisheye lens: focus target will move towards the approaching lens and vice versa
Focus Targeting

• Even worse: with the fisheye lens, targets move towards the focus more and more rapidly as the focus approaches them
• Depending on the distortion factor, the targets may move several times faster than the focus
• Leads to overshooting
• Approach to reduce problem: speed-coupled flattening
  – Detecting a target acquisition, the system automatically reduces the distortion
  – Distortion is automatically restored when the target action is completed
  – Algorithm is based on pointer velocity and acceleration thresholds
Speed-Coupled Flattening

- Found to significantly reduce targeting time and errors

Figure 4. Speed-coupled flattening. Top row shows the fisheye view and pointer path. Bottom row shows a stylized plot of pointer velocity and distortion level. The dotted line indicates the point in time that the corresponding screen was captured.

Gutwin 2002
Discussion: Mac OS X Dock
Symbolic Representation of Context

• F+c is limited to small zoom factors
• Allow for greater zoom factors by fusing graphical and symbolic content representations
• Example: Table lens (Rao & Card et al. 1994), (screenshot taken from inxight.com)
• Visualizes many more rows than a conventional spread sheet application
• Simple squishing of text rows would have rendered the content in the context unreadable
• Instead use small-size encodings of attribute values
Data obtained from CMU StatLib Server
Collected by American Statistical Association
Summary Focus+Context

• Advantages
  – Overview information is provided
  – No visual switching between separate views (compared to O+D)
  – Less display space is needed (compared to O+D)

• Potential problems
  – Performance is strongly task-dependent
  – Distortion has negative effect on the perception of proportions, angles, distances
  – Hampers precise targeting and the recall of spatial locations
  – Usually only suitable for small zoom factors: maximum of 5 (Shneiderman & Plaisant 2005)
  – Can be inappropriate for visualizing maps (usually require high fidelity to the standard layout)
Use-Case: Mobile Devices

- The presentation techniques discussed become even more important when designing for mobile devices
- Form factor implies a small screen
- Strong research need to improve orientation and navigation issues when displaying large information spaces
- Various commercial web browsers already use ZUIs and focus +context techniques (e.g. deepfish, minimap)
LaunchTile & AppLens

- ZUI and fisheye approach (Karlson et al. 2005)
Designing Mobile Scatterplot Displays

• Work at University of Konstanz
• Objective: Merge scatterplot displays with presentation techniques to achieve scalable, concise and highly usable mobile applications to facilitate access to large information spaces for next-generation PDAs and smartphones
• Several projects including system implementations and usability evaluations were carried out
  – Smooth semantic zooming
  – Overview+detail starfield versus detail-only ZUI
  – Focus+context starfield versus detail-only ZUI
Smooth Semantic Zooming

- Büring et al 2005
- First design prototype of a smooth zooming multiscale starfield application
- Starfield displays encode abstract data to a scatterplot visualization
- Semantic zooming: objects change their representation based on how much space is available to them
- Used for
  - Pruning visual clutter
  - Enabling smooth transition between overview and detail information
  - Multiple-data-point visualization
  - Query history and bookmarks visualization
Overview+Detail ZUI

• Büring et al. 2006a

• Smooth zooming could not prevent the users from getting lost in the information space

• More powerful concept to preserve orientation: overview+detail (o+d) interface
  – An additional overview window to show a miniature of the entire information space
  – Field-of-view-box to indicate the clipping currently displayed in the detail view

• Problems of o+d
  – Less space for the detail view means more clutter
  – Visual switching

• Compare a second design iteration of the smooth zooming starfield display with an overview+detail variant
Screen Recordings

Detail only

Overview+detail
Summary of findings

• On small screens, a larger detail window can outweigh the benefits gained from an overview
• Participants showed problems with precise interaction on the small overview window
• Overview window has reduced the need for long-distance panning and zooming (interaction log)
• Loss of performance may be due to the added cost of visual switching and interaction complexity
Focus+Context ZUI

- Büring et al. 2006b
- Previous experiment showed that overview information can reduce the need for unnecessary navigation
- Exploit this potential while avoiding the need for visual switching
- Fisheye: integrates both focus and context in a single view by using distortion
- Compare a third design iteration of the smooth zooming detail-only starfield to a variant using a rectangular fisheye distortion
Detail-Only Semantic ZUI

- Fluent transitions between zoom steps to support user orientation
- Smooth semantic zoom for detail access
- The ratio of overview and detail information is controlled via the zoom level
- Two-step zoom algorithm
- Empty space is minimized by manipulating the scale factor
- Selection by proximity avoids desert fog problem
- Panning by rate-based scrolling (sliding)
- Priority layout for record cards
- Continuous adjustment of scatterplot units
Fisheye Interface

- Integrates focus and context in a single view
- Based on the metaphor of a wide angle-lens
- Bounding-box zoom
- Magnify focus region, contract surrounding regions
- Preserves parallelism between lines for mapping items to scatterplot labels
- Zoom directly into context regions
- Panning via drag&drop
- Detail access via zoom-out pop-up
Screen Recordings

Detail-only ZUI

Fisheye ZUI
Summary of findings

• The fisheye required less navigation (log data), but did not lead to shorter task-completion times
• Still users significantly favored the integrated focus and context view and the bounding-box zoom
• Partly contradicts previous research
• Hypothesis: fisheye techniques may integrate better with abstract information spaces such as diagrams, but decrease with domains such as maps, in which a higher fidelity to the standard layout is essential
• For those cases a detail-only ZUI with enhanced orientation features (e.g. halos) may provide the better solution
Related Literature