11. Presentation Approaches II

Dealing with the presentation problem

Dr. Thorsten Büring, 24. Januar 2008, Vorlesung Wintersemester 2007/08

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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
- Earliest mentioning of the idea in Ph.D. thesis: Farrand 1973

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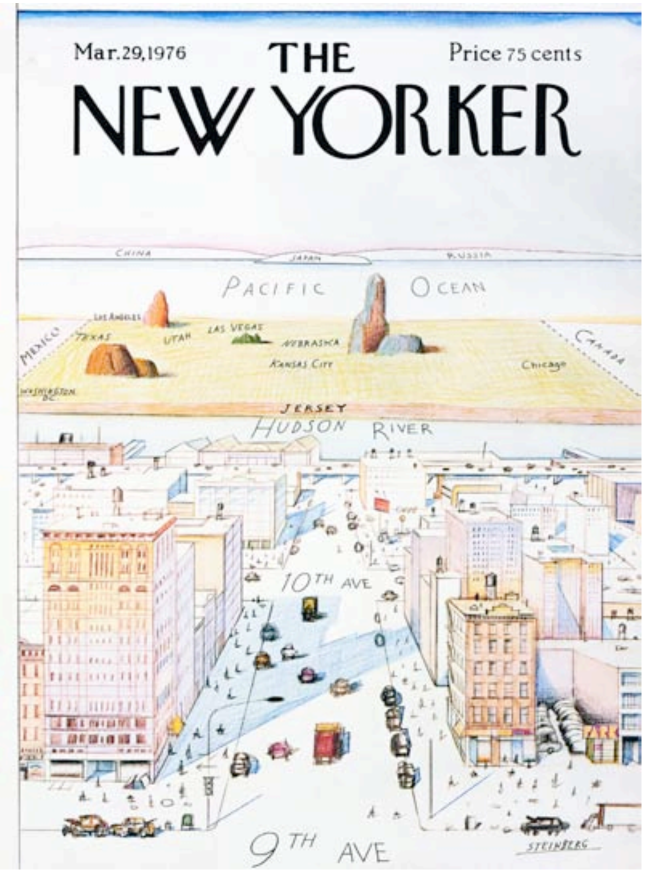
Generalized Fisheye Views

- 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



Saul Steinberg

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Degree-of-Interest

- $DOI_{fisheye}(x|y) = API(x) - D(x,y)$
  - $DOI_{fisheye}$: the users' degree of interest in point x, given the current 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 where the components can be defined
- Example: rooted tree structure of programming code
- Components definition
  - $D(x,y) = d_{tree}(x,y)$ = path length distance between node x and node y in the tree
  - $API(x) = -d_{tree}(x,root)$ = distance of node x from the root node (assumption: nodes closer to the root are generally more important than nodes farer away)
- $DOI_{fisheye(tree)}(x|y) = API(x) - D(x,y) = -(d_{tree}(x,y) + d_{tree}(x,root))$

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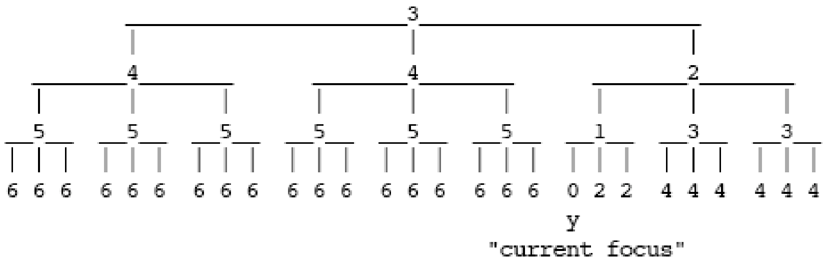
Fisheye Tree

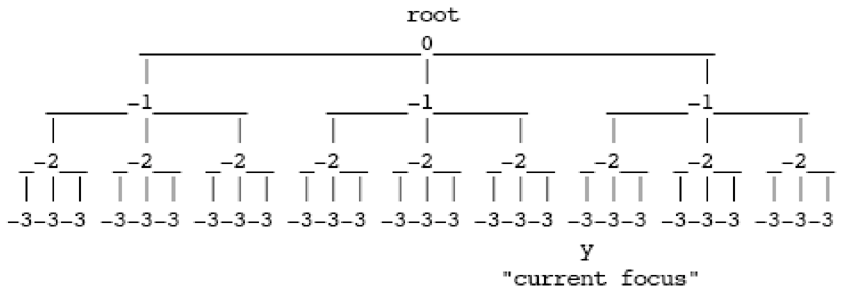
(a) Distance from y:

$d_{tree}(x,y)$



(b) *A Priori* Importance in the tree:

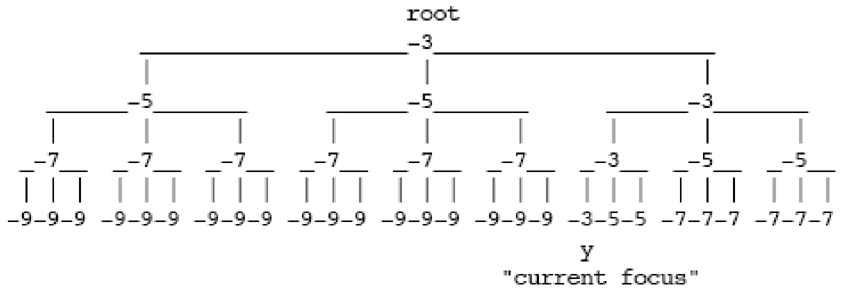
$Imp(x) = -d_{tree}(x, root)$



(c) The Fisheye DOI:

$DOI_{fisheye(tree)}(x|.=y) = API(x) - D(x,y)$

$= -(d_{tree}(x,y) + d_{tree}(x,root))$



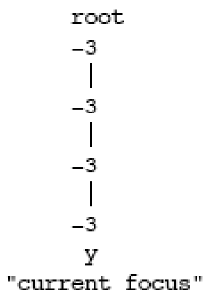
An arithmetically larger number means that the node is more interesting for interactions focused on y

Fisheye Tree

- To obtain fisheye views of different sizes, set a DOI threshold k with DOI(x) > k

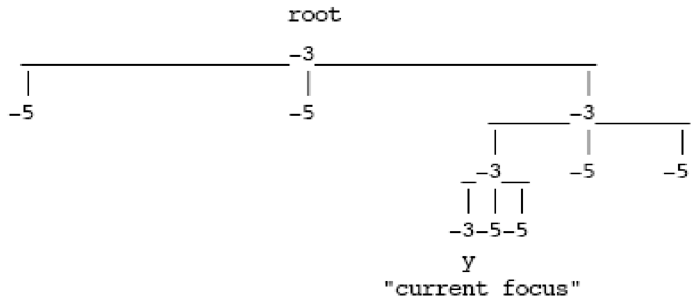
k = -3; direct ancestral lineage

(a) Zero-order tree fisheye:



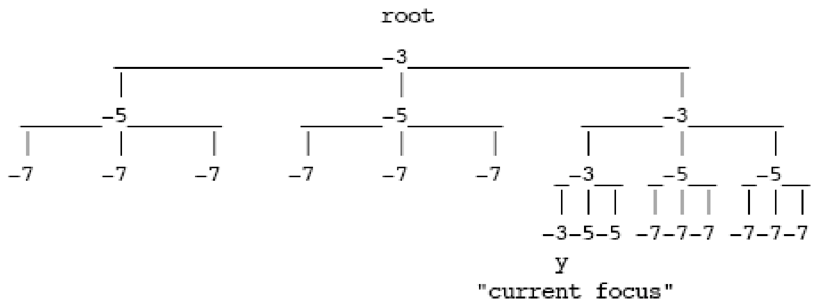
k = -5; siblings are added

(b) First-order tree fisheye:



k = -7; cousins are added

(c) Second-order tree fisheye:



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Fisheye Tree Aplied

- Working on line marked with „>>“

```
  28                     t[0] = (t[0] + 10000)
  29                          - x[0];
  30                     for(i=1;i<k;i++){
  31                          t[i] = (t[i] + 10000)
  32                               - x[i]
  33                               - (1 - t[i-1]/10000);
  34                          t[i-1] %= 10000;
  35                     }
  36                     t[k-1] %= 10000;
  37                     break;
  38                case 'e':
>>39                     for(i=0;i<k;i++) t[i] = x[i];
  40                     break;
  41                case 'q':
  42                     exit(0);
  43                default:
  44                     noprint = 1;
  45                     break;
  46           }
  47           if(!noprint){
  48                for(i=k - 1;t[i] <= 0 && i > 0;i--);
  49                printf("%d",t[i]);
  50                if(i > 0) {
```

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

```
   1 #define DIG 40
   2 #include <stdio.h>
...4 main()
   5 {
   6      int c, i, x[DIG/4], t[DIG/4], k = DIG/4, noprint = 0;
...8      while((c=getchar()) != EOF){
   9           if(c >= '0' && c <= '9'){
..16           } else {
  17                switch(c){
  18                     case '+':
..27                     case '-':
..38                     case 'e':
>>39                          for(i=0;i<k;i++) t[i] = x[i];
  40                          break;
  41                     case 'q':
..43                     default:
..46                }
  47                if(!noprint){
..57                }
  58           }
  59           noprint = 0;
  60      }
  61 }
```

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

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Fisheye Tree Aplied

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

```
#define DIG 40
#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;
                  }
            } else {
                  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;t[i] <= 0 && i > 0;i--);
                        printf("%d",t[i]);
                        if(i > 0) {
                              for(i-- ; i >= 0; i--){
                                    printf("%04d",t[i]);
                              }
                        }
                        putchar('\n');
                        for(i=0; i > k;i++) x[i] = 0;
                  }
            }
            noprint = 0;
      }
}
```

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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

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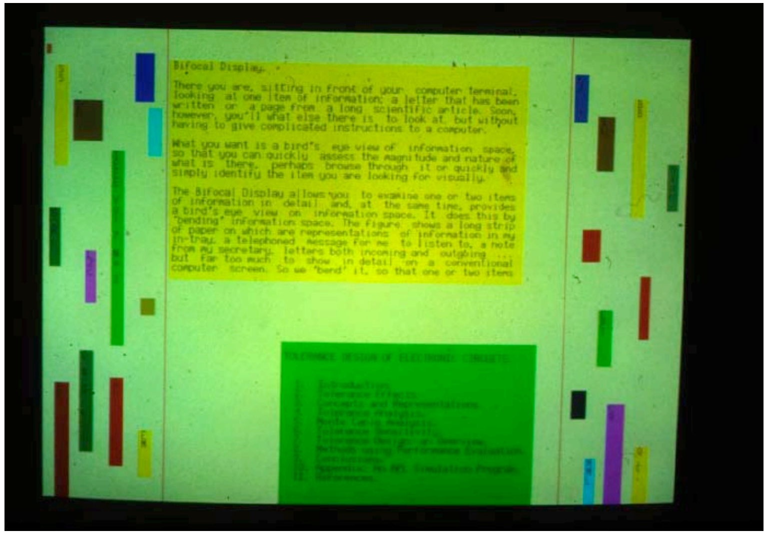
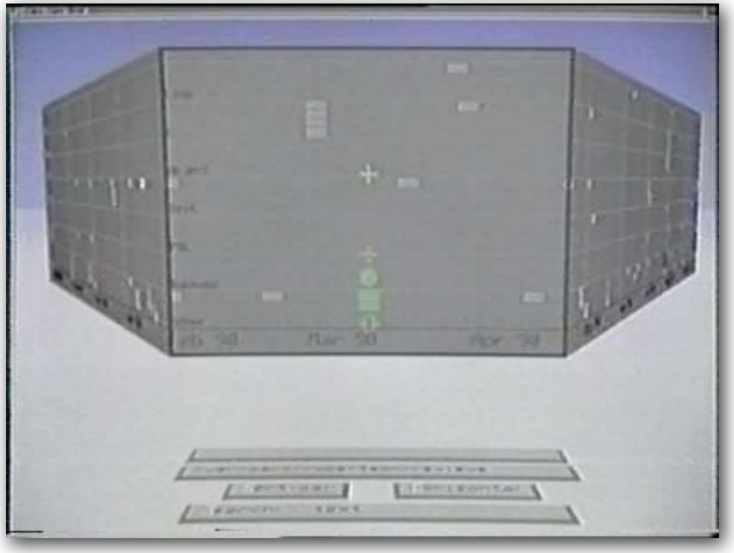
Bifocal Display

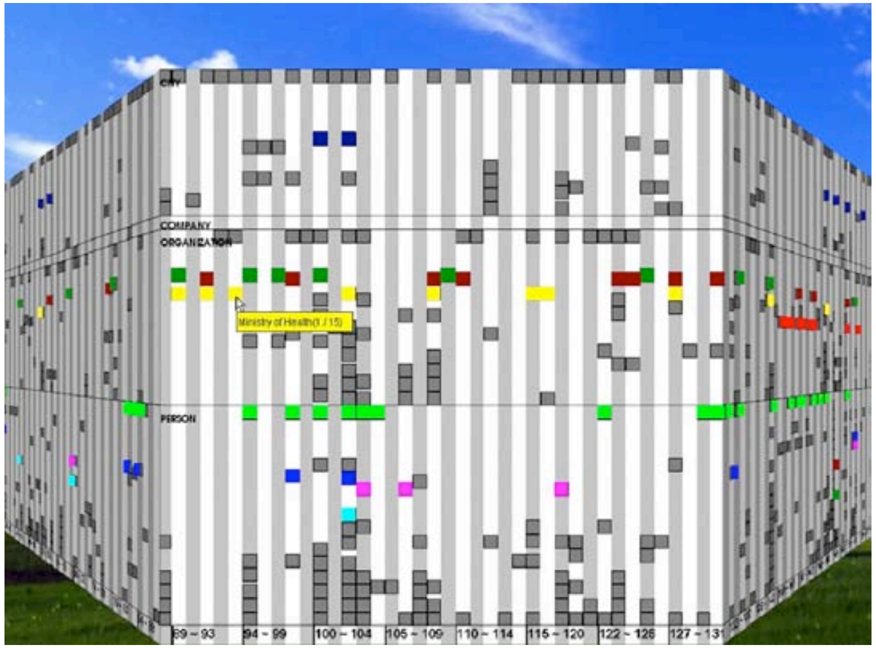
- Spence & Apperley 1982
- Office environment of the future
- Virtual workspace showing documents on a horizontal strip
- Centered detail region and two compressed context regions
- Scroll compressed documents in the detail region to decompress
- Distortion increases the amount of information that can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





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Document Lens

- Robertson 1993

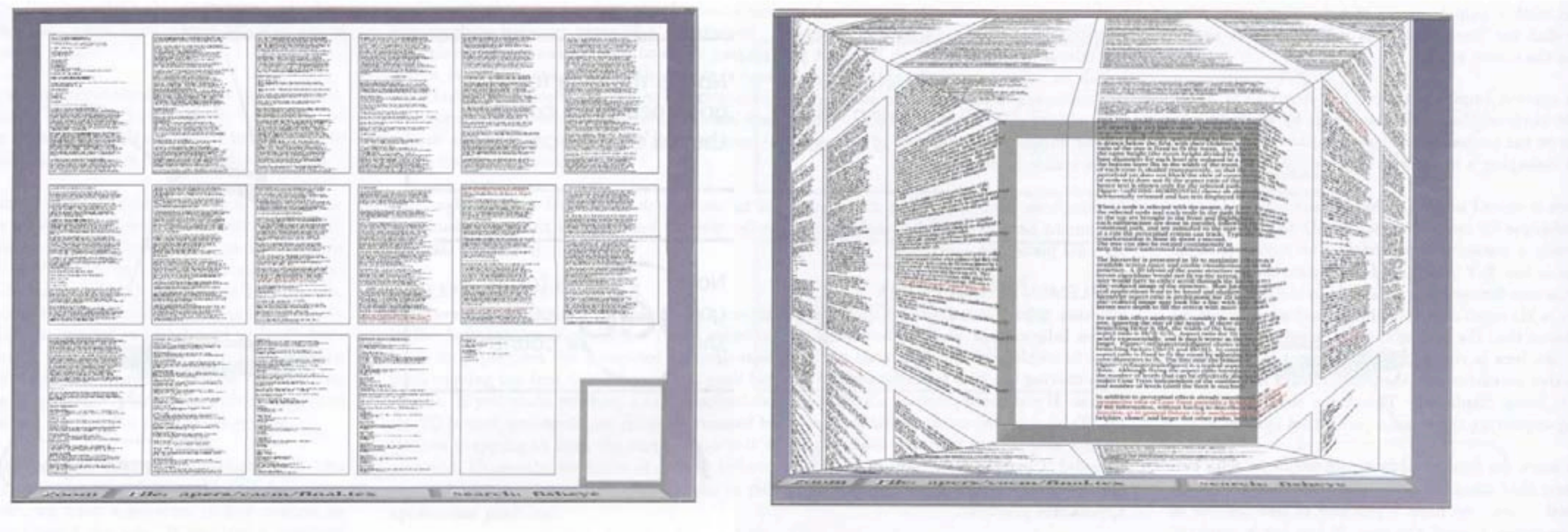

Figure 1: Document laid out on a 2D surface. Red highlights are the result of a search. 3: Document Lens with lens pulled toward the user. The resulting truncated pyramid makes text

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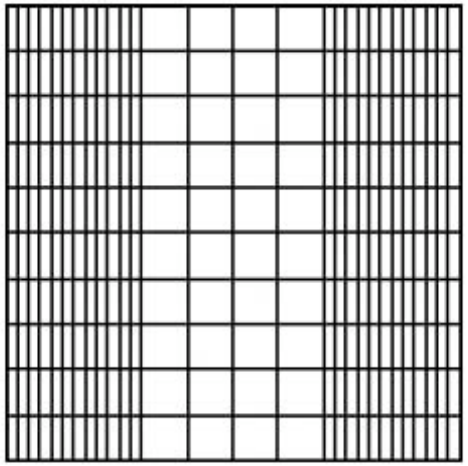
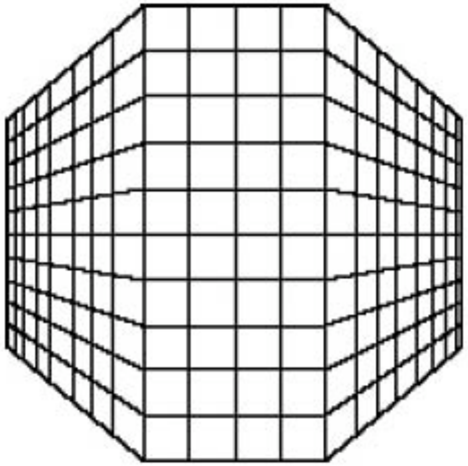
Distortion Approaches Used

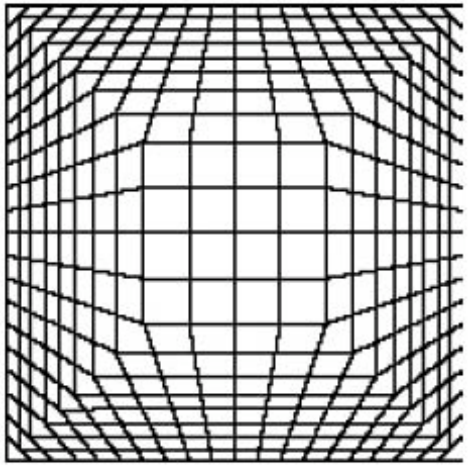
Bifocal display



Perspective wall



Document lens



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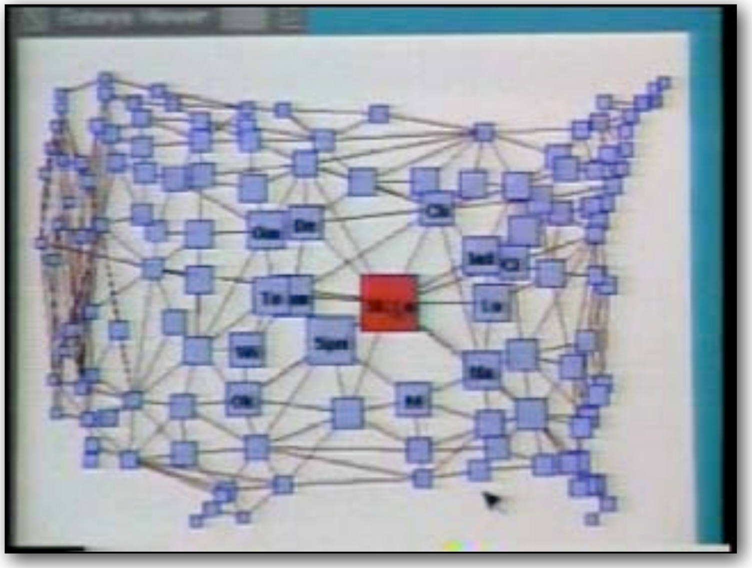
Graph Fisheye

- Sarkar & Brown 1994
- Fisheye lens for viewing and browsing large graphs
- Present focus vertex in high detail but preserve context
- Movie
- Recap node-link representation
  - Vertex (node)
  - Edges (links)



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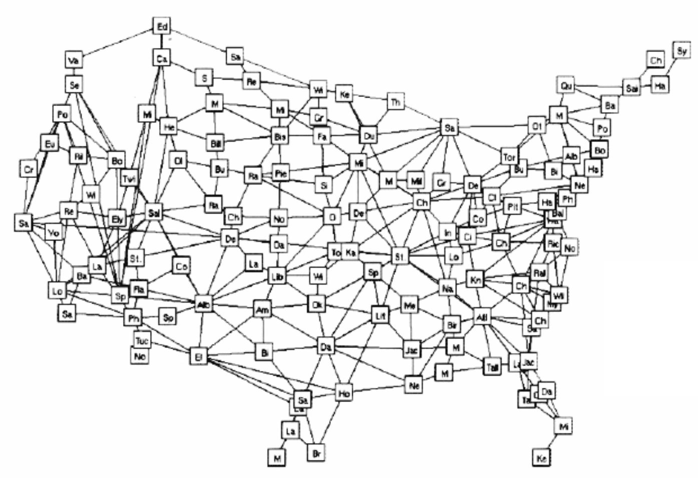
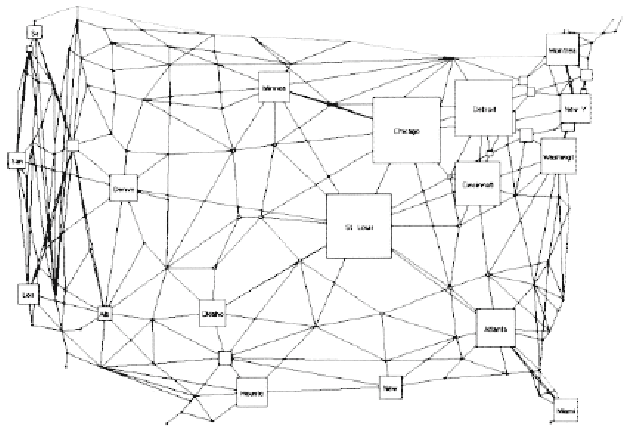
How did they do that...?

- 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

- Computer the position of a point P_{norm} from normal coordinates to fisheye coordinates

$$P_{feye} = \left\langle \mathcal{G}\left(\frac{D_{norm_x}}{D_{max_x}}\right) D_{max_x} + P_{focus_x}, \right.$$
$$\left. \mathcal{G}\left(\frac{D_{norm_y}}{D_{max_y}}\right) D_{max_y} + P_{focus_y} \right\rangle$$

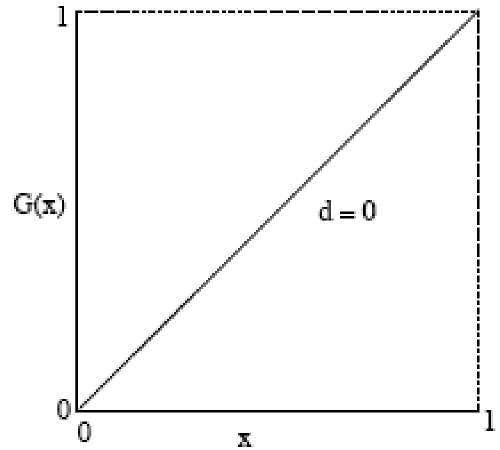
where

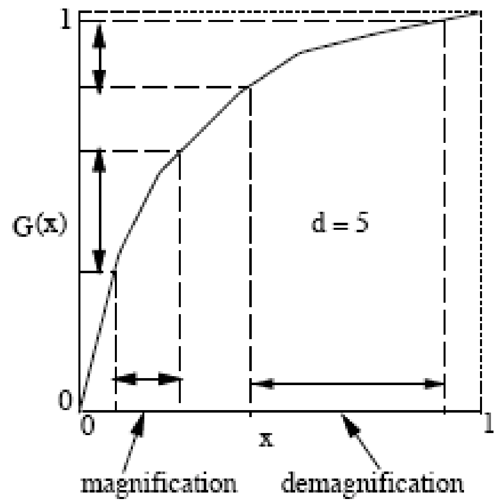
$$\mathcal{G}(x) = \frac{(d+1)x}{dx+1}$$

D_{max} : the horizontal / vertical distance between the boundary of the screen and the focus in normal coordinates

D_{norm} : horizontal / vertical distance between the point being transformed and the focus in normal coordinates

d: distortion factor, see graphs





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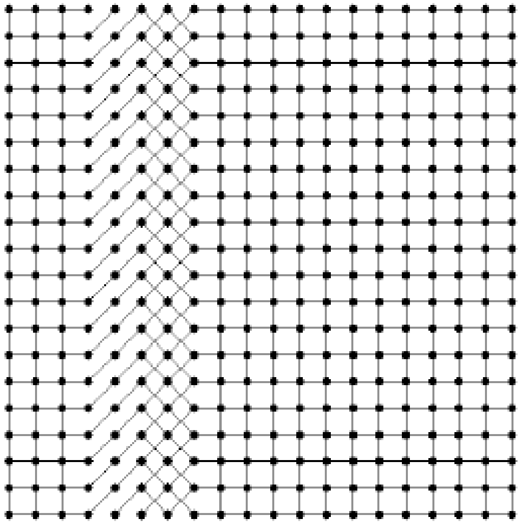
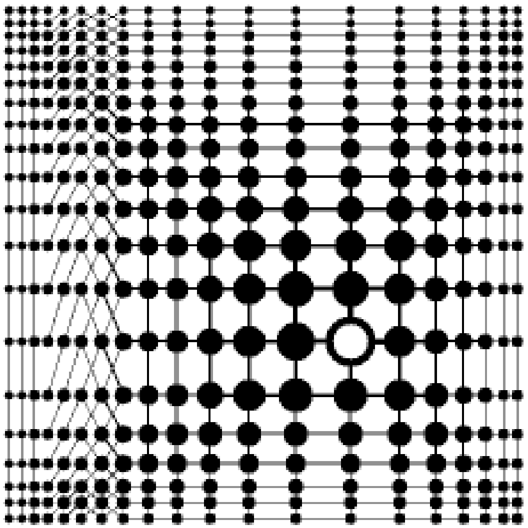
Distortion Factor

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

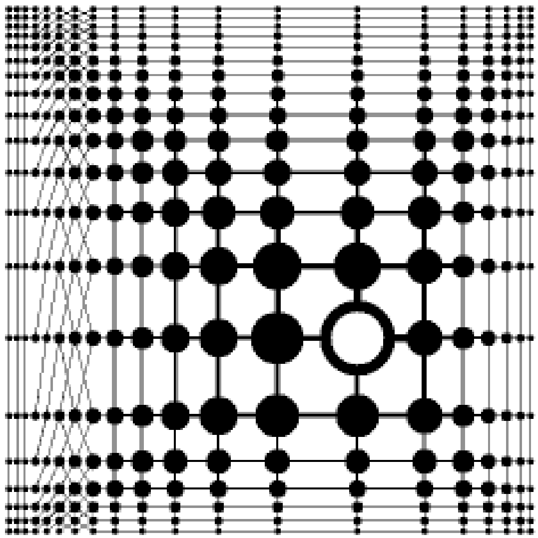


Undistorted, $d = 0$

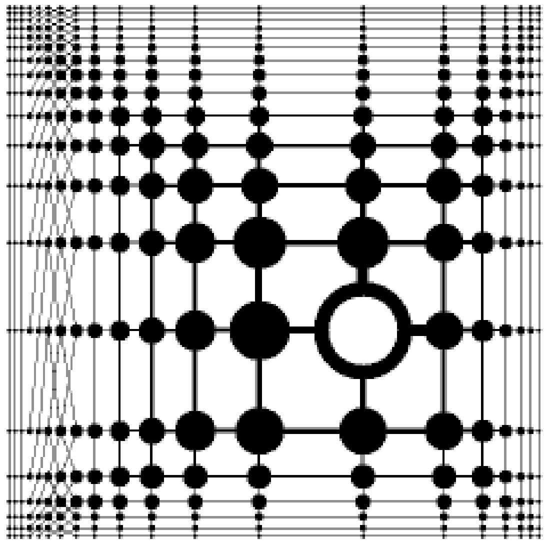
$d = 1.46$



$d = 2.92$



$d = 4.38$



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_{norm}, θ) is mapped to fisheye coordinates (r_{feye}, θ), where

$$r_{feye} = r_{max} \frac{(d+1)\frac{r_{norm}}{r_{max}}}{d\frac{r_{norm}}{r_{max}} + 1}$$

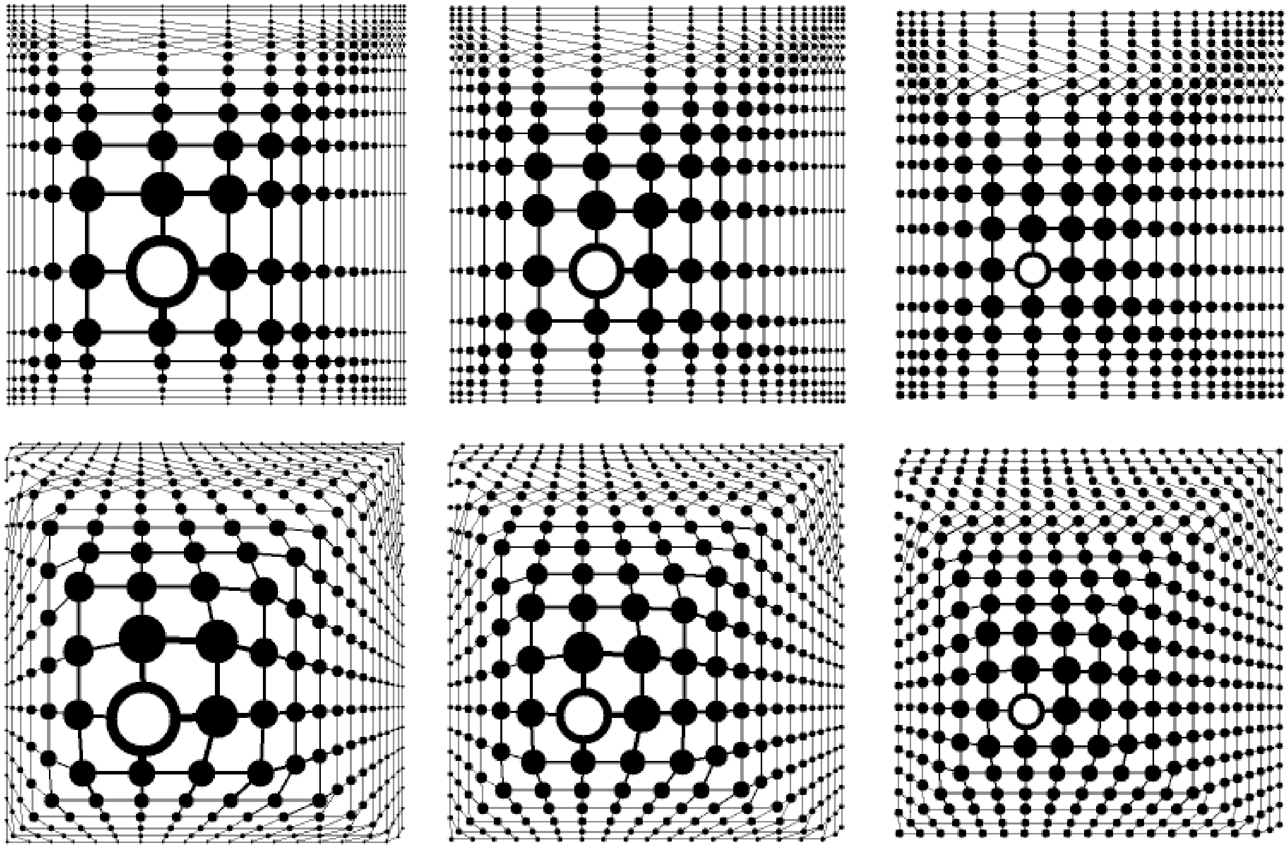
  r_{max} : maximum possible value of r in the same direction as θ

  Note: **θ 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

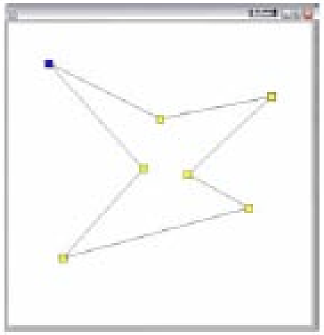
Cartesian



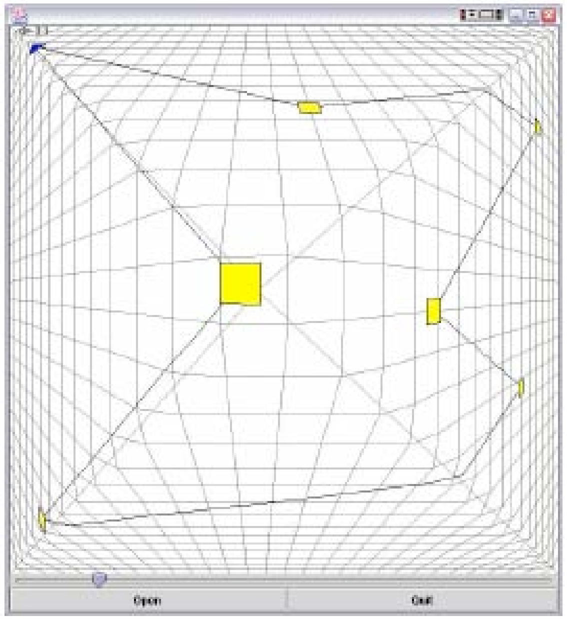
Polar

More Fisheye Lenses

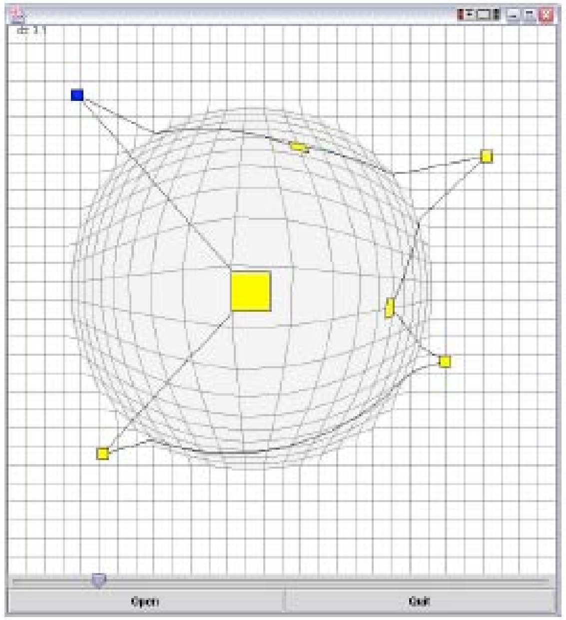
- Gutwin & Fedak 2004



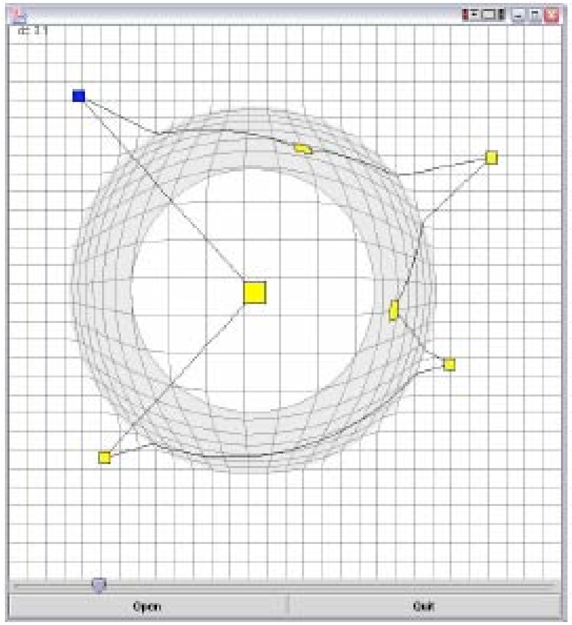
Original pyramid lens (polar transformation, full screen)



Constrained hemispherical lens: constrain polar algorithm to a fixed radius

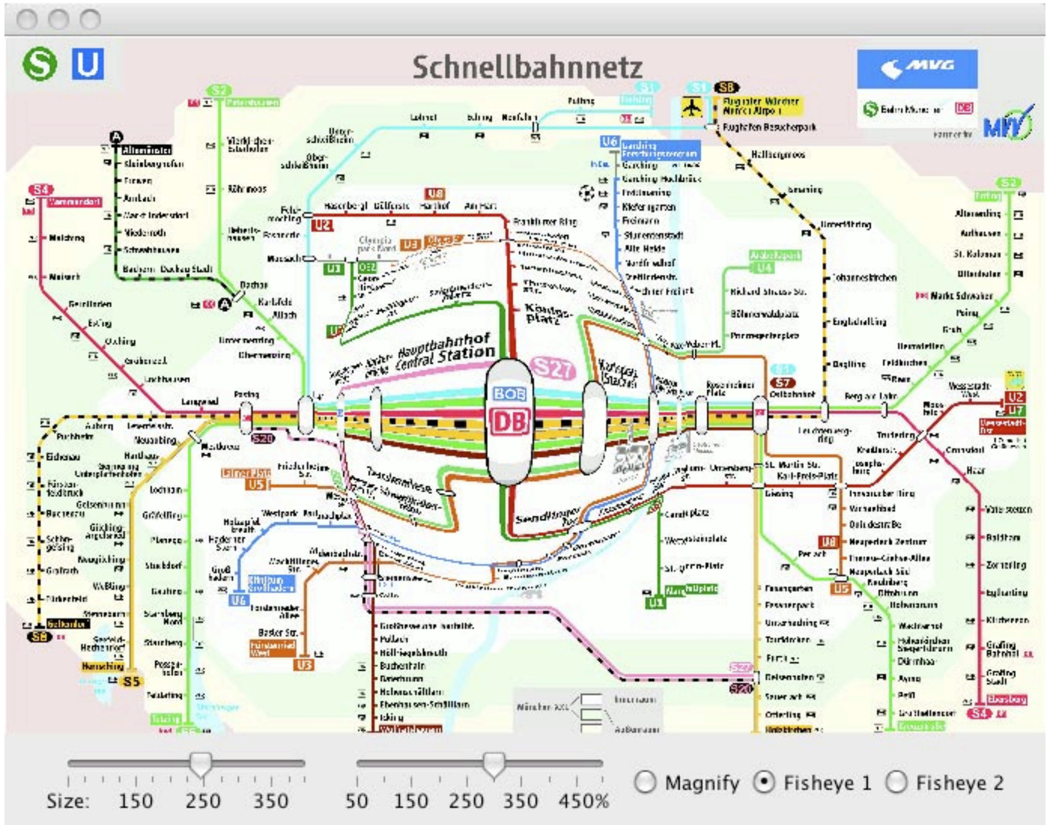


Constrained flat-hemispherical lens: insert a region of constant magnification



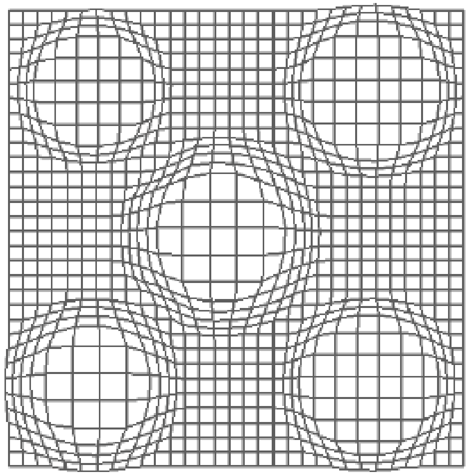
Outlook

- I know what you will do next summer (in MMI 2)...

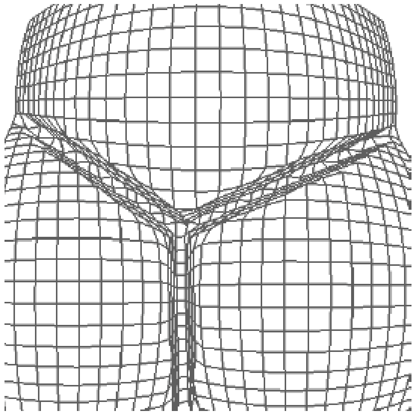


Multiple Foci

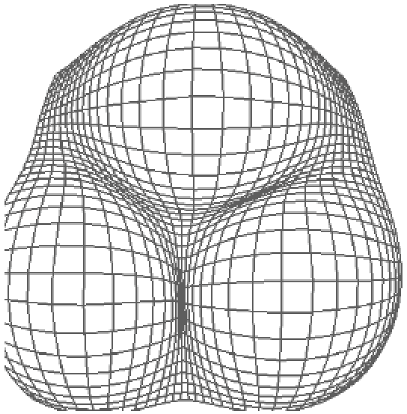
- Keahey & Robertson 1996
- Also multiple foci in a single domain are possible
- Interesting question: how to handle overlap?



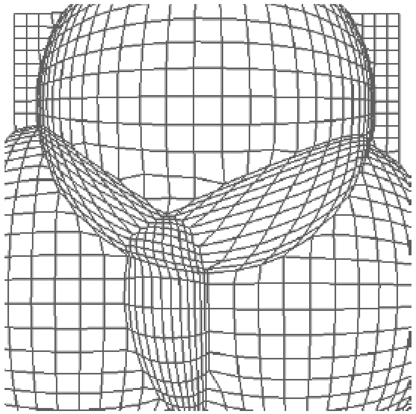
Clipped



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

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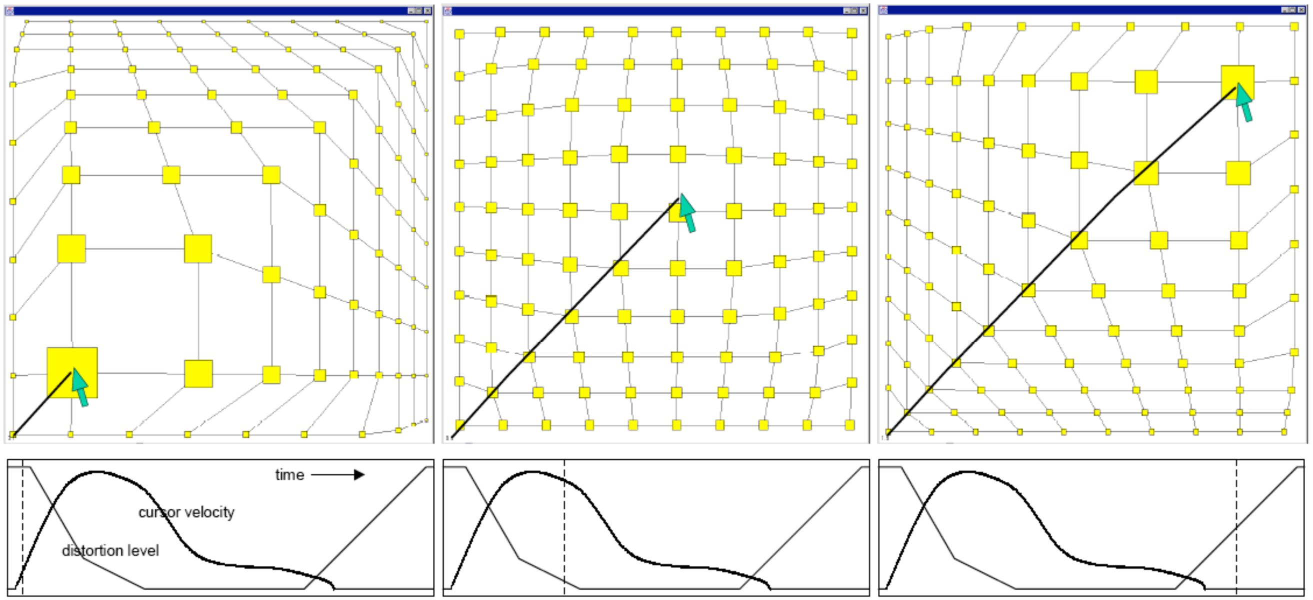
Speed-Coupled Flattening

- Found to significantly reduce targeting time and errors
- Movie

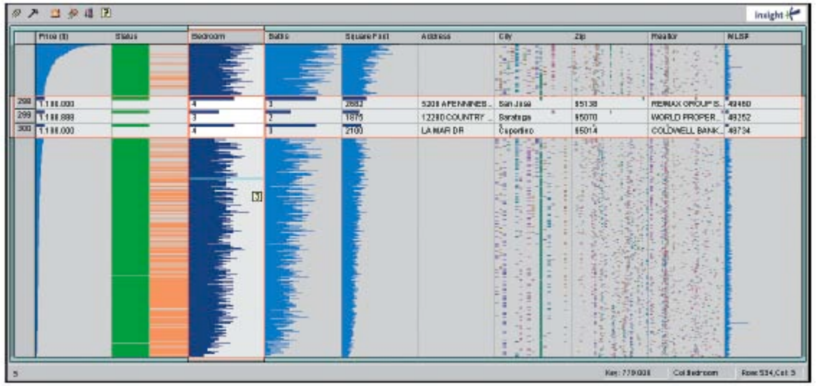


Gutwin 2002

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.

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
- Movie



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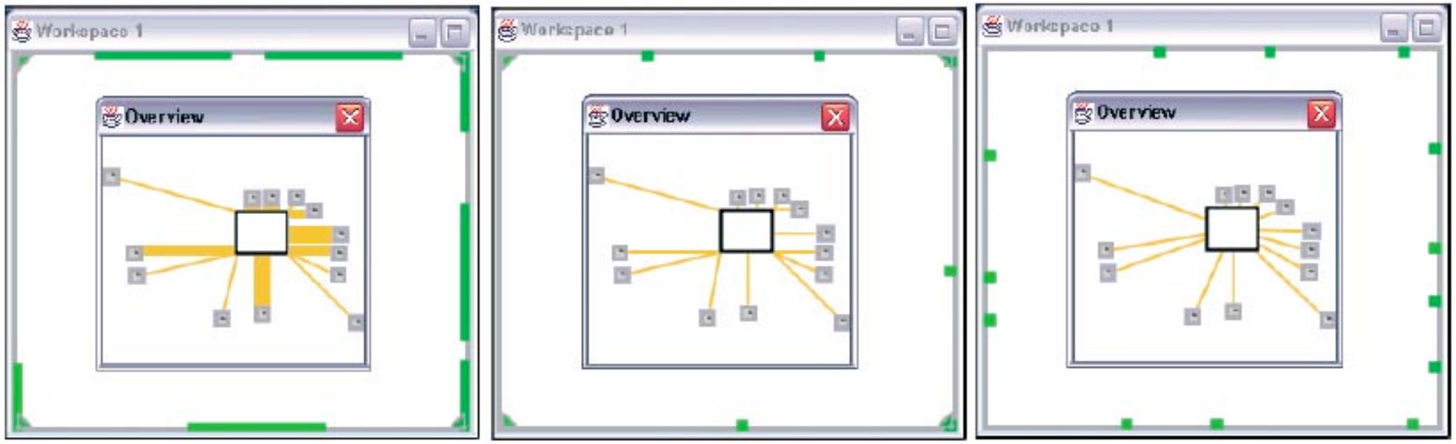
Symbolic Representation of Context

- Symbolic representations to visualize objects in the off-screen space
- City lights technique (screenshots adapted from (Good 2003))
  - Orthogonal + corner projections
  - Point projection
  - Radial projection
- Distance is encoded by color brightness
- Click representations to navigate to objects



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)

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

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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)

F+c sketching (Lank & Phan 2004)

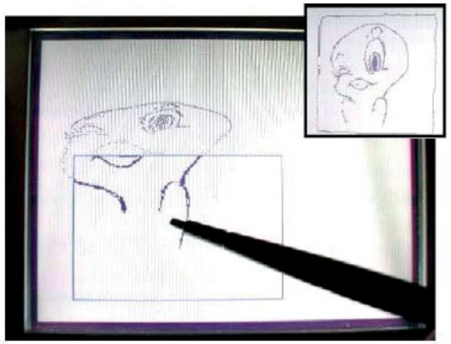

Image distortion (Liu & Gleicher 2005)

Halos (Baudisch 2003)

LaunchTile & AppLens

- ZUI and fisheye approach (Karlson et al. 2005)

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Outline

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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

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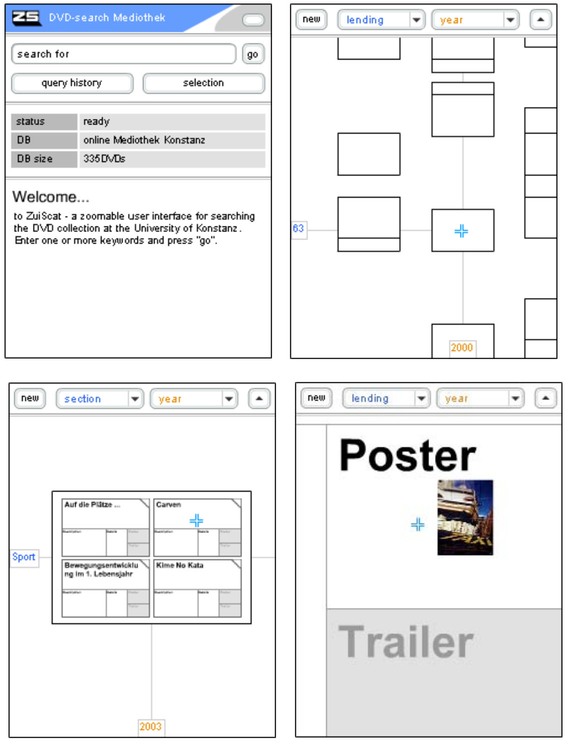
Smooth Semantic Zooming

- 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

Smooth Semantic Zooming

- Informal user test based on observation & interviews
- 6 users (2 male, 4 female), 21 to 33 years in age
- Ipaq 4700hx, movie database with 335 items
- Explore the interface while thinking aloud
- Retrieval tasks with increasing navigation effort
- Main results
  - Semantic zooming: an intuitive concept for data exploration and granularity transition
  - Orientation problems due to the clipping of context, frequent zoom out and panning operations
  - Sequential zoom interaction: tedious and slow



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

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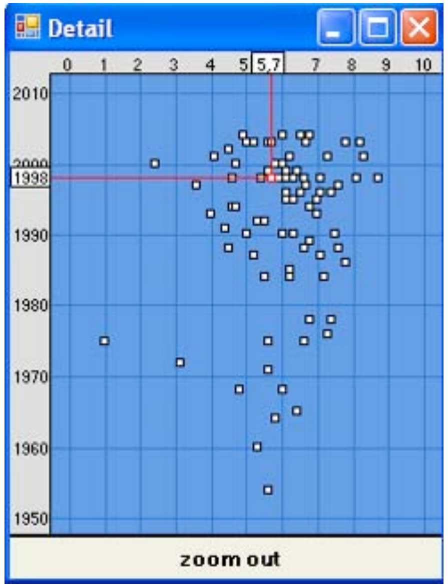
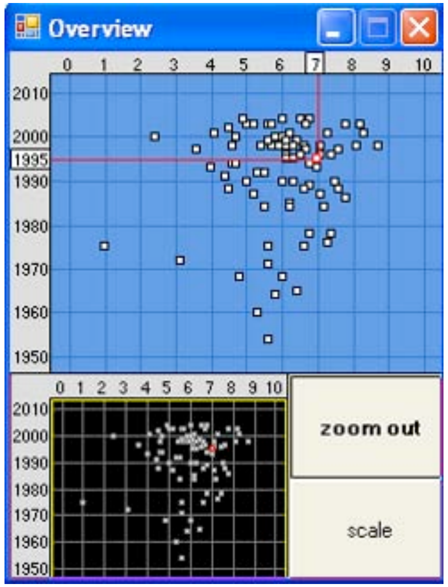
Screen Recordings

- Detail-only



- Overview+detail



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Usability Experiment

- Quantitative user study with 24 students (non-IT), (12 female, 12 male), M: 24 years, SD: 2,3
- Ipaq 4700hx, movie database with 85 items
- Counter-balanced within-subjects design
- Two task sets, each containing 12 tasks
- Task Types: Visual Scan, Information Access & Comparison
- Independent variables: interface type, spatial ability (psychometric test by Horn)
- Dependent variables: task completion time, system preference, user-satisfaction (Attrakdiff), error-rate, navigation-actions (logged)
- Introduction video + training phase

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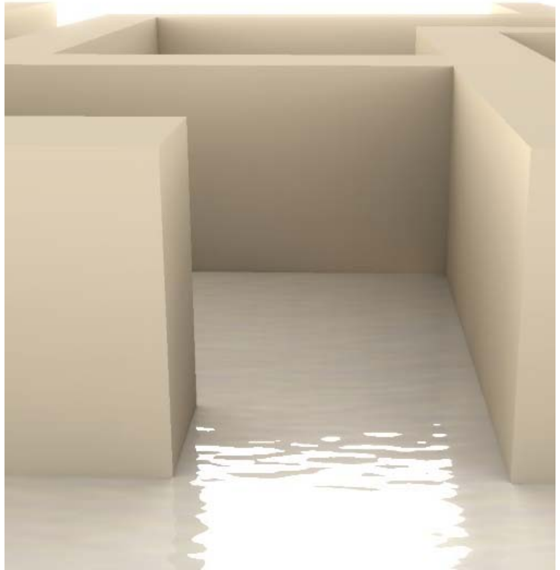
Spatial Ability

- Definition: The ability to generate, retain, retrieve and transform well-structured visual images
- One of the best predictors for human-computer performance
- O+d interfaces may compensate for the inability of low-spatial users to construct a mental model of the information space
- Visual interfaces can improve the performance of low-spatial individuals, but may also hinder high-spatial users



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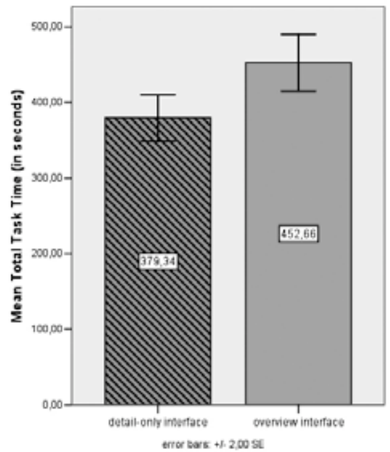
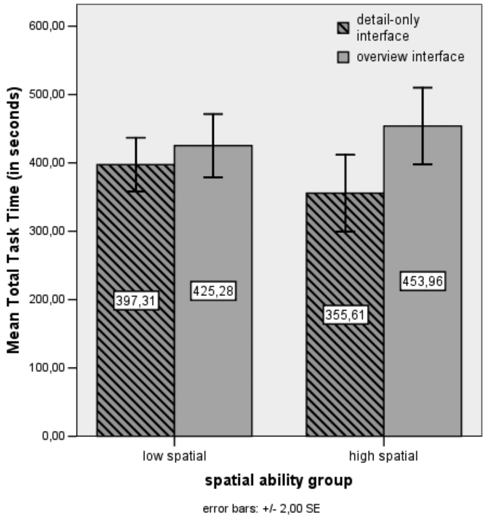
Results

- Hypothesis 1: Users would prefer the overview to the detail-only interface because of the orientation and navigation features (e.g. [Baudisch et al. 2004])
- Result preference: user preference balanced (13 detail-only, 10 o+d), $X^2(1,N=23)=0{,}391p$ = n.s.
- Hypothesis 2: Task-completion time would be better for the detail-only interface due to the rich orientation cues given by the scatterplot labels (e.g. [Hornbæk et al. 2002])
- Results task-completion time: in favor of the detail-only interface
  - 379.34s (SD: 75.19s) detail-only vs. 452.64s (SD:92.10s) o+d
  - ANOVA results: $F(1,23) = 16.5$, $p<0.001$
- Reject null hypothesis



Results

- Hypothesis 3: users with low spatial ability would have a longer task-completion time across interfaces than participants with higher spatial ability
- Results spatial ability: No significant correlation between spatial ability and neither task performance or user preference
  - Homogenous test group (mean C-Value=7.46, SD = 0.977)
  - Even our low-spatial participants were significantly above the population average (6.5 compared to 5, T(1,9)=6.78; p<0.01)
- Task-completion times indicate that high-spatial users were hindered by the detail+overview interface



Summary

- 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)
- Lost of performance may be due to the added the cost of visual switching and interaction complexity

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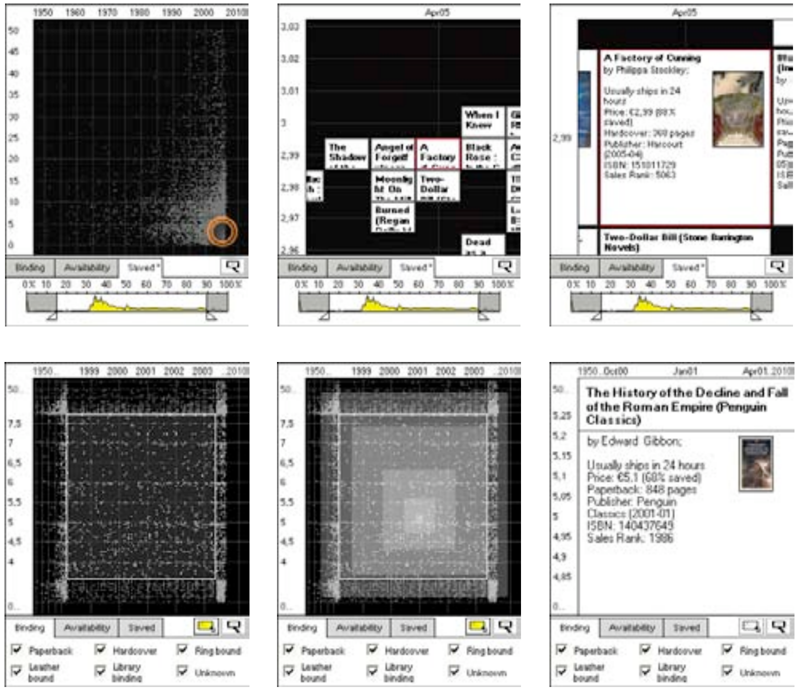
Focus+Context ZUI

- 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



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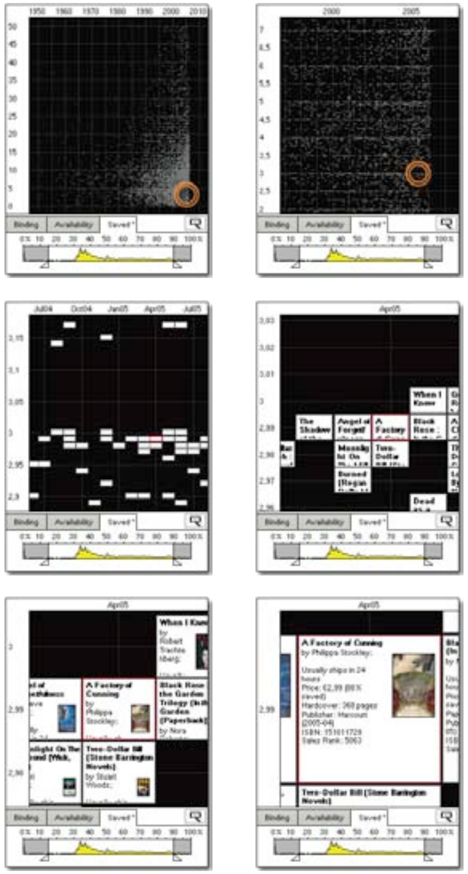
Detail-Only Semantic ZUI

- 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



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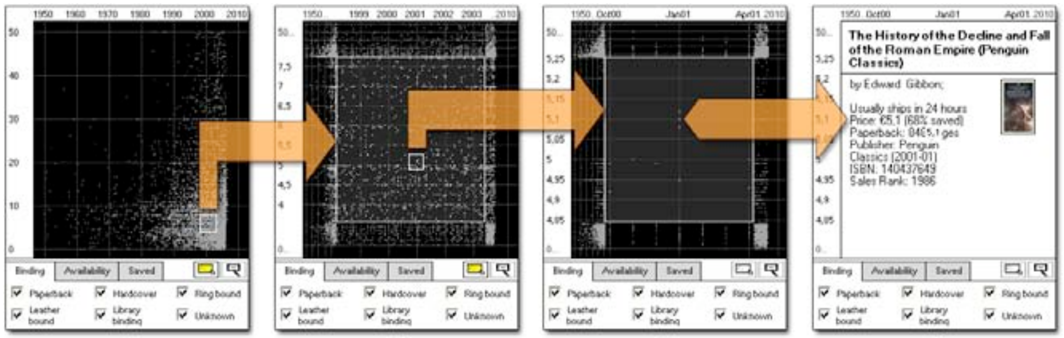
Fisheye Interface

- 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



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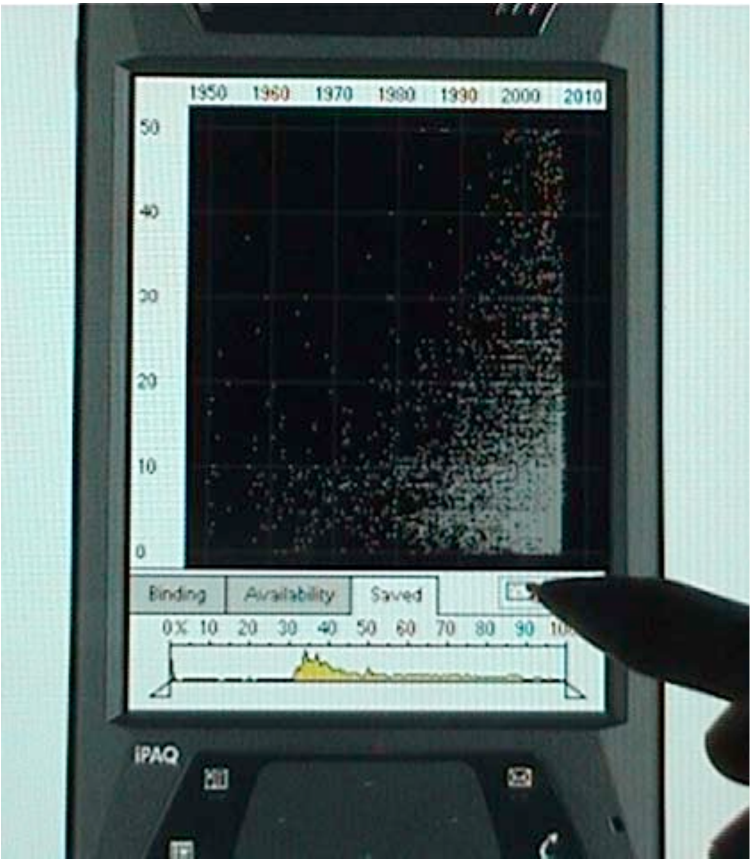
Screen Recordings

- Detail-only ZUI

- Fisheye ZUI



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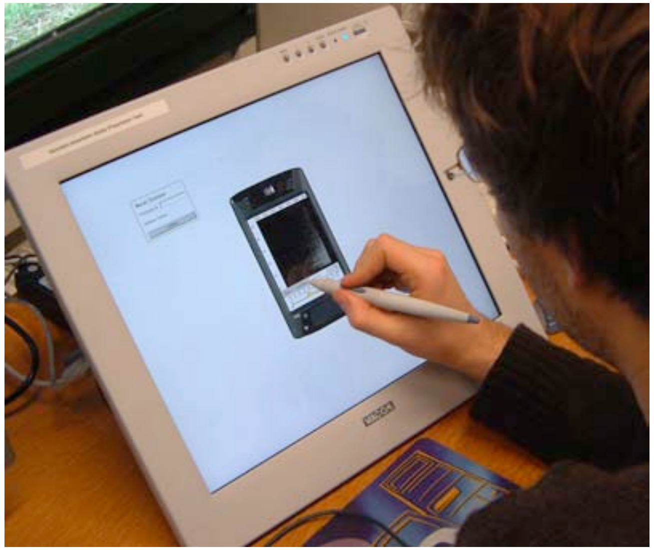
Usability Experiment

- Comparative evaluation of the two interfaces
- User test, 24 participants (23 students – age 19-33, 1 engineer age 50)
- PDA simulation on a Wacom Board, 7500 items
- Counter-balanced within-subjects design
- Two task sets, each containing 10 tasks
- Task Types: Visual Scan, Information Access & Comparison
- Independent variable: interface type
- Dependent variables: task-completion time, system preference, user-satisfaction (Attrakdiff), error-rate, navigation-actions (logged)
- Introduction video + training phase



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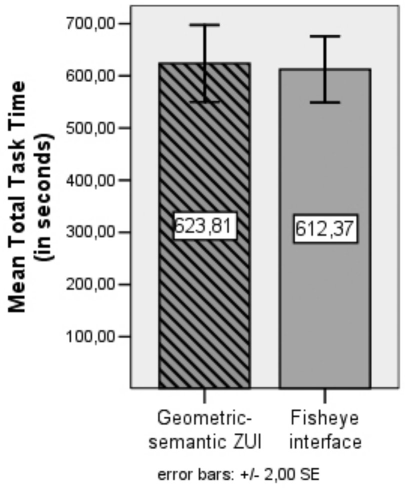
Results

- Hypothesis 1: Task-completion time would be better for the fisheye interface
- Fewer unnecessary navigation due to preservation of context [Schaffer et al. 1996]
- Results
  - 623.8 seconds (detail-only) vs. 612.4 seconds (fisheye-interface)
  - F(1,22) = 0.002, not significant.
- Cannot reject null hypothesis
- Although fewer navigation actions needed, those required more time to execute and probably were cognitively more demanding



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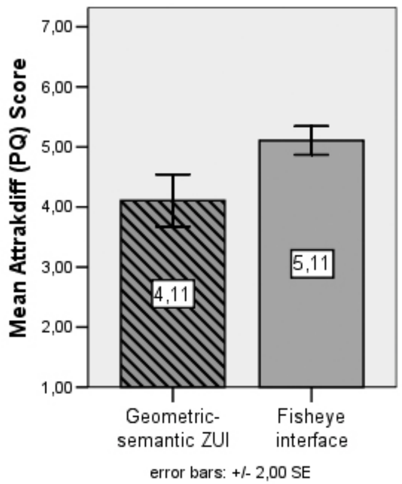
Results

- Hypothesis 2: Users would prefer the detail-only ZUI to the fisheye interface
  - Artificial distortion may decrease user satisfaction [Gutwin&Fedak 2004]
  - Geometric-semantic ZUI reminds in some aspects of a computer game
- 20 subjects (fisheye) vs. 3 subjects (detail-only ZUI), $X^2(1,N = 23) = 12.565$, $p<0.001$, significant
- Attrakdiff PQ Scores: 5.11 (fisheye) vs. 4.11 detial-only ZUI), $F(1,23)=20.84$, $p<0.001$, significant
- Cannot reject null hypothesis
- Users preferred orientation benefit of the fisheye and the bounding-box zoom
- Users experienced problems with sliding



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Summary

- 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

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Obligatory Literature

- M. Sarkar & M. Brown: Graphical Fisheye Views, 1992.