Part 6

Focus+Context:
Distortion Techniques,
Overview and Detail, etc.
Fundamental Problem

Scale

Many Data Sets are too Large to Visualize on one Screen
  May Simply be too Many Cases
  May be too Many Variables
  May only be able to Highlight Particular Cases or Particular Variables, but Viewer’s Focus may Change from Time to Time

Potential solutions lie in

Representation
Interaction
Both

[Stasko, InfoVis Course 2010]
From Problems to Goals

Problems

Scale: Large Data Sets

Small Window as Single Access-Point

Difficult to Interpret Single Information Items when Viewing it Outside of its Context

Goals

Allow the User to Examine a Local Area in Detail without loss of overall Context

Facilitate Navigation
Focus and Context

Usually

Either Detail or Full Picture
Lose Context When Zooming
⇒ Zoom In and Out a Lot

F+C

Integrate Detail and Big Picture
Make Better Use of Available Screen Space
Focus+Context Techniques

Spatial / Distortion-Oriented Methods
Fisheye Views, Perspective Wall, Stretchable Rubber Sheets, Hyperbolic Space, etc.

Dimensional Methods
Magic Lenses, Tool Glasses, etc.

Cue Methods
Color Saturation, Transparency, Brightness, ...

User-Driven

Data-Driven
Focus+Context Techniques

Spatial / Distortion-Oriented Methods

Fisheye Views, Perspective Wall, Stretchable Rubber Sheets, Hyperbolic Space, etc.

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Magic Lenses, Tool Glasses, etc.

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Color Saturation, Transparency, Brightness, ...
Distortion Techniques

Basic Idea

Distortion of an Image to Allow a Visualization of Larger Amounts of Data

Polyfocal Display [Kadmon & Shlomi 1978]
Bifocal Display [Spence & Apperley 1982]
Fisheye View [Furnas, 1981/1986]
Perspective Wall [Mackinlay et al. 1991]
Graphical Fisheye View [Sarkar & Brown, 1992]
Methods

Abstract the Data
To Ensure Information Visibility

Apply a *Transformation Function*
to the Abstract Data

Apply a *Magnification Function*
to the Transformed Data

[Leung & Apperly, 1994]
Methods (cont.)

[Leung & Apperly, 1994]

Fig. 3. (a) The transformation of an elliptic object by applying the transformation function of a Bifocal Display in one dimension; (b) the corresponding magnification function of the Bifocal Display.

T. Alan Keahey
www.visintuit.com
## Taxonomy

[Leung & Apperly, 1994]

<table>
<thead>
<tr>
<th>Large Volumes of Data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Inherently Graphical Data</td>
<td>Non-Graphical Data</td>
</tr>
<tr>
<td>direct</td>
<td>graphical abstraction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Large Information Space (Graphical)</th>
<th>Large Information Space (Non-Graphical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distorted View (Detail in context)</td>
<td>Non-Distorted View (Detail with little or no context)</td>
</tr>
<tr>
<td>encoding spatial transformation (geometric)</td>
<td>zooming windowing</td>
</tr>
<tr>
<td></td>
<td>data suppression (abstraction and thresholding)</td>
</tr>
<tr>
<td></td>
<td>paging clipping</td>
</tr>
</tbody>
</table>
Overview -- History

1982 Bifocal Display (Spence & Apperley)

1986 Fisheye Views (Furnas)

1991 Perspective Wall
(MacKinlay, Robertson, Card)

1992 Fisheye Views for Graphs
(Sarkar & Brown)

1993 Stretching rubber sheet:
(Sarkar, Snibbe, Reiss)

Document Lens +
3D Interactive Animation
(Robertson, MacKinlay)
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   3D Interactive Animation
   (Robertson, MacKinlay)
Overview -- History

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1986 Fisheye Views (Furnas)

(a) Zero-order tree fisheye:

(b) First-order tree fisheye:

(c) Second-order tree fisheye:
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Document Lens +
3D Interactive Animation
   (Robertson, MacKinlay)
Bifocal Display

Combination of a Detailed View and two Distorted Sideview

1-dim. Form
The Bifocal Display solution (1980):

Form a scrollable but visible display
Viewed from the front, one or two items are in focus, but all items are present in a ‘bird’s eye’ view
The Bifocal Display (cont'd)

Fig. 6. The Bifocal Display: (a) a typical transformation function; (b) the corresponding magnification function; (c) the application of the display in one dimension; (d) the application of the display in two dimensions.
Early Implementation of Bifocal Display

1980

© 2001 Robert Spence
Combined X- and Y-Distortion

Two Examples ...

London Underground Map
Diary
Ex1: London Underground Map

Combined X- and Y-Distortion

© 2001 Robert Spence
Polyfocal Display

Projection of Statistical Data on Cartographic Maps

Non-interactive Method

Mathematical Foundation for many later Distortion-Oriented Presentations (Fisheye)

[Kadmon & Shlomi 1978]
Fig. 5. The polyfocal projection: (a) a typical transformation function of a polyfocal projection; (b) the corresponding magnification function; (c) the application of the projection in one dimension; (d) the application of the projection in two dimensions; (e) a multiple-foci view of the projection using the same parameters for each focus point; (f) a multiple-foci view using different parameters.
Polyfocal Display

Continuous Cartograms

Area-normalized thematic views

[Keahey 1999]
DateLens by Ben Bederson

Demo (3:02 min)
Fisheye View

Originally Proposed for Hierarchical Information Structures

Each Information Element

A Priori Importance (API)

(old name: Level of Detail)

Distance between
Information Element and Point of Focus

Thresholding

Represent Relevant Information in Detail

Suppress Irrelevant Information

[Furnas, 1981/1986]
Fisheye View

Mathematical Degree of Interest (DOI) Function

\[ DOI(a|.=b) = API(a) - D(a, b) \]

- DOI in \( a \), given that the current point of focus is \( b \)
- API(\( a \)) ... is a static global value called A Priori importance; pre-assigned to each point in the structure
- D(\( a, b \)) ... is the distance between point \( a \) and the point of focus \( b \)

“how interested” is the user in seeing \( a \) when \( b \) is focused

[Furnas, 1981/1986]
Fig. 11. The Fisheye View: (a) a typical transformation function; (b) the corresponding magnification function; (c) the application of the Fisheye View in one dimension; (d) a Cartesian Fisheye View in two dimensions; (e) a polar Fisheye View; (f) a normalized polar Fisheye View.
Fisheye View

Text-Based Application

Calendar

Large Selection of Program Code

→ Menus

→ Text

[Furnas, 1981/1986]
Fisheye Menus

E-commerce on the Web
Selection of an Item from a Long Linear List

http://www.cs.umd.edu/hcil/fisheyemenu/
Figure 4: A fisheye menu in focus lock mode whose focus area is being extended upwards.
SILVIA MIKSCI

“Flache Darstellung”

2.062 Aus dem Bestehen oder Nichtbestehen eines Sachverhaltes kann nicht auf das Bestehen oder Nichtbestehen eines anderen geschlossen werden.

2.063 Die gesamte Wirklichkeit ist die Welt.

2.1 Wir machen uns Bilder der Tatsachen.

2.11 Das Bild stellt die Sachlage im logischen Raume, das Bestehen und Nichtbestehen von Sachverhalten, vor.

2.12 Das Bild ist ein Modell der Wirklichkeit.

2.13 Den Gegenständen entsprechen im Bilde die Elemente des Bildes.

2.131 Die Elemente des Bildes vertreten im Bild die Gegenstände.

2.14 Das Bild besteht darin, daß sich seine Elemente in bestimmter Art und Weise zu einander verhalten.

2.141 **Das Bild ist eine Tatsache.**

2.15 Daß sich die Elemente des Bildes in bestimmter Art und Weise zu einander verhalten, stellt vor, daß sich die Sachen so zu einander verhalten.

2.151 Dieser Zusammenhang der Elemente des Bildes heißt seine Struktur und ihre Möglichkeit seine Form der Abbildung.

2.1511 Die Form der Abbildung ist die Möglichkeit, daß sich die Dinge so zu einander verhalten, wie die Elemente des Bildes.

2.1512 Das Bild ist so mit der Wirklichkeit verknüpft; es reicht bis zu ihr.

2.1513 Es ist wie ein Maßstab an die Wirklichkeit angelegt.

2.15121 Nur die äußersten Punkte der Teilstriche **berühren** den zu messenden Gegenstand.

2.1513 Nach dieser Auffassung gehößt also zum Bilde auch noch die abbildende Beziehung, die es zum Bild macht.

2.1514 Die abbildende Beziehung besteht aus den Zuordnungen der Elemente des Bildes und der Sachen.

2.1515 Diese Zuordnungen sind gleichsam die **Führung** der Bildelemente, mit denen das Bild die Wirklichkeit berührt.

2.16 Die Tatsache muß, um Bild zu sein, etwas mit dem Abgebildeten gemeinsam haben.

2.161 In Bild und Abgebildetem muß etwas identisch sein, damit das eine überhaupt ein Bild des anderen sein kann.

2.17 Was das Bild mit der Wirklichkeit gemein haben muß, um sie auf seine Art und Weise – richtig oder falsch – abbilden zu können, ist seine Form der Abbildung.
Fisheye View: Definitions

Data

Text Paragraphs

DST (u, x)

Sum of the Levels until the Joined Main Paragraph

API (x)

Negative Number of Digit

\[ DOI(x|u) = API(x) - DST(u, x) = - (#Digit + DST(u, x)) \]

Function of Representation: Threshold \( \geq -6 \)
Perspective Wall

Video: Spence (54 sec)

[Mackinlay et al. 1991]
Perspective Wall

Class Schedule Wall

Nov 93  Dec 93

Files-Time Wall

1Q 92
Perspective Wall

[McKinlay et al. 1991]
Inxight’s Time Wall [www.inxight.com]
Perspective Wall

Fig. 10. The Perspective Wall: (a) a typical transformation function; (b) the corresponding magnification function; (c) the application of the wall in one dimension; (d) the application of the wall in two dimensions. Here the number of dimensions relates to the dimensions in which the perspective transformation is applied on the projection, not to the dimensionality of the model on which the projection is based.
Perspective Wall

Out-of-Focus Region Demagnifies at an Increasing Rate

Discontinuity where Side Panels meets the Middle Panel

Adds a Full 3-dim. View to the flat bifocal Display
Graphical Fisheye View

Based on *Furnas, 1986*

Different Distortions with Different Properties

Stretchable Rubber Sheet (*Sarkar et al, 1993*)

[Sarkar and Brown, 1992]
Stretchable Rubber Sheet

[Sarkar et al, 1993]
Graphical Fisheye View

Compare: Course networks & hierarchies

[Sarkar and Brown, 1992]

Fisheye View Extended for Topological Networks, Multi-layered Data, and Hierarchical Structures
Graphical Fisheye View

Compare: Course networks & hierarchies

[Sarkar and Brown, 1992]

Figure 2: A fisheye view of the graph in Figure 1. The focus is on St. Louis. (The values of the fisheye parameters are $d = 5$, $c = 0$, $r = 0$, $VWcutoff = 0$; the meanings of these parameters are explained in Sections 4 and 6.)
Fisheye View of Graph Data

Compare: Course networks & hierarchies

[Sarkar and Brown, 1992]
Fisheye View of Cone Tree

Compare: Course networks & hierarchies

Figure 5: A Standard 2D Tree.

Figure 10: A Fish-eye View of a 2D Cone Tree.
Fisheye views

Models:

Figure 8: Fisheye views of the nearly-symmetric graph from Figure 7 using a cartesian mapping. The left column uses a focus in the northwest, and the right column uses a focus in the southeast. The distortion increases from top to bottom: In the top row $d = 1.46$, in the middle row $d = 2.92$, and in the bottom row $d = 4.38$. Note that the thickness of each edge varies with the sizes of the vertices it joins.
Seamless Multi-Level Views

[Keahey, 1998]
Rubber Sheet Map Distortion

Demo: 1 min

Pliable Display Technology (PDT)
for Handheld Devices

by IDELIX Software Inc.
www.idelix.com
TableLens

Demo (Video: 6:35 min)

Focus+Context Techniques

Spatial / Distortion-Oriented Methods

  Fisheye Views, Perspective Wall, Stretchable Rubber Sheets, Hyperbolic Space, etc.

Dimensional Methods

  Magic Lenses, Tool Glasses, etc.

Cue Methods

  Color Saturation, Transparency, Brightness, ...
Magic Lenses

Local Changes of Views

[Stone, et al. 1994]
Powers of Ten Thousand
Navigating in Large Information Space

The Macroscope

Henry Lieberman

Media Laboratory
Massachusetts Institute of Technology
The Macroscope Focus + Context

Displays Several Zoom Levels at Same Time

Different Location Projected Over Each Other

[Lieberman, 1994 and 1997]
"Powers of Ten"

Power of Ten – from Quarks to Quasars

Order of Pictures Scaled by 10 orders of magnitude

BUT: static, NOT dynamic

[Lieberman, 1994 and 1997]
The Macroscope: Zoom and Move

[Lieberman, 1994 and 1997]

Zoom

Select a Part of the Image (Viewfinder)

Viewfinder of the Whole Image

Problem: Context Lost!
The Macroscope: Zoom and Move

Solution

Transparent Image - Overlapping

[Lieberman, 1994 and 1997]
The Macroscope: Zoom and Move

[Lieberman, 1994 and 1997]
The Macroscope: Zoom and Move

[Lieberman, 1994 and 1997]
The Macroscope: Interactive Control

[Lieberman, 1994 and 1997]

Change the Viewfinder’s Position = Move
Change the Viewfinder’s Size = Zoom
The Macroscope: Interactive Control

Select the Viewfinders and Adapt them without Overview Lost

Layers with Corresponding Viewfinder --> Emphasize

Dynamic Generation of Transparency between the Layers

[Lieberman, 1994 and 1997]
Movie

The Macroscope
QuickTime, 0:51 Minuten

[Lieberman, 1994 and 1997]
Examples

[Lieberman, 1994 and 1997]
Examples

[Lieberman, 1994 and 1997]
Examples

[Lieberman, 1994 and 1997]
Examples

[Lieberman, 1994 and 1997]
Circular Space Filling Technique

Angular Detail method
Detail Outside method
Detail Inside method

Demo (Video: 4 min)
**Sunburst: Angular Detail Method 1**

**Step 1**
Overview Shrinks
Moves to Opposite Corner

**Step 2**
- Selected Item Extends
- Bulls Eye Over Selected Item

[Stasko, et al. 2000]
Sunburst: Angular Detail Method 2

Step 3
Item’s Children Expand Radially

[Stasko, et al. 2000]
Sunburst: Detail Outside Method 1

Step 1

Overview Shrinks

Stays in Center

[Stasko, et al. 2000]
Sunburst: Detail Outside Method 2

Step 2

Selected Item Emerges

Item Expands → New Ring

[Stasko, et al. 2000]
Sunburst: Detail Inside Method 1

Step 1

Overview → Pushed Outwards

Selected item → Extends in Center

[Stasko, et al. 2000]
Sunburst: Detail Inside Method 2

Step 2

Item → New Circle in Center → Expands Radially

[Stasko, et al. 2000]
Sunburst: Goals & Limitations

Good Representation of Hierarchy
Better Use of Area Than Tree Maps
Small Peripheral Slices

[Stasko, et al. 2000]
Sunburst - Summary

Space-Efficient
More Detailed Examination
Balance Overview & Detail
Keep Context

Changes → Difficult for User
Large Hierarchies → Performance Problems

[Stasko, et al. 2000]
Focus+Context Techniques

Spatial / Distortion-Oriented Methods
  Fisheye Views, Perspective Wall, Stretchable Rubber Sheets,
  Hyperbolic Space, etc.

Dimensional Methods
  Magic Lenses, Tool Glasses, etc.

Cue Methods
  Color Saturation, Transparency, Brightness, ...
Robert Kosara*, Silvia Miksch*, Helwig Hauser**

Semantic Depth of Field

* Institute of Software Technology &
  Interactive Systems
  Vienna University of Technology
  Austria
  http://www.asgaard.tuwien.ac.at/
  {rkosara, silvia}@asgaard.tuwien.ac.at

** VRVis Research Center
  Austria
  http://www.VRVis.at/vis/
  Hauser@VRVis.at
Overview

Focus+Context
Depth of Field (DOF) in Photography
Semantic Depth of Field (SDOF)
Applications
Implementation
Evaluation
Conclusions & Future Plans
Focus and Context: Threats?

Which chessmen threaten the white knight on e3?

Where is e3, anyway?

No Difference Between Focus and Context
Focus, but no Context...

Reduction to Most Important Objects

Focus Easy to See

But no Context
Focus *and* Context: Threats?

Show Important Objects as Usual

Blur Context

Focus Easy to See

Context Still Visible

Idea Behind SDOF!
DOF in Photography

Depth of Field (DOF)
Provides Context
Guides Viewer to Main Object
Easy to See (Preattentive)
Very Intuitive
People are Used to DOF
  Photography
  Movies
Semantic Depth of Field

SDOF is based on DOF

Blur depends on *relevance*, rather than on *physical layout*

Well-known visual metaphor

Works in 2D and 3D

Intuitive (eye)

Preattentive
Idea: 2D SDOF Scene

irrelevant  focus plane

relevant

[Kosara, et al. 2001]
SDOF Principle

Spatial Arrangement
- 2D
- 3D

Relevance and Blurring
- Selection Distance
  ...

Viewing and Camera Model
- Photorealistic Adaptive
  ...

\[ r \in [0; 1] \Rightarrow b \in [1; \infty] \]

[Kosara, et al. 2001]
SDOF Application: MapViewer

[Kosara, et al. 2001]
SDOF Application: MapViewer

[Kosara, et al. 2001]
3D SDOF: Covering Pieces

[Kosara, et al. 2001]
sfvs: Files in Focus

[Kosara, et al. 2001]
Semantic Depth of Field

Fisheye Views
Stretchable Rubber Sheet
Hyperbolic Trees
Cone Trees

SDOF: Works for Text, too!

[Kosara, et al. 2001]
wardrobe, no doubt in lieu of a land trunk. Likewise, there was a parcel of out-andish bone fish hooks on the shelf over the fire-place, and a tall harpoon standing at the head of the bed.

But what is this on the chest? I took it up, and held it close to the light, and felt it, and smelt it, and tried every way possible to arrive at some satisfactory conclusion concerning it. I can compare it to nothing but a large door mat, ornamented at the edges with little tinkling tags something like the stained porcupine quills round an Indian mocassin. There was a hole or slit in the middle of this mat, as you see the same in South American ponchos. But could it be possible that any sober harpooneer would get into a door mat, and parade the streets of any Christian town in that sort of guise? I put it on, to try it, and it weighed me down like a hamper, being uncommonly shaggy and thick, and I thought a little damp, as though this mysterious harpooneer had been wearing it of a rainy day. I went up in it to a bit of glass stuck against the wall, and I never saw such a sight in my life. I tore myself out of it in such a hurry that I gave myself a kink in the neck.

I sat down on the side of the bed, and commenced thinking about this once long lance, now wildly elbowed, on which I saw fifteen whales between a
sscatter: sdoF Scatter Plots

[Kosara, et al. 2001]
ssscatter: sdof Scatter Plots

[Kosara, et al. 2001]
sscatter: sdoF Scatter Plots

[Kosara, et al. 2001]
sMapViewer

[Kosara, et al. 2001]
Preattentive Perception

after ~200ms
Parallel, High Bandwidth
Detection of Target, Location

User Study

16 Participants
2 Hours Each
Professional Usability Lab

[Kosara, et al. 2001]
Overview of Results (1/2)

Participants can Preattentively
- Detect Targets
- Locate Targets
- Estimate Number of Targets

High Precision
- Dependant on Blur Levels of Distractors
- Dependant on Number of Distractors

[Kosara, et al. 2001]
Overview of Results (2/2)

Distinction Between Blur Levels Difficult
Very Weak Perception of Blur Difference
Blur and Orientation not Slower than Orientation alone
Blur not Significantly Slower than Color!

Some did not like Blurred Text
Conclusions

SDOF is an Effective and Efficient F+C Technique
Does not Provide More Space, but Better Discrimination
Natural, Intuitive, *Preattentive*

Future

- Combination with other F+C methods
- Combination with other Cues to Encode More Information
More Information

Acknowledgements

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Institute of Software Technology & Interactive Systems
Center for Usability Research and Engineering (CURE)
FWF (Austrian Science Fund)

http://www.VRVis.at/vis/research/sdof/
http://www.asgaard.tuwien.ac.at/sdof/
Pacific Vis 2011

CareCRUISER
Exploring and Visualizing Data, Processes, and Effects Interactively

Theresia Gschwandtner
Wolfgang Aigner
Katharina Kaiser
Silvia Miksch
Andreas Seyfang
CareCRUISER

Visually communicating:

1. Patient’s condition
2. Applied treatment plans
3. Effects of the treatment

Multiple Views & Interactive Features

[Gschwandther, et al. 2011]
Views

Hierarchical structure

Logical sequence

Brushing & Linking between Views!

[Gschwandther, et al. 2011]
Temporal view on treatment plans and patient data [Gschwandther, et al. 2011]
Temporal view on treatment plans and patient data
Stepwise Interactive Exploration of Effects

[Gschewandtner, et al. 2011]

1) Aligning treatment plans or clinical actions
Stepwise Interactive Exploration of Effects

2) Color coding effects of actions/treatments

- Distance from intended value
- Progress from initial value
- Slope

[Gschwandther, et al. 2011]
Stepwise Interactive Exploration of Effects

2) Color coding effects of actions/treatments

Distance from intended value

[Dynamic filter]

[Gschwandthaler, et al. 2011]
Stepwise Interactive Exploration of Effects

3) Focus and Context Lens: detecting patterns of effects

[Slope]

[Gschwandther, et al. 2011]
CareCruiser Project
Conclusion

Visualizing
  Patient’s condition
  Applied treatment plans
  Effects of the treatment

Multiple views:
  Hierarchical structure of treatment plans
  Logical sequence of treatment plans
  Temporal view on treatment plans and patient data

Interactive features for a stepwise exploration of treatment effects:
  Aligning treatment plans or clinical actions
  Color coding effects of actions/treatments
  Filtering color-highlighted events
  Focus and Context Lens: detecting patterns of effects
Information Mural

Idea

2D

Miniature Representation of Large Information Data

Entire Information Space

Visual Attributes (Color, Intensity)

→ Information Density

Complete Display Window / Screen

[Stasko, et al. 2000]
Information Mural: Goals

Create Representation of Large Information Space

Mimic Original Visual Representation

Minimize Loss of Information

[Stasko, et al. 2000]
Information Mural: Idea

Use techniques of Computer Graphics (Shading and Antialiasing) to More Carefully Draw Overview Displays of Large Data Sets

Think of each Data Point as Ink and each Screen Pixel as a Bin

Data Points (Ink) don't fit Cleanly into one Bin, some Ink may Go into Neighboring Bins

Can Map Density to Gray or Color Scale
Mural Applications: Execution Mural 2

Using new Mural technique

Using classic technique (overplotting)
Mural Applications: Time-oriented Visualizations

Mural → Context & Navigation

View → Focus

[Stasko, et al. 2000]
Mural Applications: Parallel Coordinates

[Stasko, et al. 2000]

Parallel Coordinates

- normal
- muralized
- colorized
Mural Applications: Census Data

[Stasko, et al. 2000]
Multiple Windows (Information Mural)

Event Viewer

[Stasko, et al. 2000]
Mural Applications: Execution Mural

[Stasko, et al. 2000]
Multiple Windows (Information Mural)

Software-Viz Editor

1. This Visual Insights code viewer screen displays 16,439 lines of source code across 55 files. The most recently modified lines are red, the oldest blue, and a color scale indicates intermediate status.

2. This Visual Insights code viewer screen shows lines of source code associated with a particular feature (i5699). The browser window adds an expanded view of the code that is part of feature i5699 in file rtscnrndc.c. Line 27 of the file is highlighted in the browser window.
Mural Applications: Document Visualization

[Stasko, et al. 2000]

3 Documents ➔ Keyword Distribution

“Visualization” (yellow)
“Object-oriented” (green)
“OO” (cyan)
Information Mural Suitable Applications

[Stasko, et al. 2000]

Time-Oriented Visualizations

Visualizations With Miniature Re-presentation (Problem With Details)

Text Files, Documents

Graphs, Charts → Scaling, Rounding

Image (Resize → Loss of Information)
Benefits & Limitations: Information Mural

New Approach
→ Representing Data Density

All Points in Source Image
→ May Be Slower

Very Large Data Set
→ Mural Becomes Fuzzy
F+C: Summary

Spatial / Distortion-Oriented Methods
Fisheye Views, Perspective Wall, Stretchable Rubber Sheets, Hyperbolic Space, etc.

Dimensional Methods
Magic Lenses, Tool Glasses, etc.

Cue Methods
Color Saturation, Transparency, Brightness, ...

User-Driven

Data-Driven
F+C: Potential Limitations

Limited Degree of Magnification?

10X Maximum?

Open Research Question

Disorientation

Complex Transformations Might Cause Viewer to Get Lost

Need Effective Visual Cues to Avoid this

Distortion can be Annoying

Can be very Difficult to Implement

F+C, Disorientation :: Complexity

Any Change in Focal Point Potentially Requires Recalculation of DoI for all Objects and Hence re-rendering of all Objects -> Expensive!

[Keahey 2003] extended
Strengths of F+C

Mirrors the Way the Visual Cortex is Designed

Good Navigation Tool for Interactively Exploring Data
    Probe Regions of Interest Before Committing to Navigating to
    Them (Easily Reversible)

Can be Combined with other Viewing Paradigms such as
    Pan&Zoom

[Keahey 2003] extended
Alternatives to F+C

Pan&Zoom
- Scales to High Factors
- Navigation can be a Problem

Overview + Detail

Multiple Views at Different Scales
- No Distortion between Scales
- No Continuity Either

Filtering

Selective aggregation

Micro-macro readings

Highlighting

...
Overview + Detail

K. Hornbaek et al., Navigation patterns and Usability of Zoomable User Interfaces with and without an Overview, ACM TOCHI, 9(4), December 2002