Information Visualization
Dense Pixel Displays and Focus + Context

Krešimir Matković
Vienna University of Technology,
VRVis Research Center, Vienna

Dense Pixel Methods - Basic Idea

Use pixel to represent one data item
- Number of pixels (~1M) determines number of items
- Relies on use of color - color mapping
- Value ranges are mapped to a fixed color sequence of full color (hue) scale but monotonically decreasing brightness

Horizontal arrangement

8 horizontal bars correspond to 8 years
Subdivisions between the bars represent 12 months within each year
Example analysis results
- Gold price was very low in the sixth year
- IBM price fell quickly after the first 1 ½ month
- US-Dollar exchange rate was highest in the third year

Query Dependent Arrangement

Pixel Bar Chart

Overload typical bar chart with more information about individual elements

[Keim et al. 1995]

Pixel Bar Chart 1

Overload typical bar chart with more information about individual elements

[Keim et al.]
Make each pixel within a bar correspond to a data point in that group represented by the bar.

Can do millions that way.

Color the pixel to represent the value of one of the data point's variables.

Product type is x-axis divider.

Customers ordered by:
- y-axis: dollar amount
- x-axis: number of visits

Color is (a) dollar amount spent, (b) number of visits, (c) sales quantity.

Mapping specified by 5 tuple <Dx, Dy, Ox, Oy, C>:
- Dx—Attribute partitions x axis
- Dy—Attribute partitions y axis
- Ox—Attribute specifies x ordering
- Oy—Attribute specifies y ordering
- C—Attribute specifies color mapping

Data K.-M. et al.
Color Lines View 1

Pixel based technique for families of curves
- Interaction!

InfoVis Techniques

D. Keim proposes a taxonomy of techniques
Standard 2D/3D display
- Bar charts, scatter plots
Geometrically transformed display
- Parallel coordinates
Iconic display
- Needle icons, Chernoff faces
Dense pixel display
- Pixel Bar Chart, Color Lines
Stacked display
- Treemaps, dimensional stacking

Focus and Context Visualization

Overview
Overview first, zoom-in, details on demand!
- Starting point
- Very important
- Helps present overall patterns
- Needed for navigation

Basic Problem

Many data sets are too large to visualize on one screen
- Too many cases
- Too many variables
- Highlight particular cases or particular variables, but viewer's focus may change from time to time

How to work with, navigate through, and analyze a set of data that is too large to fit in the display?
Potential solutions lie in
- Representation
- Interaction
- Both
Details

Overview first, zoom-in, details on demand!

**Details**
- Generally provided on demand
- Individual cases and variables
- How to allow user to find and focus on details of interest?

Pan and Zoom

**Pan/Scroll**
- Provide a larger, virtual screen by allowing user to move to different areas
- Still a problem
- Clunky interaction
- Only get to see one piece

**Zoom**
- Zoom out shows an overview of data space
- Zoom in allows viewer to examine details
- Getting lost - zoom in or out way too far can’t see anything

Long pan isn’t good - zoom out, pan a little, zoom in

Focus and Context 1

Combine overview + detail
- Via space - use different portions of screen to show overview and details
- Via time - alternate between overview and details sequentially in same place

No universal solution, many possibilities

Focus+context visualization: integration of (zoomed) focus & context within one view

Focus + Context 2

Various classification possible

Distorsion Oriented F+C
Views-/layers-based F+C
InPlace F+C

Focus + Context

Various classification possible

Distorsion Oriented F+C
Views-/layers-based F+C
InPlace F+C

Distortion-oriented F+C vis. 2

Hyperbolic tree view
[Lamping/Rao 1994]
3D hyperbolic space
[Munzner 1995]
[xerox.com]
**Fisheye views**

Distortion oriented technique

Introduced by George Furnas in 1981 report, more famous article is 1986 SIGCHI paper

Definition:

“Provide[s] detailed views (focus) and overviews (context) without obscuring anything... The focus area (or areas) is magnified to show detail, while preserving the context, all in a single display.”

(Shneiderman, DTUI, 1998)

---

**Fisheye views terminology**

Focal point

Level of detail

Distance from focus

Degree of interest function

---

**Fisheye views Focal Point**

Assume that viewers focus is on some item, some coordinate, some position,

Focal Point, (0.8, 0.1)

(0.0, 0.0)

(1.0, 1.0)
Fisheye views Level of Detail
Some intrinsic value or quantity on each data element
How important is it to you in a general sense?
Simplest example is that all data items have same level of detail

Fisheye views Distance from Focus
Calculation of how far each item is from the focal point
Query position
Focal Point, (0.8, 0.1)
(0.0, 0.0)

Fisheye views Degree of Interest Function
“DOI” - Function that determines how items in display are rendered
  DOI= Level of Detail - Distance from Focus
  Level of Detail / Distance from Focus
Focal Point, (0.8, 0.1)
(0.0, 0.0)

Fisheye views Degree of Interest Function
DOI Function
Can take on various forms
Continuous - Smooth interpolation away from focus
Filtering - Past a certain point, objects disappear
Step - Levels or regions dictating rendering 0<x<.3 all same, .3<x<.6 all same
Semantic changes - Objects change rendering at different levels

Distortion-oriented F+C vis. 4
Perspective wall [Mackinlay et al. 1991]
Document lens [Robertson/Mackinlay 1993]

Distortion-oriented F+C vis. 5
Table lens [Rao/Card 1994]
Distortion-oriented F+C vis. 6

F+C Process Vis. [Matkovic et al. 2002]

Focus + Context Process Visualization
Using LCDs for F+C 3D Anchoring Collision Avoidance Focus + Context Rendering

Various classification possible
Distorsion Oriented F+C
Views-/layers-based F+C
InPlace F+C

Views-/layers-based F+C vis. 1

Information Mural [Jerding/Stasko 1998]
SeeSoft [Eick et al. 1992]

Toolglass & Magic Lens [Bier et al. 1993]
[Fuhrmann et al. 1998]

Views-/layers-based F+C vis. 2

Views-/layers-based F+C vis. 3

Macroscope [Lieberman 1994]

Various classification possible
Distorsion Oriented F+C
Views-/layers-based F+C
InPlace F+C
In-place F+C vis. 1

GeoSpace [Lokuge/Ishizaki 1995]

In-place F+C vis. 2

Semantic Depth of Field (SDOF) [Kosara et al. 2001]

In-place F+C vis. 3

F+C Screen [Baudisch et al. 2001]

Generalized F+C Visualization

Focus+context visualization: uneven use of graphics resources for visualization

<table>
<thead>
<tr>
<th>resource space</th>
<th>approach</th>
<th>example</th>
</tr>
</thead>
<tbody>
<tr>
<td>freq. opacity color sat.</td>
<td>focus enlargement smooth context translucent context NPR context focus highlighting</td>
<td>fisheye, ProcVis SDOF DVR, RTVR 2iVR GeoSpace, Voxelstube SimVis</td>
</tr>
</tbody>
</table>

F+C visualization – comments

Very useful, often used (esp. in InfoVis)

Usually distortion-oriented, but more general concept (cf. generalization)

Requires interaction (focussing, navigation), smooth changes due to interaction

Aligns well with information drill-down, data analysis (visual information seeking mantra)

Also useable for presentation (e.g., SDOF)
Thank you!

Special thanks for used materials to H. Hauser, M.E. Gröller, and colleagues from VRVis!