Information Visualization Pipeline

- Data
  - Data abstraction
  - Presentation transformation
  - View transformation

- Data representation
  - Visual abstraction

- Visual representation
  - Visual transformation

- Visual presentation
  - View
Representation

- a formal system by which the information can be specified
- different representations reveal different aspects of the information
  - roman, XXXIV: counting, adding, subtracting
  - decimal, 34: counting & information about powers of 10,
  - binary, 100010: counting & information about powers of 2,

Representations

- Good representations
  - captures essential elements of the event / world
  - deliberately leaves out / mutes the irrelevant
  - appropriate for the person and their interpretation
  - appropriate for the task, enhancing judgment ability
- How many buffalo?

8        4
Presentation

“Organization of information for the attention of the mind” (Webster)

(34, 34, 34)

Screen Real Estate

windowing

detail-in-context

full, compressed context

sufficient, filtered context

partitioned context

filtered, distorted context

full distorted context

zoomed context
Presentation Dimensions

- **Filtering**: removing some aspect of the representation.
- **Partition**: dividing a given presentation into components or regions.
- **Clustering**: aggregating a given presentation by collecting components or regions of a presentation into a groups.
- **Spatial re-organization**: spatial re-organization that changes the original proportions.
Presentation Dimensions (cont’d)

- **Augmentation**: selective visual addition that is intended to increase the clarity of the presentation.

- **Time**: presentations can be changed over time, presentation space includes the possibility of motion.

- **Illumination**: The illumination continuum extends from no use or uniform lighting through complex use of lighting to highlight and emphasize regions of interest to use of lighting that has semantic value.

Partition: Windowing

Xerox Star

The main presentation ideas in windows are:

- the partitioning of space,
- the tiling of regions,
- the free-form overlapping of regions, supporting freedom to reposition,
- the replacing of large objects with a smaller symbols,
- the zooming, panning and scrolling capabilities within a window, and
- the inclusion of pointing using the mouse as a movable indication device.
A Presentation Problem

Insufficient detail

Windowing

- partitioning of space
- possibility of re-positioning
- free-form over-lapping of regions
- zooming
- panning, scrolling
- pointing
- conflict between detail and context
  - Johnson et al.
A Presentation Problem

Insufficient context

Insets
• have detail
• have some context
• lose local context
• not detail-in-context
A Presentation Problem

Separate views
• have detail
• have context
• not detail-in-context

Context

Missing in the multiple over-lapping space of windows
Two ideas in response
Full context and
Sufficient context
Full Context

Spence and Apperly (1982)
• noted crowding and navigation problems with WIMP interfaces
• search problem -> humans have a less than precise recollection of exactly what they are looking for (not exact name of a book but where last seen)
• leads to browsing and searching activities before retrieval
• searching in physical space is supported by spatial memory, memory of previous actions, and visual and verbal clues
• in subsequent physical searches these clues are reinforced by a reasonable degree of constancy

Sufficient Context

New Yorker’s view of the USA, Manhattan street by street and Chicago, the Rockies, and California.
Sufficient Context


• fisheye, or very wide angle, lens shows a world view with a detailed central focus and the surrounding context in gradually decreasing detail.
• artistic presentations of this type used the fisheye distortion and kept selected objects in disproportionate detail considering their distance from the focus.
• display includes detail around the focus and only those aspects that are considered important elsewhere.

Sufficient Context

• studied how people retain and present information in various subject areas and work-places
• geography, history and newspapers
• studies revealed that people usually know the details about their own interests set in enough domain knowledge to provide context.
• studies confirm the importance of maintaining context and of setting a focus within its context.
• suggests that the widespread evidence shown in his studies indicates that detail-in-context may be a useful and intuitive way to present information.
Sufficient Context

- a filtered context may be sufficient
- How to filter?
  - Random (as in sampling)?
  - Threshold?
  - Data attribute(s)?

Sufficient Context

- a centre of interest or focus about which detail is important
- interest decreases as distance from the focus increases.
- plus some domain specific items
- filtering the context using a *degree of interest (DOI)* function.
- A DOI is based upon the distance from the current focus and an *a priori importance (API)* that is domain specific and known for each item
- Using a *domain specific* function requires that the person creating the presentation have knowledge about the information or data in the representation
Sufficient Context

- if ‘n’ points can be displayed
- find ‘n’ most interesting
- plus some domain specific items
- filtering the context using a degree of interest (DOI) function.
- a DOI is based upon
  - a current point of interest – the focus.
  - the distance from the current focus and
  - a priori importance (API) domain specific and known for each item

Degree of Interest (DOI)

\[ DOI_{gf}(b|a) = API(b) - \text{Dis}(b,a) \]

\( DOI_{gf} \) - degree of interest, gf in the Generalized Fisheye Views paper by G. Furnas (CHI’86)

\( b|a \) - of ‘b’ given that ‘a’ is the current focus object (node, or point) of interest

\( API(b) \) - a priori interest in (importance of) b (can be a function, or an aspect of the data, or an assigned attribute)
Degree of Interest (DOI)

$$DOI_{gf}(b|a) = API(b) - \text{Dis}(b, a)$$

Dis(b,a) – distance from b to a

Possible types of distance

For nodes in a tree – path length

In relationship to root (Dis(b, root) + Dis(a, root))
or to nearest common parent (NCP)
(Dis(b, NCP) + Dis(a, NPC))

For nodes in a graph – length of shortest path

Generalizing spatial distance

$$L_2 = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

$$L_p = \sqrt[p]{(x_1 - x_2)^p + (y_1 - y_2)^p}$$

$$L_1 = \sqrt[1]{(x_1 - x_2)^1 + (y_1 - y_2)^1}$$

$$L_\infty = \sqrt[\infty]{(x_1 - x_2)^\infty + (y_1 - y_2)^\infty}$$

$$= \max((x_1 - x_2), (y_1 - y_2))$$
Sufficient Context

The main presentation ideas in Generalized Fisheye Views are:
• the maintenance of a sufficient context (this requires domain specific knowledge),
• variation in the size of the area of interest around the focus (this is again domain, task and user specific), and
• the possibility of more than one area of interest.

• DOITrees VIDEO

Sufficient, Filtered Context (Furnas ‘82)
• DOI (domain specific)
• variations in size of focus
• multiple foci
(Consens et al., Becker et al., Ahlberg and Shneiderman)
Filtering distortion affects human performance and learning, particularly in the domains of multiple states and hierarchy. The Filtered, Distorted Context (Hollands et al., Sarkar and Brown) highlights that graphic interpretations of DOI’s lead to distortion (Bartram et al., Schaffer et al., Fisher et al.) and elides hierarchically.


- Suggest compressed full context maintains at least some symbolic vestige of all information.
- Suggest use of spatial constancy to support visual scan and spatial memory.
- Maintaining spatial constancy requires ensuring that all parts or regions of the representation stay in the same positions relative to each other.
- Positions of items in context respected and moved as little as possible.
- Incorporation of two levels of detail within a single unified display.
Spence and Apperly (1982)
The main presentation ideas in Bifocal Display are:

- the maintenance of spatial constancy to support spatial memory,
- the introduction of more than one scale in a unified presentation, and
- the compression of a full context.

VIDEO
Orthogonal Stretching

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$c_1$</td>
<td>$b_1$</td>
<td>$c_2$</td>
</tr>
<tr>
<td>$b_4$</td>
<td>$a$</td>
<td>$b_3$</td>
</tr>
<tr>
<td>$c_4$</td>
<td>$b_3$</td>
<td>$c_3$</td>
</tr>
</tbody>
</table>

Bifocal Display

The diagrams illustrate the concept of bifocal display, showing how different elements are arranged in a grid format.
Distortion in object space

- Sometimes it is important that objects in the model have integrity.
  - a mechanical piece in an engine
  - anatomy: an organ in relation to the rest
- Yet emphasis can still be important.

Expansion approach

2 pass algorithm: expand and contract

Expansion approach

- Sequential selection of focal nodes
  - Additional magnifications lead to considerable white space.

- Constrained areas
  - less white space
  - limited expansion
  - parallelism jeopardized

Interval approach

Interval approach

Conceptually

• scale up as requested
  – either intervals or objects

• scale to back to fit display space

• similar to expansion method except:
  – operates on intervals as well as objects
  – operates independently in each dimension
  – this makes it functional in any number of dimensions
  – can introduce non-uniform scaling

TableLens
TableLens

Inxight: www.inxight.com

Housing Market for Santa Clara County, CA - March 2000

http://www.inxight.com/products/sdks/tl/
Full Context

Important concept: preservation of the mental map
Eades, Misue et al 1996

• orthogonality - objects maintain relative right/left up/down positioning,
• proximity - adjacent objects remain adjacent, and
• topology - containment relationships are preserved.

• the thought is that limiting the pattern of changes will provide better support for the mental map that the viewer has formed of the information.