CIS 4930/6930-902

Scientific Visualization

Review of Fundamentals

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WHY DOES VISUALIZATION WORK?

cognition is limited
MTHIVLWYADCEQGHKILKMTWYN
ARDCAIREQGHLVKMFPSTWYARN
GFPSVCEILQGKMFPSONRDCEQDI
PSGHLMFHKMVSTWYACEQTWRN
WHY DOES VISUALIZATION WORK?

memory is limited
GIVEN THESE NUMBERS . . .

. . . what number appears most often?
GIVEN THESE NUMBERS . . .

. . . what number appears most often?
HUMAN LIMITATIONS
SIMULTANEOUS CONTRAST
SIMULTANEOUS CONTRAST
SIMULTANEOUS CONTRAST
COLOR RELATIVITY
COLOR RELATIVITY
**CONTRAST SENSITIVITY**

C. Ware, “Visual Thinking for Design”
ILLUSIONS OF VISUAL BANDWIDTH

people over-predict what they will see and become aware of
OVERESTIMATE OF BREADTH
- belief that viewers can take in all (or most) of the details of a scene at once
- adding extra visual features makes it harder to find specifics bits of information

OVERESTIMATE OF COUNTEANCE
- belief that user will attend to a higher proportion of the display than they do
- users typically have expectations about where in a display to look

OVERESTIMATE OF DEPTH
- belief that attending to an object leads to more complete and deep understanding than is the case
“Tools” of Visualization
ANALYSIS: WHAT, WHY, AND HOW

what is shown?
data abstraction

why is the user looking at it?
task abstraction

how is it shown?
idiom: visual encoding and interaction

abstract vocabulary avoids domain-specific terms

translation process iterative, tricky

what-why-how analysis framework as scaffold to think systematically about design space
ATTRIBUTE TYPES

Categorical
no implicit ordering

Hierarchical

Ordered

Ordinal

Quantitative
meaningful magnitude (can do arithmetic)

Sequential

Divergent

Cyclic
{ACTION, TARGET}
### Magnitude Channels: Ordered Attributes

- Position on common scale
- Position on unaligned scale
- Length (1D size)
- Tilt/angle
- Area (2D size)
- Depth (3D position)
- Color luminance
- Color saturation
- Curvature
- Volume (3D size)

**Expressiveness** *(how much)*

### Identity Channels: Categorical Attributes

- Spatial region
- Color hue
- Motion
- Shape

**Expressiveness** *(what or where)*
**Magnitude Channels: Ordered Attributes**

- Position on common scale
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**Identity Channels: Categorical Attributes**

- Spatial region
- Color hue
- Motion
- Shape

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**EFFECTIVENESS**
Multiple View Approaches

- Juxtapose and coordinate multiple side-by-side views
  - Share Encoding: Same/Different
    - Linked Highlighting
  - Share Data: All/Subset/None
  - Share Navigation

<table>
<thead>
<tr>
<th>Data</th>
<th>All</th>
<th>Subset</th>
<th>None</th>
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<td>Encoding</td>
<td>Same</td>
<td>Different</td>
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<td></td>
<td>Redundant</td>
<td>Multiform</td>
<td>Small Multiples</td>
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<td></td>
<td>Overview/Detail</td>
<td>Multiform, Overview/Detail</td>
<td>No Linkage</td>
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</tbody>
</table>

- Partition into side-by-side views
- Superimpose layers
FOCUS+CONTEXT

- Embed
  - Elide Data
  - Superimpose Layer
  - Distort Geometry
FILTERING & AGGREGATION

Reducing Items and Attributes

- Filter
  - Items
    ![Items Diagram]
  - Attributes
    ![Attributes Diagram]

- Aggregate
  - Items
    ![Items Diagram]
  - Attributes
    ![Attributes Diagram]
VISUAL DESIGN
NESTED MODEL

design model—describes levels of design inherent to, and that should be considered in, the creation of a visualization

Munzner 2009
TUFTE
design excellence
GRAPHICAL INTEGRITY

clear, detailed, and thorough labeling should be used to defeat graphical distortion and ambiguity
Tufte’s Integrity Principles

Graphical excellence is that which
- gives the viewer the greatest number of ideas
- in the shortest time
- with the least ink
- in the smallest space

A. Einstein, “An explanation should be as simple as possible, but no simpler.”
POPOUT
GESTALT PRINCIPLES
HUES FOR CATEGORIES
DISTINGUISHABILITY
only good at distinguishing 6-12 simultaneous colors
RAINBOW COLORMAPS: CHALLENGES
RAINBOW GUIDELINES

poor

better
• **Complementary**—high contrast creates a vibrant look

• **Analogous**—often found in nature and are harmonious and pleasing to the eye

• **Triad**—vibrant, even if you use pale or unsaturated versions of your hues

• **Split-complementary**—same strong contrast as the complementary but less tension

• **Rectangle**—rich color scheme offers plenty of possibilities for variation

LOOK TO NATURE
SIMPLICITY

choose one color to be used in larger amounts

be selective about the base color

use other colors to add interest
AVOIDANCE OF COLOR

use neutrals (work with any scheme)
black, white, grey

use diagrammatic marks (may be better encoding channels)
size, shape, texture, length, width, orientation, curvature and intensity