The Purposes of Visualization

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CS448B – Visualization
Winter 2004

Definition [www.oed.com]

1. The action or fact of visualizing; the power or process of forming a mental picture or vision of something not actually present to the sight; a picture thus formed.

1883 Academy 14 July 31 Investigations into the phenomena of visualisation.

1884 GURNEY & MYERS in 19th Cent. July 72 In the next stage of visualisation the percipient sees a face or figure projected or dejected, as it were, on some convenient surface.

1894 Athenæum 10 Nov. 638/2 [The book had] a power of visualization that gave it a claim to real originality.
Definition [www.oed.com]

2. The action or process of rendering visible.

1936 Amer. Jrnl. Cancer XXVII. 49 The hexagonal tube...offers distinct advantages with its flat sides permitting good visualization.

1960 New Scientist 28 July 305/3 Echo sounding...is now being applied to the visualization of structures within the body.

1973 Nature 17 Aug. 410/1 Direct visualization of biological material at this level would tell us much about the structure and mode of action of macromolecules.

1982 Listener 23/30 Dec. 42/3 The cinematic visualisation of the script...belongs entirely to Welles and his technicians.

The Purpose of Data Visualization

is to

Convey Information to People
Why?

Answer a question
   “One image = One diagnosis”
Make decisions
   Support analysis and reasoning
To explore and discover; encourage creativity
   Look at things in a new way
   “The purpose of computing is insight,
   not numbers” [R. Hamming]
Communicate information to others
   Make a point
   Tell a story
Inspire
   Part of our cultural heritage

Functions of Visualizations

1. Recording information
   e.g. table of logarithms, blueprints and telescope images

2. Processing information
   Computer -> Display -> Person
   w/ feedback and interaction

3. Presenting information
   Display -> People
   Share, collaborate, revise, ...
Power of Visualization

The Most Powerful Brain?

<table>
<thead>
<tr>
<th>Rank</th>
<th>Name</th>
<th>Body Weight</th>
<th>Brain Weight</th>
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<tr>
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<td>House Shrew</td>
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<td>0.14</td>
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<td>Tamar Shrew-tailed Shrew</td>
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<td>0.14</td>
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<td>0.25</td>
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<td>4</td>
<td>Mouse</td>
<td>23</td>
<td>0.3</td>
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<td>Big Brown Bat</td>
<td>23</td>
<td>0.4</td>
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<td>Mo 5</td>
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<td>Eastern American Mole</td>
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<td>Nile Rat</td>
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<td>3</td>
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<td>13</td>
<td>Galago</td>
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<td>Rat</td>
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<td>15</td>
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<td>African Giant Pouched Rat</td>
<td>1000</td>
<td>6.6</td>
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<td>1640</td>
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<td>Phalanger</td>
<td>1620</td>
<td>11.4</td>
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</tbody>
</table>
The Most Powerful Brain?

C. Sagan, The Dragons of Eden

The Most Powerful Brain?

W. Cleveland, The Elements of Graphing Data
Challenger Disaster

HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

<table>
<thead>
<tr>
<th>SRM Section</th>
<th>Time</th>
<th>Location</th>
<th>Trait</th>
<th>Max Erosion</th>
<th>Total Mass</th>
<th>Top View</th>
<th>Checking Location (cm)</th>
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<tbody>
<tr>
<td>S1A LH Center Field</td>
<td>None</td>
<td>None</td>
<td>0.280</td>
<td>None</td>
<td>0.280</td>
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<td>None</td>
<td>0.280</td>
<td>None</td>
<td>0.280</td>
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<td>5.56 - 5.61</td>
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<td>S1B LH Center Field</td>
<td>0.019</td>
<td>14.6</td>
<td>0.080</td>
<td>4.75</td>
<td>4.75</td>
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<tr>
<td>S1B LH Forward Field</td>
<td>0.028</td>
<td>12.6</td>
<td>0.080</td>
<td>11.60</td>
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<td>S1B LH Forward Field (Secondary)</td>
<td>None</td>
<td>45.0</td>
<td>0.000</td>
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<tr>
<td>41D RH Forward Field</td>
<td>0.026</td>
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<td>0.280</td>
<td>3.80</td>
<td>3.80</td>
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<tr>
<td>41E RH AF Field</td>
<td>None</td>
<td>None</td>
<td>0.280</td>
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<tr>
<td>41F LH Forward Field</td>
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<td>0.280</td>
<td>3.00</td>
<td>3.00</td>
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<td>90</td>
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</table>

*This got deep detected in putty, indication of heat on O-ring, but no damage.
**Heat bathed primary O-ring, heat affected secondary O-ring.
***Checking location of leak check part - 0 day.

Other SRM-15 Field joints had no blowholes in putty and no soot near or beyond the primary O-ring.

SRM-22 and SRM-23 field joints had putty path to primary O-ring but no O-ring erosion and no soot blowby.

1 of 13 pages of material faxed to NASA by Morton Thiokol
Challenger Disaster

Pythagorean Theorem:
Chinese Proof by Dissection

Visual Thinking

Visual Proof:
$1+3+5+7+9=5^2$
Inspire

Long-Hand Multiplication

34
x 72
68
2380
2448

Time (Sec.)

Mental
Paper & Pencil
Amplifies Cognition/Perception

1. Expand working memory
2. Reduce search time
3. Pattern detection and recognition
4. Perceptual inference
5. Perceptual monitoring and controlling attention
6. Interaction is important for cognition

Card, Schneiderman, MacKinlay,
Readings in Information Visualization

Information-Seeking Mantra

Overview first,
then zoom and filter,
details on demand

B. Schneiderman, The eyes have it: A task by data type
taxonomy for information visualization, 1996
Challenges

More and more unseen data

Simulation and Instrumentation

Ctr for Int. Turbulence Simulation
PW6000 Turbine
93.8 million cell mesh
5700 time steps, 30 iter/ts
5970 hours on 1K proc

Sloan Digital Sky Survey
Robotic telescope
5x6 2048x2048 CCD sensors
40 TB of imagery
100 million object catalog
Observation of Unseen Worlds

Hooke’s Microscope  Flamsteed’s Telescope

Challenges

More and more unseen data

Principles for designing effective visualizations
Challenges

More and more unseen data

Principles for designing effective visualizations

Better tools to produce visualizations

Route Maps

Overlaid Route

Sketched Route

1. Find cognitive and perceptual principles
2. Optimize the visualization according to these principles

Agrawala and Stolte, Rendering Effective Route Maps, SIGGRAPH 2001
1. Data and Image Models

Bertin, The Semiology of Graphics

2. Perception and Cognition

<table>
<thead>
<tr>
<th>Quantitative</th>
<th>Ordinal</th>
<th>Nominal</th>
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<tbody>
<tr>
<td>Position</td>
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<td>Length</td>
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<td>Angle</td>
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<tr>
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<tr>
<td>Area</td>
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<tr>
<td>Containment</td>
<td>Shape</td>
<td>Volume</td>
</tr>
</tbody>
</table>

[McKinlay, Automating the Design of Graphical Presentations of Relational Information, ACM TOG 5.3, 1986]

3. Spatial Encodings

Equiheading vs. Equidistance Projection
4. Color

From C. Brewer

5. Interaction

Gibson’s Experiment
Goal: Match 2 shapes
Active touch: 96%
Passive (rotation) 72%
Passive (imprint) 49%

From J. J. Gibson (1966)
The Senses Considered as a Perceptual System, p. 124

Thanks to David Kirsh for this example.
6. Drawing Trees and Graphs

[Image: Internet colored by distance from a source host, www.lumeta.com]

7. Self-Illustrating Phenomena

[Image: Abstract diagram with blue background and white lines and circles]
8. Conveying Shape

Good views
Lines
Shading
Texture

From Gooch²

9. Conveying Structure

Karl Heinz Hoehne’s Voxel-Man
Images of the Visible Man

Leonardo’s Notebooks
10. Motion and Animation

Outside-In, Geometry Computing Center