The Purpose of Visualization

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CS 294-10: Visualization
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What is visualization?

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.

2. The action or process of rendering visible.
Why do we create visualizations?

Examples
Examples

Observation: A large number of auto thefts occur in the University district, even though the area ranks relatively low in total crime.
Examples

Other examples?

Why do we create visualizations?

To expose ideas/relationships
To make an argument
To observe trends
Summarize/aggregate data
Archiving
Trust
Advertise ideas
Exploratory data analysis
Why do we create visualizations?

- Answer questions
- Make decisions
- See data in context
- Expand memory
- Support graphical calculation
- Find patterns
- Present argument
- Tell a story
- Inspire

Three functions of visualizations

Record information
- Photographs, blueprints, …

Support reasoning about information (analyze)
- Process and calculate
- Reason about data
- Feedback and interaction

Convey information to others (present)
- Share and persuade
- Collaborate and revise
- Emphasize important aspects of data
Record Information

Drawing: Phases of the moon

Galileo's drawings of the phases of the moon from 1616
http://galileo.rice.edu/sci/observations/moon.html
Photographs: Phases of the moon

Answer question

Gallop, Bay Horse “Daisy” [Muybridge 1884-86]
Other recording instruments

Marey’s sphygmograph [from Braun 83]

Support Reasoning
Make a decision: Challenger

Visualizations drawn by Tufte show how low temperatures damage O-rings [Tufte 97]
Make a decision: Challenger

Visualizations drawn by Tufte show how low temperatures damage O-rings [Tufte 97]

See data in context: Cholera outbreak

In 1854 John Snow plotted the position of each cholera case on a map. [from Tufte 83]
See data in context: Cholera outbreak

Used map to hypothesize that pump on Broad St. was the cause. [from Tufte 83]

Expand memory: Multiplication

34
x 72
Expand memory: Multiplication

\[
\begin{array}{c}
34 \\
\times 72 \\
\hline
68 \\
2380 \\
2448
\end{array}
\]

Graphical calculation: Evaporation

Johannes Lambert used graphs to study the rate of water evaporation as function of temperature [from Tufte 83]
Johannes Lambert used graphs to study the rate of water evaporation as function of temperature [from Tufte 83]

Graphical calculation: Evaporation

Graphical calculation: Visual proofs

Sum of odd numbers:
$1 + 3 + 5 + 7 + 9 = 5^2$

Pythagorean theorem:
Chinese proof by dissection
Find patterns: New York weather

From the New York Times 1981

Convey Information to Others
Present argument: Exports and Imports

Inspire

Bones in hand [from 1918 edition]
Double helix model [Watson and Crick 53]
Visualization Research

Challenge

More and more unseen data
- Faster creation and collection
Challenge

More and more unseen data

- Faster creation and collection

Urban development planning
www.urbansim.org

Fluid flow
ctr.stanford.edu

Simulation

Challenge

More and more unseen data

- Faster creation and collection

Sloan digital sky survey
www.sdss.org

Sensor networks [Hill 02]
www.xbow.com

Digital photography

Sensing
Challenge

More and more unseen data
- Faster creation and collection
- Faster dissemination

More and more unseen data
- Faster creation and collection
- Faster dissemination

5 exabytes of new information in 2002 [Lyman 03]
- 37,000 Libraries of Congress

161 exabytes in 2006 [Gantz 07]

Need better tools and algorithms for visually conveying information
Attention

“What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention, and a need to allocate that attention efficiently among the overabundance of information sources that might consume it.”

~Herb Simon
as quoted by Hal Varian
Scientific American
September 1995

Goals of visualization research

1. Understand how visualizations convey information to people
   - What do people perceive/comprehend?
   - How do visualizations correspond with mental models of data?

2. Develop principles and techniques for creating effective visualizations
   - Amplify perception and cognition
   - Strengthen connection between visualization and mental models of data
1. Data and image models

[Image: Diagram of image variables]

2. Good and bad visualizations

Problematic design

Redesign

3. Perception

The psychophysics of sensory function [Stevens 61]
4. Interaction

FilmFinder [Ahlberg 94]

5. Spatial Layout

London underground [Beck 33]
6. Trees and graphs

Degree-of-Interest Trees [Heer & Card, 2004]

7. Color

[from Cynthia Brewer http://www.personal.psu.edu/faculty/c/a/cab38/ ]
8. Collaborative visualization

9. Identifying design principles

Testing effectiveness of 3 types of assembly instructions [Heiser 04]
10. Conveying shape

Lumbosacral and Sacro-iliac fusion
Russell Drake, medical illustrator,
Mayo Foundation, 1932.

11. Conveying structure

Principal Organs & Vascular System
[Leonardo da Vinci ca. 1490]
Strange Immersion of Torus in 3-Space [Curtis 92]
12. Photography

Shadowgraph of a .22-caliber bullet in flight Taken by an MIT freshman in 1962, in Edgerton's lab. The flash was triggered by the shock wave (shown) hitting a microphone (out of frame). The picture shows no solid object except the bullet. http://en.wikipedia.org/wiki/Doc_Edgerton

13. Depicting processes & actions

Wearing a sari [from Mijksenaar 99] Visualizing dance steps [from Tufte 90]
14. Animation

Outside-In, Geometry Computing Center

Course Mechanics
Textbooks

See also: www.edwardtufte.com

Readings

- Some from textbooks, also many papers
  Username/Password: vis/visReadings
- Material in class will be loosely based on readings
- Readings should be read by start of class
- Post discussion comments on class wiki
  Important: Create a wiki account

Class home page
http://vis.berkeley.edu/courses/cs294-10-fa08/wiki
Requirements

Class participation (10%)

Assignment 1a: Good and Bad Visualizations (5%)

Assignment 1b: Visualization Deconstruction and Redesign (10%)

Assignment 2: Creating Visualizations with Existing Software (10%)

Assignment 3: Creating Interactive Visualization Software (25%)

Final Project (40%)

Final project

- Visualization research project on topic of your choice
- 2nd half of class
- Project write-up in form of a research paper
- Project presentations
  1. Background research on project area
  2. Midway presentation on prototype solutions
  3. Final presentation – exact time to be determined

Projects from previous classes have been published
- IEEE Visualization
- IEEE Information Visualization
- SIGGRAPH

Final presentations to outside experts on visualization