The Purpose of Visualization

Maneesh Agrawala

CS 294-10: Visualization
Spring 2010
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
Examples

Other examples?

Why do we create visualizations?

- Picture worth 1000 words
- Bring attention to certain relationships
- Cut through noise/To attract attention
- Organize information
- To aid quick understanding
- Help understanding without words
- Combine information and get new information from combination
- To persuade
- To identify patterns
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

\[
\begin{array}{c}
34 \\
\times 72
\end{array}
\]
Expand memory: Multiplication

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

Graphical calculation: Evaporation

Johannes Lambert used graphs to study the rate of water evaporation as a 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 = 5²

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

[Playfair 1786]

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

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

[Bertin, Graphics and Graphic Information Processing 1981]
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

sense.us [Heer 07]

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.


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-sp10/wiki
Requirements

Class participation (10%)

Assignment 1: Good and Bad Visualizations (5%)

Assignment 2: Visualization Deconstruction and Redesign (10%)

Assignment 3: Creating Visualizations with Existing Software (10%)

Assignment 4: Creating Interactive Visualization Software (25%)

Final Project (40%)

Assignment 1: Good and Bad Vis.

Find two visualizations one good and one bad

Use original sources
- Journals
- Science magazines
- Newspapers
- Textbooks

Make wiki page
- Clearly mark as good or bad
- Provide short explanation
- Be prepared to succinctly describe in class on Wed Jan 27

Due before class Mon Jan 25
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