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.

Summary Statistics

Linear Regression

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\[ u_x = 9.0 \quad \sigma_x = 3.37 \quad \mu_Y = 3 + 0.5 \quad \sigma_Y = 2.93 \quad R^2 = 0.87 \]

[Anscombe 73]
Why do we create visualizations?

- Higher bandwidth to visual system
- Make easier to understand data (trends more apparent)
- Aggregate more data in a visualization
- Compare data more easily
- Artistic/Aesthetic purposes
- Helps to communicate ideas better
- Overcoming language barriers
- Add meaning to data (structures the data)
- To persuade
- Helps avoid confusion and help with safety
- Emphasize different parts of the data
- Make data available/understandable to more people
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

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**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**

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

Support Reasoning

Make a decision: Challenger

See data in context: Cholera outbreak

Marey’s sphygmograph [from Braun 83]

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

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

Class Exercise

Expand memory: Multiplication

$$34 \times 72$$

$$68$$

$$2380$$

$$2448$$

Graphical calculation: Evaporation

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

Graphical calculation: Evaporation

Johannes Lambert used graphs to study the rate of water evaporation as function of temperature. [from Tufte 83]
Graphical calculation: Visual proofs

Sum of odd numbers:
1 + 3 + 5 + 7 + 9 = 25

Pythagorean theorem:
Chinese proof by dissection

Find patterns: New York weather

From the New York Times 1981

Convey Information to Others

Tell a story: Most powerful brain?

The Dragons of Eden [Carl Sagan]

Tell a story: Most powerful brain?

The Elements of Graping Data [Cleveland]
**Present argument: Exports and Imports**

[Image of a graph showing export and import trends over time.]

**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

**Simulation**

- Urban development planning [www.urbansim.org]
- Fluid flow [www.xbow.com]

**Sensing**

- Sloan digital sky survey [www.sdss.org]
- Sensor networks [Hill 02]
- Digital photography
Challenge
More and more unseen data
- Faster creation and collection
- Faster dissemination

Photo sharing/annotation
flickr.com

Map of the Internet [Cheswick 99]
research.lumeta.com
Group Authoring Encyclopedia
wikipedia.org

Internet

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

[slide from PARC UIR group]

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 of data and image models]

[Bertin, Graphics and Graphic Information Processing 1981]
2. Visualization Re-Design

3. Perception

4. Interaction

5. Spatial Layout

6. Trees and graphs

7. Color

2. Visualization Re-Design

3. Perception

4. Interaction

5. Spatial Layout

6. Trees and graphs

7. Color
8. Collaborative visualization

9. Identifying design principles

10. Conveying shape

11. Conveying structure

12. Photography

13. Depicting processes & actions
14. Animation

Outside-In, Geometry Computing Center

Course Mechanics

Instructor: Maneesh Agrawala

Course Goals

1. Evaluate and critique visualization designs
2. Implement interactive data visualizations
3. Gain an overview of research & techniques
4. Develop a substantial visualization project

Textbooks

See also: www.edwardtufte.com

Readings

- Some from textbooks, also many papers
- Username/Password: visualReadings
- Material in class will be loosely based on readings
- Readings should be read by start of class
- Post discussion comments on class wiki
  Must post within 1 day of lecture
  Important: Create a wiki account

Class home page
http://vis.berkeley.edu/courses/cs294-10-sp11/wiki
Requirements

Class participation (10%)

Assignment 1: Visualization Design (10%)

Assignment 2: Exploratory Data Analysis (15%)

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

Assignment 1: Visualization Design

Due by 9am on Jan 26