The Value of Visualization

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ASSISTANT: Jason Chuang

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http://cs448b.stanford.edu

Set A

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Summary Statistics

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<th></th>
<th>(u_X = 9.0)</th>
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<th>(u_Y = 7.5)</th>
<th>(\sigma_Y = 2.03)</th>
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<td>(R^2)</td>
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Linear Regression

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<th>(Y)</th>
<th>(= 3 + 0.5 X)</th>
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[Anscombe 73]
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.

Transformation of the symbolic into the geometric”
[McCormick et al. 1987]

“... finding the artificial memory that best supports our natural means of perception.” [Bertin 1967]

“The use of computer-generated, interactive, visual representations of data to amplify cognition.”
[Card, Mackinlay, & Shneiderman 1999]

Why do we create visualizations?
Why do we create visualizations?

- Understand patterns in data, outliers
- To persuade people, present an argument
- To see the forest not the trees. See data in context.
- Spur discussion
- Make decisions
- Inspiration
- Efficiency? Analysis

Three functions of visualizations

**Record**: store information
- Photographs, blueprints, ...

**Analyze**: support reasoning about information
- Process and calculate
- Reason about data
- Feedback and interaction

**Communicate**: convey information to others
- Share and persuade
- Collaborate and revise
- Emphasize important aspects of data

Why do we create visualizations?

- Answer questions (or discover them)
- Make decisions
- See data in context
- Expand memory
- Support graphical calculation
- Find patterns
- Present argument or tell a story
- Inspire
Make a decision: Challenger

Visualization of O-ring damage [Tuft 97]

Make a decision: Challenger

Visualization redesign by Tuft shows how low temperatures damage O-rings [Tuft 97]

Data in context: Cholera outbreak

In 1854 John Snow plotted the position of each cholera case on a map. [from Tuft 83]
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

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

Expand memory: Multiplication

\[
\begin{array}{c}
120 \\
100 \\
80 \\
60 \\
40 \\
20 \\
0
\end{array}
\]

Mental

Paper & Pencil
Calculation: Evaporation

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

Find patterns: NYC weather

From the New York Times 1981

Convey Information to Others
Inspire

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

Challenge

- More and more unseen data
- Faster creation and collection

Visualization Research
Challenge

- More and more unseen data
- Faster creation and collection

Urban development planning
www.urbansim.org

Simulation

Fluid flow
ctr.stanford.edu

More and more unseen data
Faster creation and collection

Sloan digital sky survey
www.sdss.org

Sensing

Sensor networks [Hill 02]
www.xbow.com

Digital photography

More and more unseen data
Faster creation and collection
Faster dissemination

Photo sharing/annotation
flickr.com

Internet

Group Authoring
wikipedia.org

5 exabytes of new information in 2002 [Lyman 03]

Map of the Internet (Cheswick 99)
research.lumeta.com

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 and supporting analysis
   - Amplify perception and cognition
   - Strengthen connection between visualization and mental models of data

Course Topics

Data and Image Models

Sémiologie Graphique [Bertin 67]
**Visualization (Re-)Design**

- Problematic design
- Redesign

**Graphical Perception**

- The psychophysics of sensory function (Stevens 61)

**Interaction**

- Crimestopping.org

**Using Space Effectively**

- Dymaxion Maps [Fuller 46]
Graphs and Trees

Degree-Of-Interest Trees [Heer & Card 04]

Color

Color Brewer

Animation

Animated transitions in statistical data graphics [Heer & Robertson 07]

Identifying Design Principles

Testing effectiveness of 3 types of assembly instructions [Heiser 04]
Conveying 3D Structure

Interactive 3D Cut-Away Diagrams [Li et al 07]

Collaborative Visual Analysis

The great postmaster scourge of 1910? Or just a bug in the data?

Course Mechanics

Textbooks

See also: www.edwardtufte.com
Readings

Some from textbooks, also many papers
Material in class will be loosely based on readings
Readings should be read by start of class
Post discussion comments on class wiki
Username/Password: use your SUNET login and password

Web page: http://hci.stanford.edu/cs448b
Wiki: http://graphics.stanford.edu/wikis/cs448b-09-winter

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
Project write-up in form of a 8 page research paper
Two project presentations
  1. Background research and project proposal (Feb 23 + 25)
  2. Final presentation – exact time to be determined

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

Assignment 1: Visualization Design

Design a static visualization for a given data set.

Deliverables (post to the course wiki)
  • Image of your visualization
  • Short description and design rationale (≤ 4 paragraphs)

Due Next Monday 1/12 by end of day (11:59p).
Assignment 1: Visualization Design

Design a static visualization for a given data set.

Table 1: Brain's data

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Most powerful brain?

Tell a story: Most powerful brain?

The Dragons of Eden [Carl Sagan]

The Elements of Graphing Data [Cleveland]