CSE 512: Data Visualization - Course Overview & Curriculum Content

The world is awash with increasing amounts of data, and we must keep afloat with our relatively constant perceptual and cognitive abilities. Visualization provides one means of combating information overload, as a well-designed visual encoding can supplant cognitive calculations with simpler perceptual inferences and improve comprehension, memory, and decision making. Furthermore, visual representations may help engage more diverse audiences in the process of analytic thinking.

In this course we will study techniques and algorithms for creating effective visualizations based on principles from graphic design, visual art, perceptual psychology and cognitive science. The course is targeted both towards students interested in using visualization in their own work, as well as students interested in building better visualization tools and systems.

In addition to participating in class discussions, students will have to complete several programming and data analysis assignments as well as a final project. Students will be expected to write up the results of the project in the format of a conference paper.

There are no strict prerequisites for the class. However, a basic working knowledge of, or willingness to learn, a graphics API (e.g., HTML5/SVG/D3, OpenGL) and data analysis tools (e.g., R, Excel, Matlab) will be useful.

Learning Goals & Objectives

This course is designed to provide students with the foundations necessary for understanding and extending the current state of the art in data visualization.

By the end of the course, students will have gained:

- An understanding of the key techniques and theory used in visualization, including data models, graphical perception and techniques for visual encoding and interaction.
- Exposure to a number of common data domains and corresponding analysis tasks, including multivariate data, networks, text and cartography.
- Practical experience building and evaluating visualization systems.
- The ability to read and discuss research papers from the visualization literature.

Textbooks & Readings

- Selected book chapters and research papers.
Evaluation & Grading

10%  Class Participation / Reading Responses
10%  Assignment 1: Visualization Design
15%  Assignment 2: Exploratory Data Analysis
25%  Assignment 3: Interactive Visualization
40%  Final Project

Course Schedule

The following course schedule assumes two classes a week, for a total of 20 classes.

- **The Value of Visualization**
  o Required Reading
    - Chapter 1: Information Visualization, In Readings in Information Visualization. Stuart Card, Jock Mackinlay, and Ben Shneiderman.
  o Optional Reading
      - See also a critique of Tufte's argument:
        o http://www.onlineethics.org/cms/17453.aspx
    - The Value of Visualization. Jarke van Wijk. Visualization 2005

- **Data and Image Models**
  o Required Reading
    - Chapter 1: Graphical Excellence, In The Visual Display of Quantitative Information. Tufte.
    - Chapter 2: Graphical Integrity, In The Visual Display of Quantitative Information. Tufte.
    - Chapter 3: Sources of Graphical Integrity, In The Visual Display of Quantitative Information. Tufte.
  o Optional Reading
    - On the theory of scales of measurement. S.S. Stevens.

- **Visualization Design**
  o Required Reading
- Chapter 4: Data-Ink and Graphical Redesign, In The Visual Display of Quantitative Information. Tufte.
- Chapter 5: Chartjunk, In The Visual Display of Quantitative Information. Tufte.
- Chapter 6: Data-Ink Maximization and Graphical Design, In The Visual Display of Quantitative Information.
- A Conversation with Jeff Heer, Martin Wattenberg, and Fernanda Viegas, ACM Queue
  - Optional Reading
    - The representation of numbers. Zhang and Norman.

- **Exploratory Data Analysis**
  - Required Reading
    - Chapter 8: Data Density and Small Multiples, In The Visual Display of Quantitative Information. Tufte.
    - Chapter 2: Macro/Micro Readings, In Envisioning Information. Tufte.
    - Chapter 4: Small Multiples, In Envisioning Information. Tufte.
    - Low-Level Components of Analytic Activity in Information Visualization. Robert Amar, James Eagan, and John Stasko. InfoVis 2005
  - Optional Reading
    - Exploratory Data Analysis, NIST Engineering Statistics Handbook

- **Multidimensional Data**
  - Required Reading
  - Optional Reading
    - Dynamic queries, starfield displays, and the path to Spotfire. Shneiderman.

- **Interaction Techniques**
  - Required Reading
    - Interactive Dynamics for Visual Analysis, Heer & Shneiderman.
    - Postmortem of an Example, Bertin.
  - Optional Reading

**Visualization Software**
- Required Reading
- Optional Reading

**Graphical Perception**
- Required Reading
  - Perception in visualization. Healey.
  - Chapter 3: Layering and Separation, In Envisioning Information. Tufte.
- Optional Reading
  - The psychophysics of sensory function. S.S. Stevens.

**Color**
- Required Reading
  - Charting color from the eye of the beholder. Landa, Fairchild.
  - Chapter 5: Color and Information, In Envisioning Information. Tufte.
- Optional Reading
  - ColorBrewer: Selecting good color schemes for maps. Cindy Brewer
  - Meet iCam: A Next-Generation Color Appearance Model. CIC 2010.

- **Animation**
  - Required Reading
  - Optional Reading
    - Animated Exploration of Graphs with Radial Layout, Ping Yee, Danyel Fisher, Rachna Dhamija, and Marti Hearst. InfoVis 2001

- **Using Space Effectively**
  - Required Reading
    - A Fisheye Follow-up. George Furnas. CHI 2006.
  - Optional Reading
    - The Visual Design and Control of Trellis Display. Becker, Cleveland and Shyu.

- **Mapping & Cartography**
  - Required Reading

- Optional Reading
  - Map projections
  - Cartogram Central
  - Myriahedral Projections
    - http://www.win.tue.nl/~vanwijk/myriahedral/

- Design Critiques
  - No Readings, Students Prepare Peer-Critiques

- Graph Layout and Network Analysis
  - Required Reading
    - Scalable, Versatile and Simple Constrained Graph Layout. Tim Dwyer. EuroVis 2009.
  - Optional Reading

- Final Project Presentations
  - No Reading, Students Prepare Project Proposal Presentations

- Text Visualization
  - Required Reading
    - Information Visualization for Search Interfaces, Marti Hearst, Search User Interfaces, Chapter 10
- Information Visualization for Text Analysis, Marti Hearst, Search User Interfaces, Chapter 11
- Interpretation and Trust: Designing Model-Driven Visualizations for Text Analysis. Chuang et al. CHI 2012
  - Optional Reading

- Narrative Visualization
  - Required Reading
  - Examples

- Collaborative Visual Analysis
  - Required Reading
  - Optional Reading
    - Strategies for Crowdsourcing Social Data Analysis. Willett et al. CHI 2012.
• **Visualization Evaluation**
  o Required Reading
    ▪ A Nested Model for Visualization Design and Validation. Tamara Munzner. InfoVis 2009
  o Optional Reading
    ▪ The Value of Visualization. Jarke van Wijk. Visualization 2005
    ▪ The Challenge of Information Visualization Evaluation. Catherine Plaisant. AVI 2004
• **Final Project Review**
  o No Readings, Class time devoted to project review and feedback