CSE512 Data Visualization (Spring 2015)

INSTRUCTOR

Jeffrey Heer
OH: Th 10-11am
642 Allen Center

ASSISTANTS

Jeff Snyder
OH: W 2:30-3:30pm
021 Allen Center

Dominik Moritz
OH: F 1:30-2:30pm
218 Allen Center

MEETING

Location: MGH 241
Time: TuTh 11-12:20

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 short 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 form of a conference paper submission.

There are no prerequisites for the class and the class is open to graduate students as well as advanced undergraduates (by permission of instructor). Basic working knowledge of, or willingness to learn, graphics/visualization tools (e.g., D3, HTML5, OpenGL, etc) and data analysis tools (e.g., R, Excel, Matlab) will be useful.

Final Projects will be presented in the Paul G. Allen Center at the University of Washington, *Monday June 8, 5-8pm*.

Textbooks

- The Visual Display of Quantitative Information (2nd Edition). E. Tufte. Graphics Press, 2001.
- Envisioning Information, E. Tufte. Graphics Press, 1990.

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 key visualization techniques and theory, including data models, graphical perception and methods 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.

Schedule & Readings

Week 1

Tu 3/31 **Value of Visualization** Slides Discussion

**** Assigned: Assignment 1 ****

- REQUIRED Chapter 1: Information Visualization, In Readings in Information Visualization. Stuart Card, Jock Mackinlay, and Ben Shneiderman. pdf
- Optional Decision to launch the Challenger, In Visual Explanations. E. Tufte. (See also critique of Tufte's argument)
- Optional The Value of Visualization. Jarke van Wijk. Visualization 2005 pdf
- Optional Graphs in Statistical Analysis. F. J. Anscombe. The American Statistician, Vol. 27, No. 1 (Feb., 1973), pp. 17-21 jstor

Th 4/2 **Data and Image Models** Slides Discussion

- REQUIRED Chapter 1: Graphical Excellence, In The Visual Display of Quantitative Information. Tufte.
- REQUIRED Chapter 2: Graphical Integrity, In The Visual Display of Quantitative Information. Tufte.
- REQUIRED Chapter 3: Sources of Graphical Integrity, In The Visual Display of Quantitative Information. Tufte.
- REQUIRED The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations, Shneiderman, Proc. IEEE Conference on Visual Languages, Boulder 1996. pdf
- Optional Levels of Measurement, Wikipedia.
- Optional The Structure of the Information Visualization Design Space. Stuart Card and Jock Mackinlay. *InfoVis 97.* pdf
- Optional On the theory of scales of measurement. S.S. Stevens. jstor

Week 2

Mo 4/6 ****Due: Assignment 1 (5pm)****

Tu 4/7 **Visualization Design** Slides Discussion

- REQUIRED Chapter 3: The Power of Representation, In Things That Make Us Smart. Norman. pdf
- REQUIRED Chapter 4: Data-Ink and Graphical Redesign, In The Visual Display of Quantitative Information. Tufte.
- REQUIRED Chapter 5: Chartjunk, In The Visual Display of Quantitative Information. Tufte.
- REQUIRED Chapter 6: Data-Ink Maximization and Graphical Design, In The Visual Display of Quantitative Information.
- Optional Design and Redesign in Data Visualization. Martin Wattenberg and Fernanda Viégas. html
- Optional A Conversation with Jeff Heer, Martin Wattenberg, and Fernanda Viégas acm
- Optional The representation of numbers. Zhang and Norman. pdf

Th 4/9 **Exploratory Data Analysis** Slides Discussion

**** Assigned: Assignment 2 ****

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

Week 3

Tu 4/14 **Multidimensional Data** Slides Discussion

- REQUIRED Polaris: A System for Query, Analysis and Visualization of Multi-dimensional Relational Databases. Stolte, Tang, and Hanrahan. IEEE TVCG 2002. pdf
- REQUIRED Multidimensional detective. A. Inselberg. *InfoVis 1997.* pdf
- Optional Dynamic queries, starfield displays, and the path to Spotfire. Shneiderman. html

- Optional A Rank-by-Feature Framework for Interactive Exploration of Multidimensional Data. Seo and Shneiderman. Information Visualization 2005 pdf

Tu 4/14 Optional **Visualization Tools Tutorial** Slides

- CSE 305 3:00pm - 4:30pm

Th 4/16 **Graphical Perception** Slides Discussion

- REQUIRED Perception in visualization. Healey html
- REQUIRED Graphical Perception: Theory, Experimentation and the Application to the Development of Graphical Models. William S. Cleveland, Robert McGill, J. Am. Stat. Assoc. 79:387, pp. 531-554, 1984. pdf
- REQUIRED Chapter 3: Layering and Separation, In Envisioning Information. Tufte.
- Optional Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design. Jeffrey Heer, Michael Bostock. CHI 2010. html
- Optional Gestalt and composition. In Course #13, SIGGRAPH 2002. Durand. pdf 6-up pdf
- Optional The psychophysics of sensory function. S.S. Stevens. pdf

Fri 4/17 **** Due Assignment 2 (5pm) ****

Week 4

Mon 4/20 Optional **D3.js Tutorial** Slides

- More Hall Room 230 4:00pm - 5:30pm
- Chapter 5-10, In Interactive Data Visualization for the Web, Murray. (html)
- Optional d3's tutorial page and gallery, d3 resources

Tu 4/21 **Visualization Tools** Slides Discussion

**** Assigned: Assignment 3 ****

- REQUIRED D3: Data-Driven Documents. Bostock, Ogievetsky & Heer. *InfoVis 2011*. html
- Optional Declarative Language Design for Interactive Visualization. Heer & Bostock. *InfoVis 2010*. html
- Optional Software Design Patterns for Information Visualization. Heer & Agrawala. *InfoVis 2006*. html

Th 4/23 **Interaction** Slides Discussion

- REQUIRED Interactive Dynamics for Visual Analysis, Heer & Shneiderman. pdf
- REQUIRED Postmortem of an Example, Bertin. pdf
- Demos ggobi, Homefinder, zipdecode, Table lens, NameVoyager, LA Homicide Plot
- Video Classic systems on stat-graphics.org
- Optional Visual Queries for Finding Patterns in Time Series Data. Hochheiser & Shneiderman. pdf
- Optional Generalized Selection via Interactive Query Relaxation. Heer, Agrawala, Willett. CHI 2008. pdf
- Optional The Cognitive Coprocessor Architecture for Interactive User Interfaces. George Robertson, Stuart K. Card, and Jock D. Mackinlay. UIST 1989. pdf
- Optional Exploration of the Brain's White Matter Pathways with Dynamic Queries. Akers, Sherbondy, Mackenzie, Dougherty, Wandell. Visualization 2004. html

Week 5

Tu 4/28 **Animation** Slides Discussion

- REQUIRED Animated Transitions in Statistical Data Graphics. Heer & Robertson. IEEE *InfoVis 2007*. pdf
- REQUIRED Effectiveness of Animation in Trend Visualization. Robertson, Fernandez, Fisher, Lee, Stasko. *InfoVis 2008*. pdf
- Optional Animation: Can It Facilitate? Barbara Tversky, Julie Morrison, Mireille Betrancourt, International Journal of Human Computer Studies, v57, p247-262. 2002. pdf
- Optional Smooth and Efficient Zooming and Panning. Jack J. van Wijk and Wim A.A. Nuij. *InfoVis 2003*. pdf
- Optional Animated Exploration of Graphs with Radial Layout, Ping Yee, Danyel Fisher, Rachna Dhamija, and Marti Hearst. *InfoVis 2001* pdf
- Optional Principles of Traditional Animation Applied to Computer Animation John Lasseter. Siggraph 1987. acm

- Optional Animation: From Cartoons to the User Interface. Bay-Wei Chang, David Ungar. UIST 1993. pdf

Th 4/30 **Color** Slides Discussion

- REQUIRED Chapter 5: Color and Information, In Envisioning Information. Tufte.
- REQUIRED Brewer, Cynthia A., 1999, Color Use Guidelines for Data Representation, Proceedings of the Section on Statistical Graphics, American Statistical Association, Baltimore, pp. 55-60. html color scheme
- Optional Charting color from the eye of the beholder. Landa & Fairchild. html
- Optional ColorBrewer: Selecting good color schemes for maps. Cindy Brewer html
- Optional Color Naming Models for Color Selection, Image Editing and Palette Design. Heer & Stone. CHI 2012 html
- Optional BruceLindbloom: Useful color information, studies, and Files. Bruce Lindbloom. html
- Optional Meet iCam: A Next-Generation Color Appearance Model. CIC 2010. pdf html
- Optional Color2Gray: Salience-preserving color removal. Gooch, Olsen, Tumblin, Gooch. AMC Transactions on Graphics. pdf
- Optional A framework for transfer color based on the basic color categories. Chang, Saito, Naakajima. CGI 2003. pdf

Week 6

Mon 5/4 **** Due: Assignment 3 (5pm) ****

Tu 5/5 **Assignment 3 Design Critiques** Slides Discussion

**** Assigned: Final Project ****

Th 5/7 **Using Space Effectively** (Guest: Justin Talbot, Tableau Software)

- REQUIRED Arc Length-based Aspect Ratio Selection. Talbot, Gerth & Hanrahan. IEEE TVCG 2011. pdf Discussion
- REQUIRED Escaping Flatland. Envisioning Information. Tufte.
- REQUIRED Stacked Graphs – Geometry & Aesthetics. Byron & Wattenberg. *InfoVis 08.* pdf
- Links Nomograms
- Optional A Fisheye Follow-up. George Furnas. CHI 2006. acm
- Optional Space-scale diagrams: Understanding Multi-Scale Interfaces. Furnas and Bederson, CHI 1995. pdf
- Optional Guidelines for Using Multiple Views in Information Visualization. Wang et al. AVI 2000. acm
- Optional An Extension of Wilkinson's Algorithm for Positioning Tick Labels on Axes. Talbot, Lin & Hanrahan. IEEE TVCG 2010. pdf
- Optional The Table Lens: Merging Graphical and Symbolic Representations in an Interactive Focus + Context Visualization for Tabular Information. Ramana Rao and Stuart K. Card. SIGCHI 1994. pdf
- Optional The Visual Design and Control of Trellis Display. Becker, Cleveland and Shyu. pdf

Week 7

Tu 5/12 **Networks**

**** Due: Final Project Proposal **** Slides Discussion

- REQUIRED Scalable, Versatile and Simple Constrained Graph Layout. Tim Dwyer. EuroVis 2009. pdf
- REQUIRED Hierarchical Edge Bundles: Visualization of Adjacency Relations in Hierarchical Data. Danny Holten. *InfoVis 2006.* pdf
- Demos D3 Examples, Tree Layout in Flare (Click the "Layouts" link)
- Optional ManyNets: An Interface for Multiple Network Analysis and Visualization. Freire et al. CHI 2010. pdf
- Optional Graph Visualization and Navigation in Information Visualization: A Survey, Herman, Melancon, and Marshall, IEEE TVCG 2000. pdf (Skimming to get the overview is sufficient)
- Optional Visual Exploration of Multivariate Graphs. Wattenberg. CHI 2006. pdf
- Optional A Comparison of the Readability of Graphs Using Node-Link and Matrix-Based Representations. Ghoniem, Fekete, Castagliola. *InfoVis 2004.* pdf
- Optional Dig-cola: Directed graph layout through constrained energy minimization. Dwyer and Koren. *InfoVis 2005.* pdf

- Optional Vizster: Visualizing Online Social Networks. Heer & boyd. *InfoVis 2005*. pdf
- Optional Interactive Visualization of Genealogical Graphs. Michael J. McGuffin and Ravin Balakrishnan. *InfoVis 2005*. pdf
- Optional A Focus+Context Technique Based on Hyperbolic Geometry for Visualizing Large Hierarchies. Lamping, Rao, Pirolli. CHI 1995. html

Th 5/14 **Mapping & Cartography** Slides Discussion

- REQUIRED Chapter 11: The Cartogram: Value-by-Area Mapping. In Cartography: Thematic Map Design. Dent pdf
- REQUIRED Adaptive Composite Map Projections. Bernhard Jenny. InfoVis 2012. pdf
- Links Map Projections, Cartogram Central, Myriahedral Projections

Week 8

Tu 5/19 **Narrative** Slides Discussion

- REQUIRED Narrative Visualization: Telling Stories with Data. Segel & Heer. *InfoVis 2010*. html
- REQUIRED A Deeper Understanding of Sequence in Narrative Visualization. Jessica Hullman, Steven Drucker, Nathalie Henry Riche, Bongshin Lee, Danyel Fisher, and Eytan Adar. InfoVis 2013. pdf
- Optional Visualization Rhetoric: Framing Effects in Narrative Visualization. Hullman & Diakopoulos. *InfoVis 2011*. pdf
- Optional Budget Forecasts, Compared With Reality. NYTimes, February 2010. html
- Optional How Mariano Rivera Dominates Hitters. NYTimes, June 2010. html
- Optional Gapminder Human Development Trends 2005. html

We 5/20 ****Due: Slides for Final Project Feedback (5pm)****

Th 5/21 **Final Project Feedback** Slides MGH241 CSE305 Discussion MGH241 CSE305

Week 9

Tu 5/26 **Guest Lecture: Jock Mackinlay (Tableau Software)**

Th 5/28 **Text Visualization** Slides Discussion

- REQUIRED Information Visualization for Search Interfaces, Marti Hearst, ''Search User Interfaces'', Chapter 10 html
- REQUIRED Information Visualization for Text Analysis, Marti Hearst, ''Search User Interfaces'', Chapter 11 html
- REQUIRED Interpretation and Trust: Designing Model-Driven Visualizations for Text Analysis. Chuang et al. CHI 2012 html
- Optional Mapping Text with Phrase Nets. Frank van Ham, Martin Wattenberg, Fernanda B. Viégas. *InfoVis 2009*. pdf
- Optional Termite: Visualization Techniques for Assessing Textual Topic Models. Chuang et al. AVI 2012 html

Week 10

Tu 6/2 **Collaboration** Slides Discussion

- REQUIRED Voyagers and Voyeurs: Supporting Asynchronous Collaborative Information Visualization. Heer, Viégas, & Wattenberg. CHI 2007. html
- REQUIRED Designing for Social Data Analysis. Wattenberg and Kriss. *InfoVis 2006*. pdf
- Optional Design Considerations for Collaborative Visual Analytics. Heer and Agrawala. *InfoVis 2008*. html
- Optional Strategies for Crowdsourcing Social Data Analysis. Willett et al. CHI 2012. html
- Optional CommentSpace: Structured Support for Collaborative Visual Analysis. Willett et al. CHI 2011. html
- Optional Many Eyes: A Site for Visualization at Internet Scale. Viégas et al. *InfoVis 2007*. pdf

Th 6/4 **Evaluation** Slides Discussion

- REQUIRED A Nested Model for Visualization Design and Validation. Tamara Munzner. *InfoVis 2009* pdf

- Optional Design Study Methodology: Reflections from the Trenches and the Stacks. Sedlmair et al. *Infovis 2012* html
- Optional The Value of Visualization. Jarke van Wijk. Visualization 2005 pdf
- Optional The Challenge of Information Visualization Evaluation. Catherine Plaisant. AVI 2004 pdf

Finals Week

Mon 6/08 **Final Project Poster Session**

- Paul G. Allen Center Atrium, 5-8pm

Th 6/11 **Due: Final Projects (8am)**

Assignments

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

Class Participation

It is important to attend the lectures and read the readings. Each lecture will assume that you have read and are ready to discuss the day's readings.

Class participation includes both in-class participation as well as participation in the discussion on Canvas. All enrolled students are required to post at least 1 substantive discussion reply pertaining to each lecture and set of readings by 1 day after class (11am on the day after each class). Each student has 2 passes for skipping comments. Links to the Canvas discussion for each lecture will be posted on the schedule above.

Good comments typically exhibit one or more of the following:

- Critiques of arguments made in the papers
- Analysis of implications or future directions for work discussed in lecture or readings
- Clarification of some point or detail presented in the class
- Insightful questions about the readings or answers to other people's questions
- Links to web resources or examples that pertain to a lecture or reading

Policies

Late Policy: We will deduct 10% for each day (including weekends and holidays) an assignment is late.

Plagiarism Policy: Assignments should consist primarily of your original work. Building off of others' work--including 3rd party libraries, public source code examples, and design ideas--is acceptable and in most cases encouraged. However, failure to cite such sources will result in score deductions proportional to the severity of the oversight.

Resources

Please feel free to peruse the resources page.

Q&A

Questions should be posted on Canvas. If you have a private question, email the instructors at *cse512@cs* or come to office hours.