Cogsci220: Information Visualization

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Welcome to the class and a new year.

We need to acknowledge that this is an incredibly challenging, uncertain, and deeply troubling time.

We are still in the midst of a global pandemic.

Mounting deaths total over 350,000 in the US and approach 2 million worldwide.

The political situation is highly polarized.

We are grappling with monumental changes in our lives at work, at home, and in our communities.

These are not normal times, and we should not pretend they are.
In this challenging and unprecedented time, we all need to support each other. **The highest priority is for everyone to remain safe and healthy.**

We are all displaced from our normal context and no one knows the time course of this pandemic. Everyone is stressed and each of us is adjusting our lives to respond to complex rapidly changing situations.

My goal in the course is to be flexible and responsive to issues and problems that may arise. Communication is central to provide the feedback required to make adjustments, minimize stress, and make the best of this challenging situation.

This course has always been an interactive seminar.

The hope is the course will be a respite from the pandemic, an opportunity to think about research ideas, be creative, and develop useful visualization skills.
Before we begin

The class is too large for an interactive seminar class.

**Do consider dropping the class.** It involves considerable reading, writing, active participation in class, and the challenge of developing an NSF style research proposal with visualization demonstrations.

You will work in a project team of three or four students. Group work is challenging. It can be delightful but also can be maddening. One possible reason to drop the course is you can’t find the right people to work with or a group that shares a common project focus you find of interest. Another is your situation during the pandemic. Consider taking the course at another time when things are more normal.

As with the start of every class (and especially appropriate at the start of a new year), I will begin with some advice.
Advice for Undergrads

Why do so few people make significant contributions?

What is the difference between those who make significant impact and those who don’t?
   One factor is expectations: If you think you can’t almost certainly you won’t
   Another is that to do significant things you have to neglect other things

Be careful about your commitments but when you commit really commit

Be thoughtful about who you spend time with

Take time to think important thoughts

You can’t win the battle every time but try hard not to let the urgent drive out the important
Advice for Grad Students

I make no claim to originality, only to good taste in borrowing excellent advice from others.

Special appreciation for wisdom from Richard Hamming, Ivan Sutherland, and Dave Patterson, from my personal mentors Pat Suppes, Dave Rumelhart, and Don Norman, and especially from my students and collaborators from whom I have learned much.

Why listen to me? I have over four decades of experience in both university and industrial research labs, honored with the ACM SIGCHI Lifetime Research Award, promoted to Distinguished Professor, and have collaborated with amazing researchers (including four MacArthur Fellows and six Rumelhart Prize winners), and mentored many young faculty, grad students, and postdocs.
Advice for Grad Students

Over a research career one is fortunate to witness first-hand one paradigm shift.

I have been extremely fortunate to witness four.

The first two were in computation: the exciting beginnings of personal computing and the Internet.

I was a postdoc in the AI Lab at Stanford when I first sat down at an Alto at Xerox Parc connected to the Internet. This was profoundly influencing.
Xerox Parc and Alto

Chuck Thacker and colleagues at Parc develop the Alto in 1973. Parc approach: hire the best researchers and leave them unburdened by directives, instructions, or deadlines.

Today’s equivalent cost ~$100,000

2.5 MB

96-126 kB
Paradigm Shifts

Just as important for me as personal computing and the Internet paradigm shifts was arriving at UC San Diego and being in the midst of **a third paradigm shift: a cognitive revolution** was just emerging as part of a rapidly developing zeitgeist shared across the social sciences that has radically transformed our view of cognition and created the discipline of cognitive science.

A fourth paradigm shift didn’t arrive until the 90’s with **the marvelous explosion of the web and all that it has enabled for both good and for ill**, such as social networks, collaborative filtering, instantaneous access to massive ever expanding information resources and to previously unimaginable computational power, and an ecosystem driven primarily by advertising.

*As just one example of this shift, consider that already today there has been over a billion Google searches and each search took about the equivalent computing to answer as all the computing done – in flight and on the ground – for the Apollo program that landed the first humans on the Moon.*

These paradigm shifts have fundamentally changed the way we interact, communicate, and think. Even with the current pandemic and political situation, and the ominous consequences of climate change, it still is an absolutely amazing time. It is a good time to be in graduate school. I am envious.
How to succeed in graduate school

The short answer: Don’t think of yourself as being a grad student

Of course much to learn but grad education is unlike undergrad education. The most valuable skills from undergraduate days are probably learning to write well, to work hard, and to multitask.

Courses are important but the real challenge is you must deeply understand the research literature of your area so you can begin to contribute to it. The literature is massive and only a tiny fraction of it will be covered in courses. In addition, it is expanding at an ever accelerating rate.

Your immediate and continuing tasks are to: (1) develop a portfolio of research questions, and (2) master the skills needed to pursue and address the questions you care about.

Grad school at its best is an apprenticeship and the beginning of many research collaborations.

The good news (or perhaps the bad news) is: during graduate school you will have more discretionary and flexible time than you will ever have again.
Transition from Student to Researcher is Difficult

In classes, the world is rigged. There’s a simple correct answer and the problem and activities are structured to let you come to that answer. You even get feedback and the correct answer soon after you submit your response.

Research is different

No one tells you the right answer. We don’t often even know if there is a right answer. Frequently what you find out doesn’t answer the question but only leads to more questions. Sometimes what you find out is that you are asking the wrong question.

Skills associated with being a stellar student may even impede your becoming a stellar researcher

Can’t depend on learning everything in courses. You often need to learn just enough about X so you can make research progress. Every topic is infinitely rich but time is limited.
Advice for Grad Students

Research Requires Courage Because It Involves Risks

Social and emotional
Risks to reputation and pride
High probability any particular research project, especially if challenging, will fail

“Dealing with failure is easy: Work hard to improve.”

“Success is also easy to handle: You’ve solved the wrong problem. Work hard to improve.”

Alan Perlis
Advice for Grad Students

Reputations start early

Learn how to balance multiple things

To enjoy research you really need to accept always present ambiguity

Be smart in using your time

Get to know and be known by people in your field (email, conferences, talks, visits, …)
Advice for Grad Students

Develop a Research Portfolio

Portfolio will continue to develop and evolve over your whole career

Your time is the investment currency

Work on important problems

What makes a problem personally important? You have a way to attack it.

Portfolio should be a mix of differing risk/payoff projects.

Need to continually assess and adjust the mix.
Advice for Grad Students

Goal is to have impact
- Solve problems people care about
- Impactful projects are likely longer term projects

Need to communicate your ideas and work to others
- Not only publish but people must read
- As much (or more) time on communicating as on work itself

Know the literature! Ideas have histories

Feedback is key: seek out and value critics

Your students and other collaborators are a key part of your impact and the real multiplier of your impact

Develop taste and learn to be opportunistic in selecting research problems. An example:
Audio-Enhanced Paper Photos: Encouraging Social Interaction at Age 105, CSCW.
Challenges

Science is extremely competitive

- Have to work hard
- Need to avoid burning out

And again: One of the biggest challenges is learning to deal with ambiguity

Build a repertoire of research skills. Don’t avoid those skills you know you need but wish you could avoid. Easy to always do more of what you are already good at doing. [Jay]
Heilmeier Catechism

George Heilmeier
What is the question?
Why is the question important?
  Who cares? If you’re successful, what difference will it make?
What are you trying to do?
  Articulate your objectives without jargon
How is it done today?
  What are limits of current practice? What is promising about your approach?
How will you determine if you are successful?
What are the risks and payoffs?
  How much will it cost (especially in terms of your time) and how long will it take?
  What are midterm and final “exams” to check for success?
Science is a Social Activity

**Doing**
Collaborate, collaborate, collaborate

**Talking**
Importance of both formal and informal interactions (Hinton, DER)
From water cooler chats to lab meetings to classes/seminars to conference talks
Approach TAing and teaching as valuable practice opportunities
Seek out opportunities to give talks (both formal and informal)

**Writing**
A constant activity and continual developing skill (Knuth, Don, Jeff)
Set aside regular time to write
A new challenge is learning how to write proposals
Science is About Stories

Peter Medawar on science: “It begins as a story about a Possible World—a story which we invent and criticize and modify as we go along, so that it ends by being, as nearly as we can make it, a story about real life.”

One of the wonderful things about areas such as HCI, Design, and Visualization is that we can make some of our stories true by writing code and building things.

For me doing science is all about stories and people.

Especially important and rarely appreciated are those stories we use to convince ourselves to invest our time and energy in projects long before we have sufficient data, often before we have any data at all.
Today an overview of the course

Website: hci.ucsd.edu/220

Introductions:

Amy Rae Fox and Zhutian Chen

It is always challenging to get to know others in a class and even more so in a virtual class. To start the process of getting to know each other please fill out this Google form https://forms.gle/oxvon2JcWEqZAFsB6 by Friday (1/8). We may also try an experiment next week with some experimental software.
This seminar provides a gentle introduction to the important new field of information visualization.

Rather than a survey of the field the goal is to help you acquire sufficient background to develop a visualization proposal.
Approach

Read two of Tufte’s books as a gentle introduction to the field of information visualization. Order now, consider sharing. Also complete the excellent UW IDL data visualization interactive notebook curriculum using Vega-Lite. For projects using D3, read Scott Murray’s book.

Algorithm for Course:

1. Find partners to work with. Three or four person groups are ideal. You should start to form groups as soon as possible. Both the topic and people are important. People are likely more important than topic.

2. Select a visualization area you are mutually interested in. Choice is constrained to personal information space ideas as described in recent NSF proposal.

3. Read selected literature in the area and identify a small set of excellent readings for class.

4. Write an NSF-style research proposal.

Along the way each group will share with the seminar their project idea, plans, and the best of the associated literature. A major goal of the seminar is for all of us to work together to help each group to do an excellent proposal.
This is a reading and writing intensive seminar.
In each class you should be prepared to summarize the readings and to participate in a discussion of them. I may call on people to briefly summarize readings and to help lead discussions. Come prepared.

You should be an active participant in our Google Group.

It is the place for critical commentary about the readings, things you find especially interesting or problematic, or that stimulate a research idea. It is also the place to ask questions, discuss topics, and ask for help and advice.

Your participation in the group will count for 25% of your grade.
Proposal and Group Presentations

Your group of three or four people will jointly write an NSF style research proposal.

In week 5 each group will give a brief initial presentation about their project and select one or two readings for the class relevant to their project. This presentation is informal and the goal is for the class to provide feedback and help focus the project.

In weeks 6 to 9, groups will provide updates on their projects as well as lead discussion of their selected papers.

A video presentation of each project and the written proposal are due during finals week.
Initial Readings
(Linked on hci.ucsd.edu/220)

Schedule & Readings

Week 1

Tues 1/5  Information Visualization Course Overview and Introductions  Slides
The first step in Selecting A Project and Group is to read the proposal and paper mentioned above in order to provide background and context for your selection of a proposal topic. This should be completed before 1/12.

- REQUIRED Communicating with Interactive Articles, Fred Hohman, Matt Conlen, Jeffrey Heer, Duen Horng (Polo) ChauDistill, 2020 Journal.
- Optional Human-Centered Interactivity of Visualization Tools: Micro- and Macro-level Considerations, Kamran Sedig, Paul Parsons, Mark Dittmer, and Robert Haworth.
- Optional A Tour Through the Visualization Zoo, Jeffrey Heer, Michael Bostock, and Vadim Ogievetsky.
- Optional Visualizing Algorithms, Mike Bostock

Optional Readings: Ideally you will read these too if you have time after reading required readings. You should at least skim and read parts that are interesting. Many will be relevant to your proposal and great sources of ideas.
Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.

Charles Joseph Minard, 1861

Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour six mille hommes; ils sont de plus écartés en travers des zérons. Le rouge désigne les hommes qui entrèrent en Russie, le noir ceux qui en sortirent. Les renseignements qui rendirent à dons la carte ont été pris dans les ouvrages de M. M. Chirat, de Figuié, de Decembre, de Chambry et le journal moyen de Napoléon, son armée et de l'Armée de Russie depuis le 23 Octobre.

Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supporté que les corps du Prince Jerome et du Marechal Davoust qui avaient été détachés sur Moskow et sur l'union vers Orel et Moskow, avaient toujours marchés avec l'armée.

Les canons sont au gelée le Velours gras.

Tableau graphique de la température en degrés du thermomètre de Réaumur au dessous de zéro.

Charles Joseph Minard, 1861
Statistical graphics did not emerge until the late 18th century. Most notably with William Playfield.
William Playfield

A scientific revolution began at the end of the 18th century with the invention and popularization of the graphic display of data by the remarkable Scot William Playfair. His marvelous Atlas showed how much could be learned if one plotted data atheoretically and looked for suggestive patterns. Those patterns provide evidence, albeit circumstantial, on which to build new science. Playfair’s work has much to teach us, but finding a copy of it is very difficult. This full-color reproduction of two of his classic works, with new explanatory material, makes Playfair’s wisdom widely available for the first time in two centuries.
Data, Data, Data, and more Data

The availability of data and massive computational power is changing the world, as all the recent deep learning advances have make clear and as micro-targeting on social media has too.

It is certainly a different world. As I mentioned earlier, already today there have been a billion Google searches and each search took the equivalent computing of all the computing of the Apollo project that landed humans on the moon.
Something on the order of 5000 exabytes of data are produced each year and this is always increasing. 10x increase in the last five years.

My laptop has 16 gigabytes of storage and 500gb of disk. A 1,024 gigabytes is a terabyte. A 1,024 terabytes is a petabyte. A 1,024 petabytes is a exabyte. One exabyte could hold the entire Library of Congress 3,000 times over.

In 2013 it was estimated that Google’s data centers had about 10 exabytes of disk.
Scientific Visualization versus Information Visualization

Information Visualization: New Techniques

Left: 2 Million Lines of C
Right: 290,000 Filenames
Bottom Left: 6 Words of Shakespeare
Bottom Right: A Million Words of Shakespeare


Scientific Visualization Examples:
Airflow over aircraft wing
Electrical current in thorax
A DNA dotplot
Visualization Software

One goal of the course is for you develop expertise with some visualization software to augment your research.

Different research communities have selected different software systems (Python, R, Javascript, …)

Our focus is on Vega-Lite and D3 (Data Directed Documents).

Very active communities.
D3 (Data-Driven Documents) https://d3js.org/
Looking for a good D3 example? Here's a few (okay, 168...) to peruse.

**Animation**

D3's **data join**, **interpolators**, and **easings** enable flexible **animated transitions** between views while preserving **object constancy**.
All the O’Reilly books are available for free on the ucsd library site. Must be at ucsd or on via vpn.
Tableau

Tableau for Students
-get a free Tableau license as a student
tableau.com/academic/students

Tableau Public
-a free version of Tableau which publishes to the web
public.tableau.com

Pat Hanrahan
Vega-Lite specifications describe visualizations as mappings from data to properties of graphical marks (e.g., points or bars).

The Vega-Lite compiler automatically produces visualization components including axes, legends, and scales. It then determines properties of these components based on a set of carefully designed rules. This approach allows specifications to be succinct and expressive, but also provide user control.

As Vega-Lite is designed for analysis, it supports data transformations such as aggregation, binning, filtering, sorting, and visual transformations including stacking and faceting. Moreover, Vega-Lite specifications can be composed into layered and multi-view displays, and made interactive with selections.
Vega-Lite: A Crash Course

“Vega-Lite is a high-level grammar of interactive graphics. It provides a concise JSON syntax for rapidly generating visualizations to support analysis.”

D3 → Vega → Vega-Lite

Visnu Pitiyanuvath
Engineer
observablehq.com
Vega-Lite Crash Course
https://www.youtube.com/watch?v=ZV_Yjcs5WtM