HCI Foundations and Frontiers

CS 347
Michael Bernstein
A scientist of the future records experiments with a tiny camera fitted with universal-focus lens. The small square in the eyeglass at the left sights the object (*LIFE* 19(11), p. 112).
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“Wholly new forms of encyclopedias will appear, ready-made with a mesh of associative trails running through them.”
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Modern MacOS desktop
Card, English and Burr. 1978. Evaluation of mouse, rate-controlled isometric joystick, step keys, and text keys for text selection on a CRT.

Modern mouse
Fiala. 2005. ARTag, a fiducial marker system using digital techniques.

QR codes, visual augmented reality markers

Swipe keyboards (iOS, Android) [image from 9to5mac]

iOS Screen Recognition

Your iPhone will automatically improve the accessibility of apps that have no accessibility information, such as identifying the state of buttons or toggles, and by grouping related items together. In other apps, Screen Recognition can be accessed through the rotor.

Screen Recognition

30 MB Used

Apply to Apps

Modern recommender systems [image from HBS]

Modern fitness trackers [image from Apple]


Idieum. Modern multitouch interface.
“How about a virtual reality headset that uses blockchain technology to securely store user data and personalize the VR experience using deep learning algorithms? The headset would be able to analyze a user's brain activity and eye movements in real-time to continuously adapt the VR content to their preferences and interests. It would also use blockchain to store a record of the user's interactions within the VR world, allowing them to seamlessly switch between devices and pick up where they left off. This technology would revolutionize the way we experience virtual reality, making it more immersive and personalized than ever before.”

(ChafGPT prompt: “Generate a tech product idea that is full of technobabble about VR, blockchain, and deep learning”)
This class

Envisioning and understanding the future of interaction between people, society, and technology
This class

Teaches foundational theories and modern frontiers
Learning goals
This is not like other HCI classes.

Your goal is not just to fashion an alignment between people and technology.

Your goal is to articulate, critique, and generate entirely new ideas about that relationship.
Foundations and frontiers

You will learn the major theories and concepts that underpin HCI.

You will engage in critical analyses of these theories and concepts, apply them, and extend them.
Interface's mental model of a person

[O'Sullivan and Igoe 2004]
The future of interaction?
“...this vision, from an interaction perspective, is not visionary. It's a timid increment from the status quo, and the status quo, from an interaction perspective, is actually rather terrible.” – Bret Victor

http://worrydream.com/ABriefRantOnTheFutureOfInteractionDesign/
vs. “Pictures Under Glass”
[Victor 2011]
Why is this so terrible?

[Dourish 2004; Klemmer, Hartmann, Takayama 2006]

Our cognition leverages **embodiment**—our bodies:

- We learn through interaction with the world
- We leverage the environments around us to make us smarter
- We communicate our intent through much broader mechanisms than just our fingertips: consider musicians, dancers, construction workers, professors on stage trying to get your attention
Ubiquitous computing
“The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.”
– Mark Weiser

[Weiser 1991]
Ubiquitous Computing [Weiser 1991]

Ubiquitous computing: a vision in which computers “vanish into the background” rather than focus our attention on a single box. This vision requires interactive systems to become reactive, context-aware, ambient, and embedded in everyday activities.
Activity recognition [Laput et al. 2015]

Detecting ambient EM signals using a commodity smart watch
Context-aware computing

Collect information about the user's environment, and use it to customize their computing experience

Some types of context: location, social surroundings, activity level

But beware overuse of the term ‘context’!

Towards a Better Understanding of Context and Context-Awareness

Anind K. Dey and Gregory D. Abowd
Reactive environments

[Jones et al. 2013]

Wide-screen projector can augment whatever content you are watching or playing on your TV

(Requires a depth camera to map the room surface)
Programmable objects [Jin et al. 2019]

Photochromic inks change color when exposed to lights of a specific wavelength.

- One side: 45 min
- Both sides: 90 min
Privacy [Chen et al. 2020]

Wearable microphone jamming: ultrasonic speakers are read as white noise by mics.

Wearing the bracelet means the speakers move, so we get better coverage.
Ubiquitous?
Ubiquitous?
What Weiser calls one of the first “calm” technologies: Live Wire, a wire on a stepper motor, monitoring net traffic [Jeremijenko '95]
Weiser envisioned ubiquitous computing devices at three scales.
Tabs

Most similar to today’s smart watches

Significant Otter: sharing biosignals with romantic partners [Liu et al. 2021]
Pads Most similar to today’s tablets

[Bae, Balakrishnan, and Singh 2008] [Hinckley et al. 2010]
Boards

Create a grid of conductive diamonds similar to a phone screen

Sense the columns and scan the rows to ID the touch location

[Zhang et al. 2018]
Tangible computing
Tangible Computing

Directly-manipulable physical interfaces to data and computation
‘Pure’ form of ubicomp in that there is no computer to be seen
Follmer, Leithinger, Olwal, Hogge, Ishii. inFORM: Dynamic Physical Affordances and Constraints through Shape and Object Actuation. UIST '13.
Urp: a luminous-tangible workbench for urban planning and design.
Underkoffler, Ishii. CHI '99.
Urp: a luminous-tangible workbench for urban planning and design.
Underkoffler, Ishii. CHI '99.
Apple is exploring new Apple Pencil technology that could allow the device to sample colors from the real world to use in digital art, drawings, edits, and more, according to an Apple patent application published by the United States Patent and Trademark Office this week.
Questions you ought to be asking

Why do, and don’t, we have elements of the ubiquitous and tangible computing visions in our lives today, thirty years later?

What are resilient challenges or mistaken assumptions, and what challenges might we actually be able to tackle?
Ubiquitous computing is driven not by a technological goal, but by a shared vision of the future.

However, this vision is a future in 1991.

What should the future of ubicomp be, from today’s perspective?
Where we go from here

week 1  Ubiquitous computing
week 2  Design
week 3
week 4  Social Computing
week 5  Software + AI
week 6  Cognition
week 7
week 8  Methods
week 9  Society
week 10
How this class works
Class activity 1 of 4: Readings
Yes, you are reading in a Computer Science class.

There will be two papers to read for each class day.

This will take substantial time. It will get faster as the course proceeds and you get more used to reading papers.

If you are reading off-campus, use the Stanford library proxy linked at the top of the syllabus webpage.
Commentaries

After reading the papers for each class, you will reflect on the main ideas in each paper and submit a written commentary.

These commentaries serve as a mechanism to drive deeper reflection on the concepts in each paper:

Commentaries are due at 5pm the day before lecture.

We will drop the three lowest commentary grades at the end of class: meaning, you may drop three readings’ worth of commentaries

We will be using these commentaries to drive discussion in class.
Commentary strategies

Future research directions that this paper inspires for you
Why the paper does/doesn't seem important
Observations of novel methodology or methodology that seems suspect
Why the paper is/isn't effective at getting its message across
How the paper has changed your opinion or outlook on a topic
“This paper has so many problems:”

“This paper inspired me to develop an idea:”
As We May Think

This paper was fascinating because it forces us to consider technologies that nowadays we take for granted. In some ways Bush was overly optimistic; for example walnut-sized wearable cameras are uncommon (even though they are possible), likely because optical and physical constraints favor handheld sizes. In other ways he underestimated, such as the explosion of data. For example, some modern cameras can store ten thousand photos rather than a hundred.

Underestimating the data explosion is also apparent in the disconnect between the initial problem description ("publication has been extended far beyond our present ability to make real use of the record") and the first two-thirds of the paper, which describe technologies that would (and did!) exacerbate the issue by further proliferating data. Yet, he recognizes this issue later in the paper, and then goes on to predict search engines.

It is remarkable how many technologies are predicted in this paper: digital photography, speech recognition, search engines, centralized record-keeping for businesses, hypertext (even Wikipedia?). At the same time, many of the predicted implementations are distorted by technologies and practices common at the time, like "dry photography" or "a roomful of girls armed with simple keyboard punches". While these presumably served to make the hypotheses more accessible to readers of the time, is it even possible to hypothesize technology without such artifacts.

Aside from predictions, this paper is important for the way Bush frames science in the support of the human race, by augmenting the power of the human mind. It is likely that many of the scientists (and physicists in particular) that were his audience felt guilt and despair from the destruction wrought by advances in nuclear, and even conventional, weaponry in the war. In that social context, seeing science described as a powerful constructive tool for good must have been inspiring.
First readings for Thursday
Class activity 2 of 4: Discussion
Yes, there is human-human interaction in a CS class.

You will join a weekly discussion section

You will dig into themes that arose in commentaries and in class

Discussions run Thursdays and Fridays
Required section application

Submit the course application by 11:59 tonight for priority placement

Link to the application is on cs347.stanford.edu under the "Syllabus" page

We will use this application to assign you a section and discussant date
Being a discussant

For one class day, you will be the **discussant**, responsible for helping drive effective in-class discussion.

Discussants have two goals:

- Summarize the commentaries on one paper into a meta-commentary before the next day’s lecture
- Helping lead discussion on the paper in your discussion section that week
Writing a metacommentary

Read the submitted commentaries from your section, on the assigned paper. Put together a summary document that:

- Identifies especially insightful commentary ideas and quotes
- Clusters commentary responses into themes, with a few pull quotes per theme

Submit the document by the start of lecture, so the staff can print out copies for us and bring them with us.
Lead discussion

Pick theme(s) that you identified in the metacommentary and prepare a 2 minute response that you can share in section to kick off discussion on that paper.

First: a synthesis of the main points being raised in that theme, using quotes as relevant.

Second: your response to the points being raised. What do you agree with, and why? What do you disagree with, and why? Can you offer an alternative perspective?
Class activity 3 of 4: Quizzes
Four short in-class quizzes

Quizzes cover the lecture and reading material since the last quiz

e.g., Quiz 1 at the end of Week 2 will cover today through next Tuesday

Closed-book, will ask you to recognize and apply the concepts from lecture
Class activity 4 of 4: Project
Course project

Conceive, execute, and communicate a new idea in the world of HCI

A novel contribution to any area of HCI research

An appropriate method for demonstrating that contribution: design, engineering, social science, theory, etc.

You will work together in teams of up to three. You have full control over the topic. We will give feedback on an abstract and a milestone check-in.

If you are already doing HCI research with faculty, you may use it
Performing Under Pressure: A Biofeedback System for Stress-is-Enhancing Mindset

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ABSTRACT
Psychology research has found that the effect of stress on a subject is determined by the subject’s attitude, or mindset, about stress. Most prior research in the intersection of HCI and stress focuses primarily on mitigation, i.e. calming users down when they are experiencing stress, and the consideration of mindset is absent in these systems. In contrast, we present a biofeedback system that frames a user’s stress levels as enhancing. Key features include a real-time stress monitoring system using a heart rate sensor, and a glanceable display which reframes stress as enhancing. We conducted a preliminary evaluation by measuring user performance in timed mental arithmetic problems, but did not find a statistically significant difference in performance between users who received the biofeedback and those who did not (n = 10, p = .12). Even so, we observe a promising trend, and a qualitative analysis suggests that users found the system non-distracting and empowering.

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation: Misc.

BACKGROUND
Stress Mindset
While many health psychologists, ubicomp health researchers, and the general public consider stress to be bad for health and performance, some evidence suggests a more complicated reality: Psychology research [4] has identified the challenge response, which is activated when a person faces a hurdle they believe they have the capacity to overcome. In this scenario, the body primes itself for action, resulting in immediate enhanced cognitive and physical abilities, as well as long term health benefits. The threat response, on the other hand, is evoked when a person feels they cannot reasonably overcome an obstacle, resulting in cognitive strain and long term health hazards.

Significantly, Crum et al. found that one’s mindset about the nature of stress itself is a significant factor in determining whether one experiences the beneficial challenge response or the deleterious threat response[2]. A stress-is-enhancing mindset implies you believe stress generally enhances your performance, while a stress-is-debilitating mindset implies you believe stress generally hampers your performance.
Human Perception of Swarm Robot Motion

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Abstract

As robots become ubiquitous in our everyday environment, we start seeing them used in groups, rather than individually, to complete tasks. We present a study aimed at understanding how different movement patterns impact humans' perceptions of groups of small tabletop robots. To understand this, we focus on the effects of changing the robots' speed, smoothness, and synchronization on perceived valence, arousal, and dominance. We find that speed had the strongest correlation to these factors. With regard to human emotional response to the robots, we align with and build on prior work dealing with individual robots that correlates speed to valence and smoothness to arousal. In addition, participants noted an increase in positive affect in response to synchronized motion, though synchronization had no significant impact on measured perception. Based on our quantitative and qualitative results, we suggest design implications for swarm robot motion.

Author Keywords

Human-robot interaction (HRI); perception; affect; robot swarms; swarm user interfaces; tangible user interfaces

ACM Classification Keywords

H.5.2 [Information interfaces and presentation]: User interfaces; User-centered design
Eevee: Transforming Images by Bridging High-level Goals and Low-level Edit Operations

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ABSTRACT
There is a significant gap between the high-level, semantic manner in which we reason about image edits and the low-level, pixel-oriented way in which we execute these edits. While existing image-editing tools provide a great deal of flexibility for professionals, they can be disorienting to novice users.

Figure 1: The EevEe system, which enables users to directly specify high-level edits such as replacing objects with entirely new ones.
I suggest submitting your work!

Undergraduates: UAR has conference travel grants if you submit your project to an HCI conference.
Course Timeline

week 1
week 2  Quiz
week 3
week 4  Quiz
week 5
week 6  Project abstract due; Quiz
week 7
week 8  Quiz
week 9  Project milestone due
week 10
finals  Final project poster session
Prereqs and background

Most important: are you prepared to dive deep into foundational HCI theories and complete a project?

Helpful:

Depth in at least one of {computer science, social science methods, design, STS}

Experience in human-computer interaction (e.g., CS 147, CS 247)

Required:

CS or SymSys HCI track undergraduate and masters: CS 147 or CS 247

PhD or other programs: no prereqs
Grading

25% Paper commentaries
25% Project
40% Four quizzes
10% Participation (discussant, section, class and team)
CS 547: HCI Seminar

cs547.stanford.edu

Fridays 11:30am-12:30pm, Gates B3

This quarter’s guests include leading luminaries in fabrication, AI+HCI, programming tools, and accessibility.
Introductions
Michael Bernstein
Associate Professor of Computer Science
Stanford HCI Group
Office hours: Wednesdays 4:15pm-5:30pm, Gates 384
TA: Victoria Delaney (she/her)

PhD student in the Learning Sciences and Technology Design, MSCS in Artificial Intelligence

Office hours: Monday noon-1:30p, location TBD
TA: Nick Feffer

MS student in Computer Science, focus in HCl, AR/VR

Office hours: Thurs 4:30pm-5:20pm 160-322
TA: Sanna Ali (she/her)

PhD student in Communication, studying AI ethics

Office Hours: Fridays 1:30 to 2:45 pm, Building 120 (McClatchy), Room 300
TA: Sean Liu (she/her)

PhD student in Computer Science, in the HCI / graphics group

Office hours:
Fridays 10:30am-11:30am, Bytes Cafe

(Exception: Week 1 office hours will be Fri 1/13, 1:30-2:30pm in Bytes)
Contact us

Email: cs347@cs.stanford.edu
Readings, policies, entertainment: cs347.stanford.edu
Assignment submission: canvas.stanford.edu
I am rewriting the content for this course for quarter in 2023.

I appreciate your enthusiasm for trying new things, your patience for bearing with things that don't quite work, and your sharing with me your opinions on what we should keep and change.
Questions?
References


References


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References

