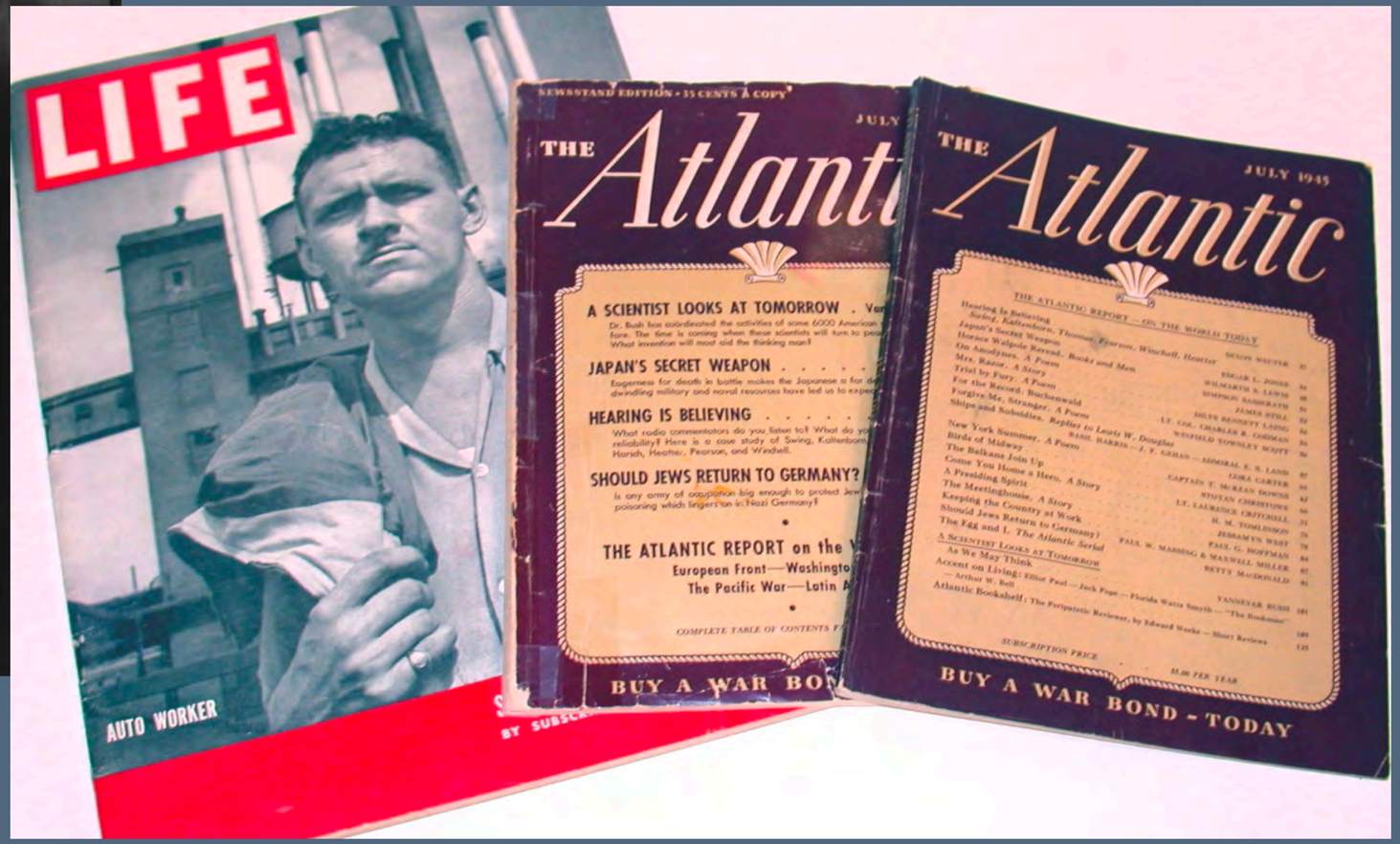
HCI Foundations and Frontiers

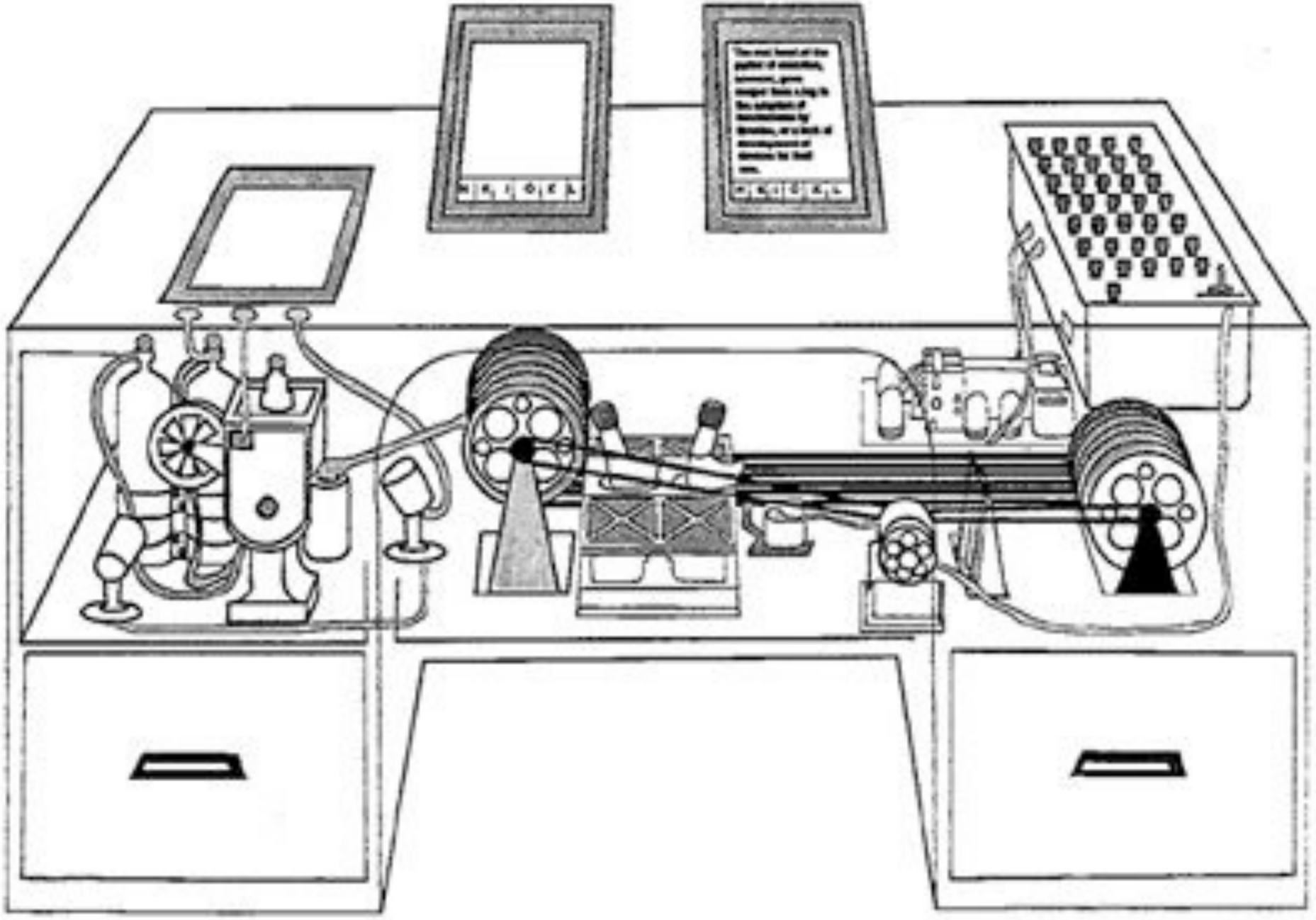
CS 347

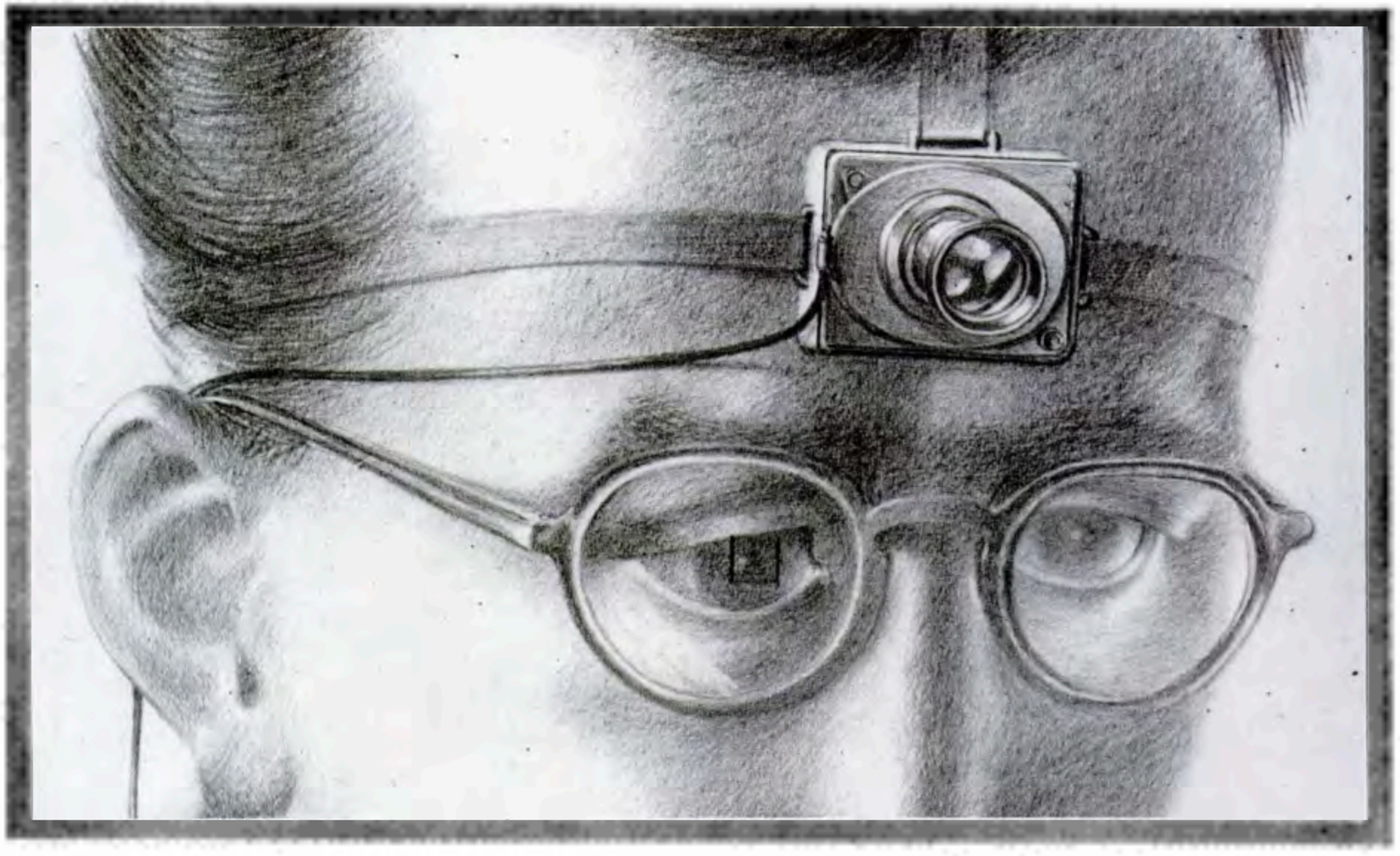
Maneesh Agrawala



As we may think.
Vannevar Bush, 1945.

First appeared in The Atlantic, later that year a condensed version in Life





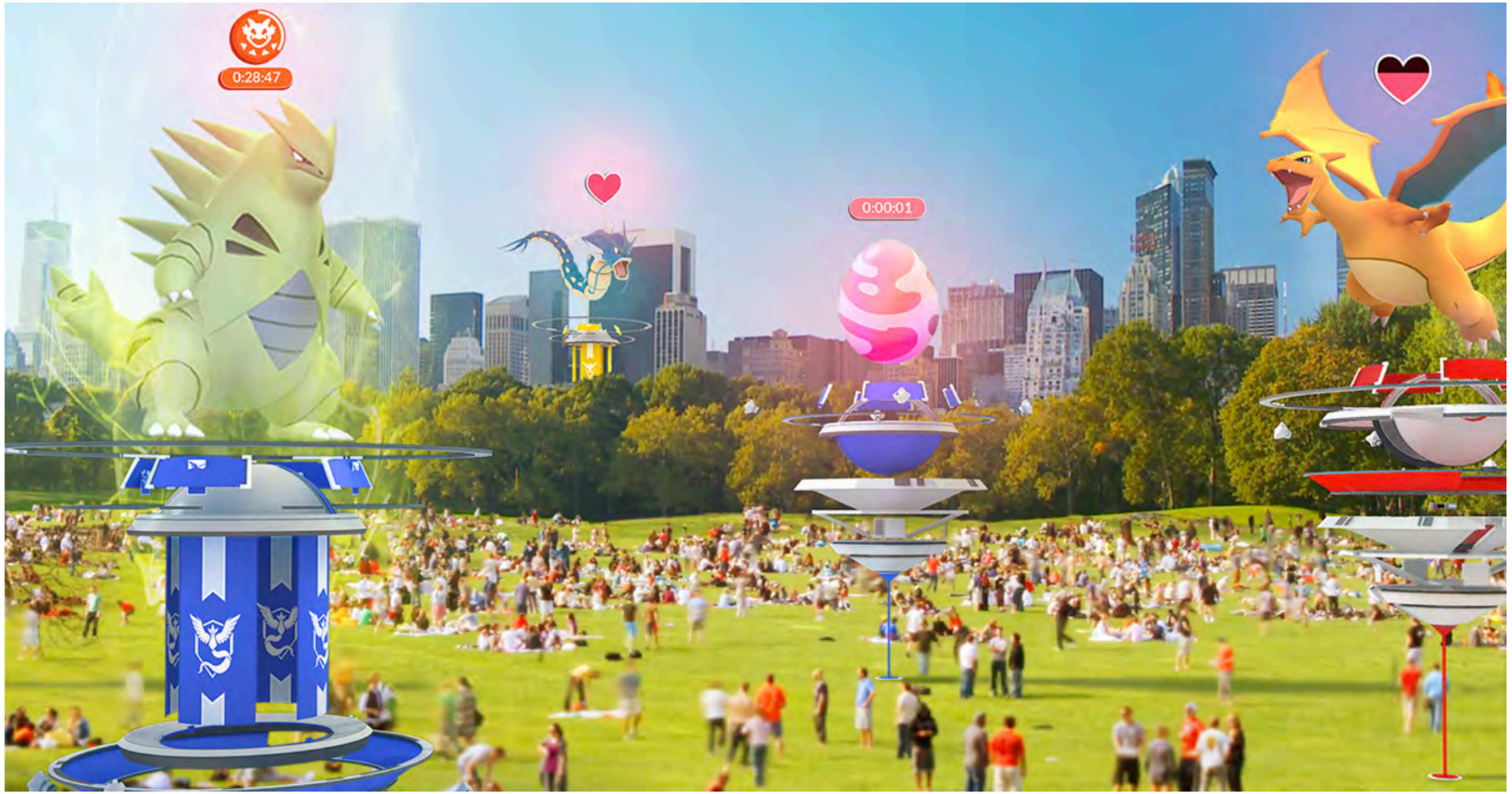
A scientist of the future records experiments with a tiny camera fitted with universal-focus lens. The small square in the eyeglass at the left sights the object (*LIFE* 19(11), p. 112).

[image from TechCrunch]

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).

[image from spar3d]

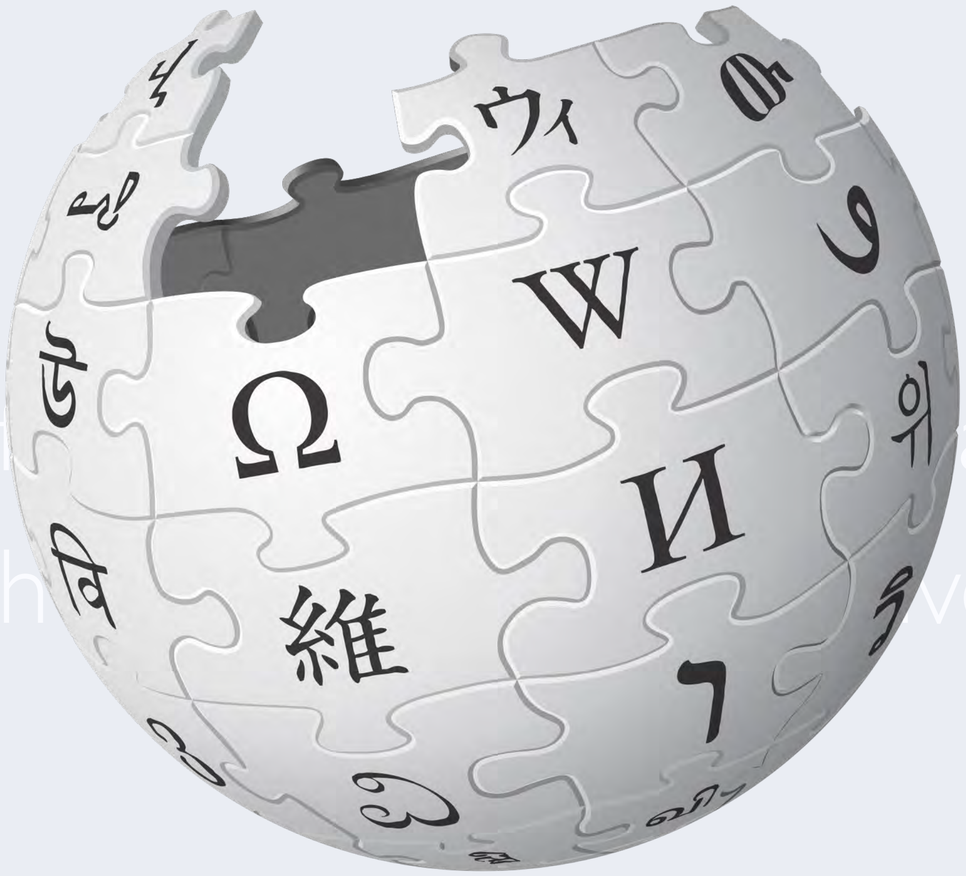
A scientist of the future records experiments with a tiny camera fitted with universal-focus lens. The small square in the eyeglass at the left sights the object (*LIFE* 19(11), p. 112).



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).

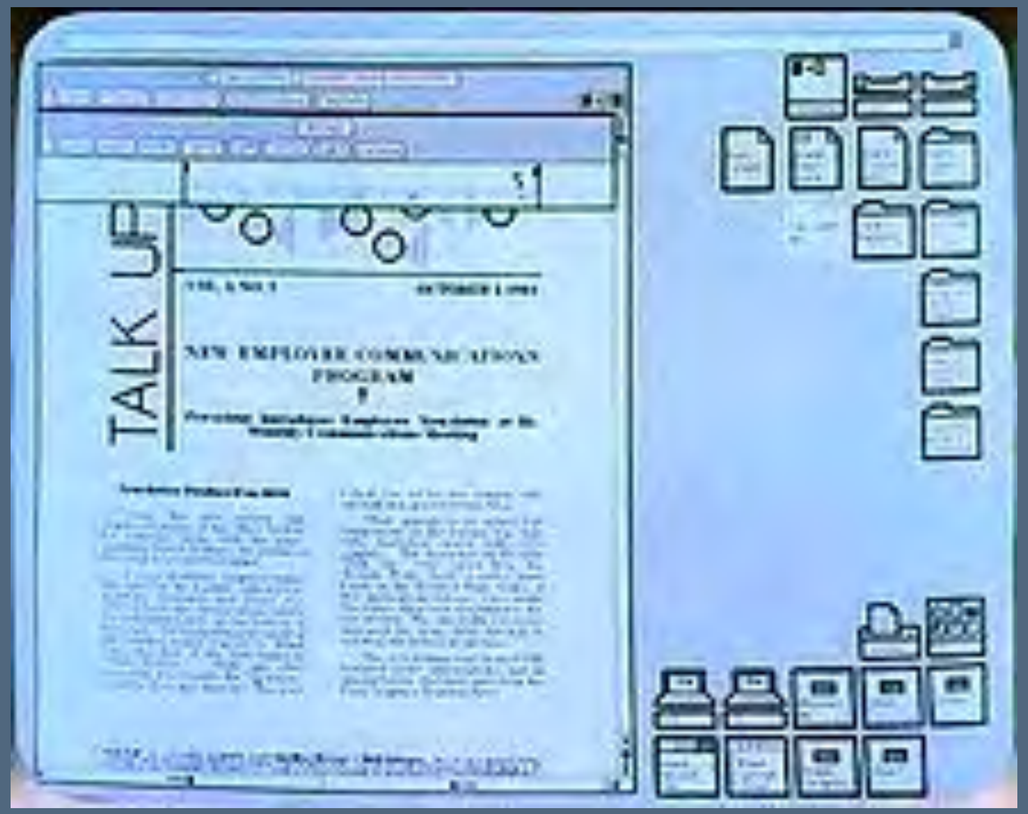
“Wholly new forms of encyclopedias will appear, ready-made with a mesh of associative trails running through them.”

“Wholly new t as will appear, ready-made with ve trails running through them.”



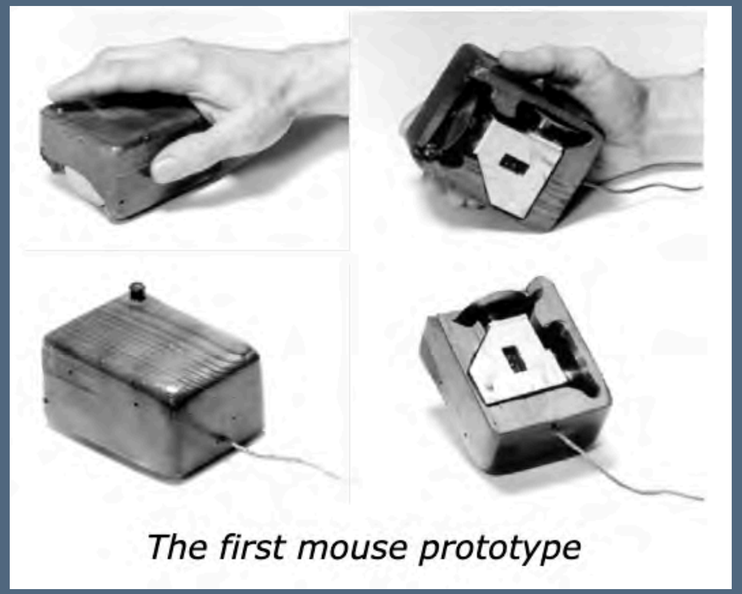
WIKIPEDIA
The Free Encyclopedia

Xerox PARC. 1973.
The Xerox Alto.

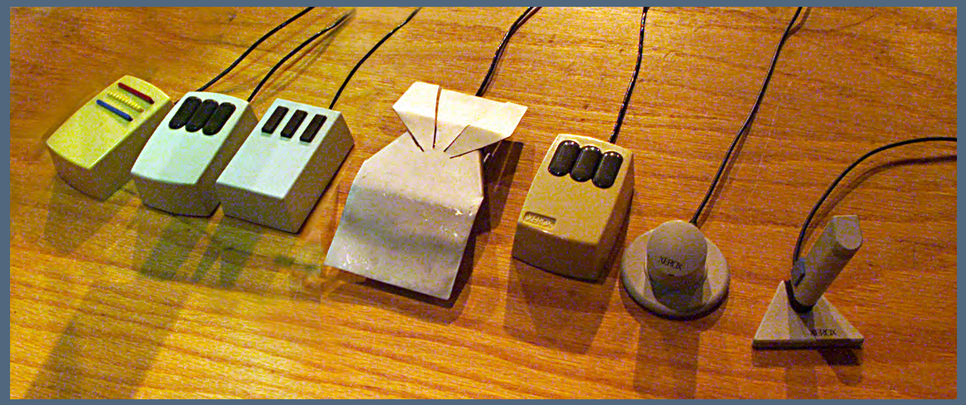


Modern MacOS desktop

Engelbart 1963-64
First mouse prototype

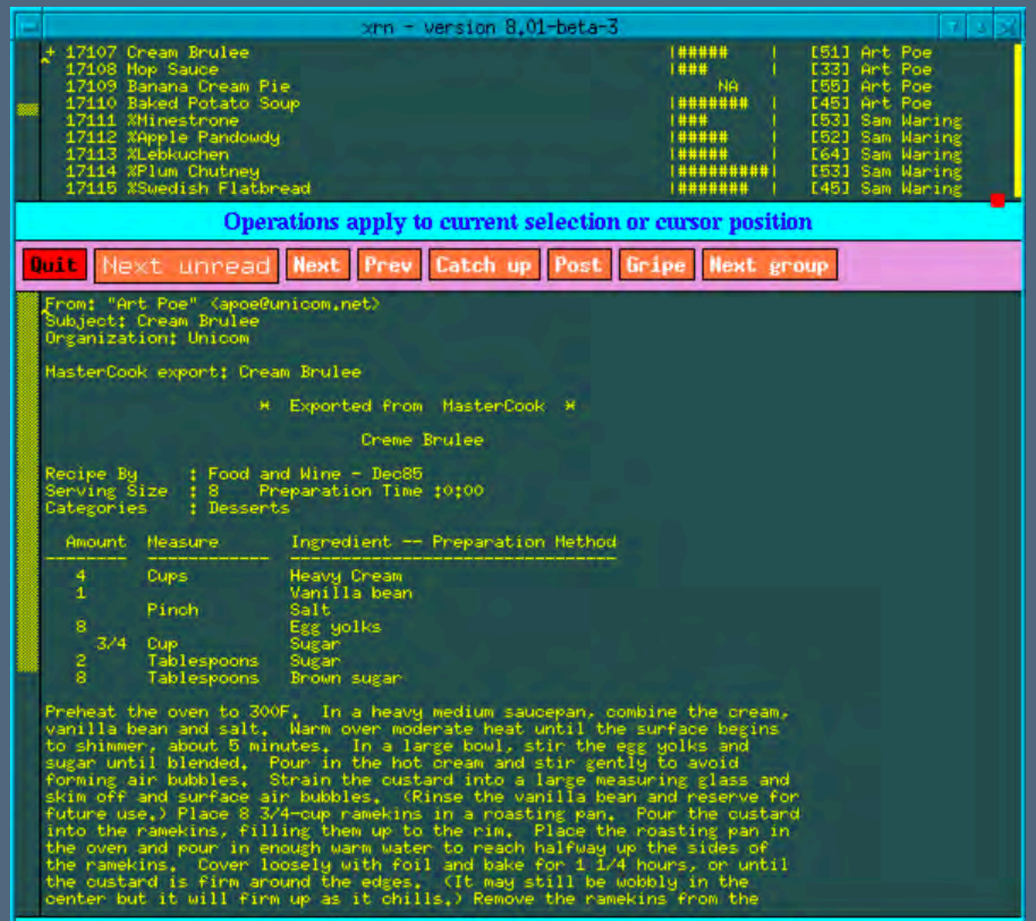


Card, English and Burr. 1978.
Evaluation of mouse, rate-controlled isometric joystick, step keys, and text keys for text selection on a CRT.

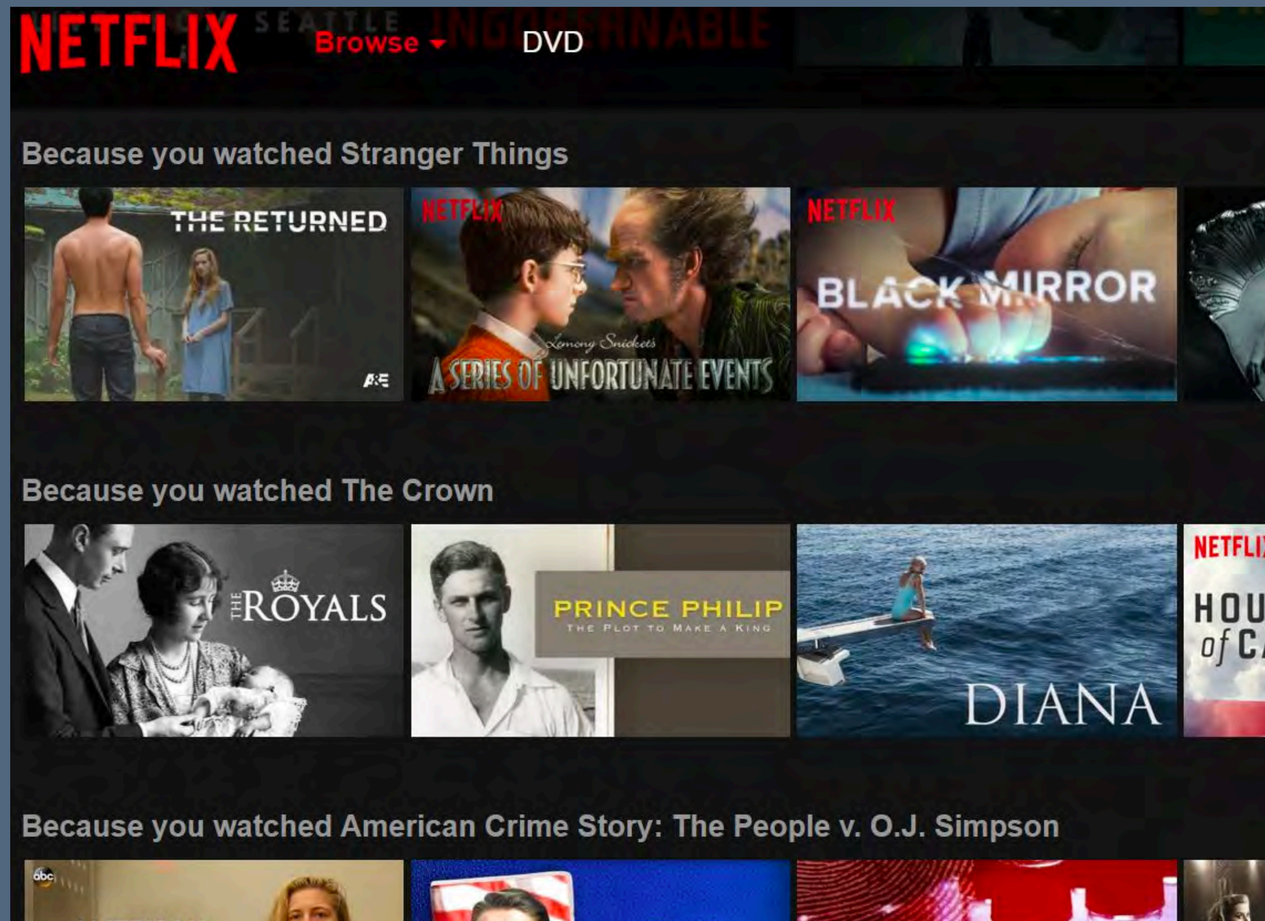


Modern mouse

Resnick et al. 1994. GroupLens: an open architecture for collaborative filtering of netnews.

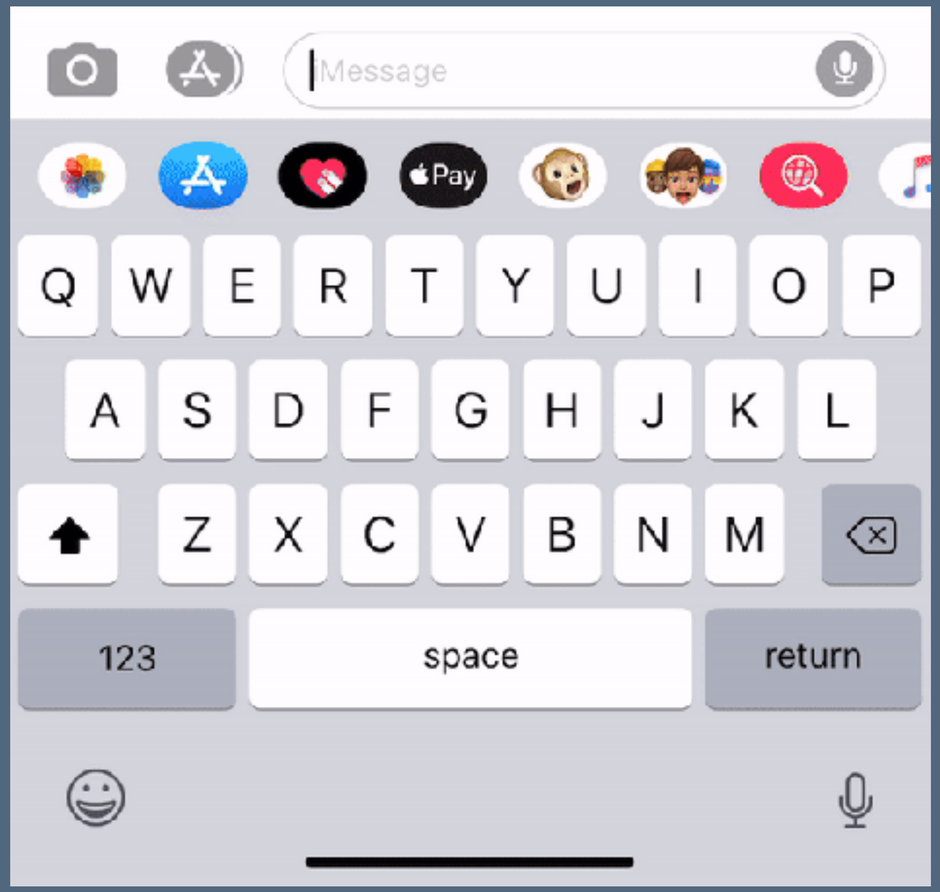


Modern recommender systems [image from HBS]



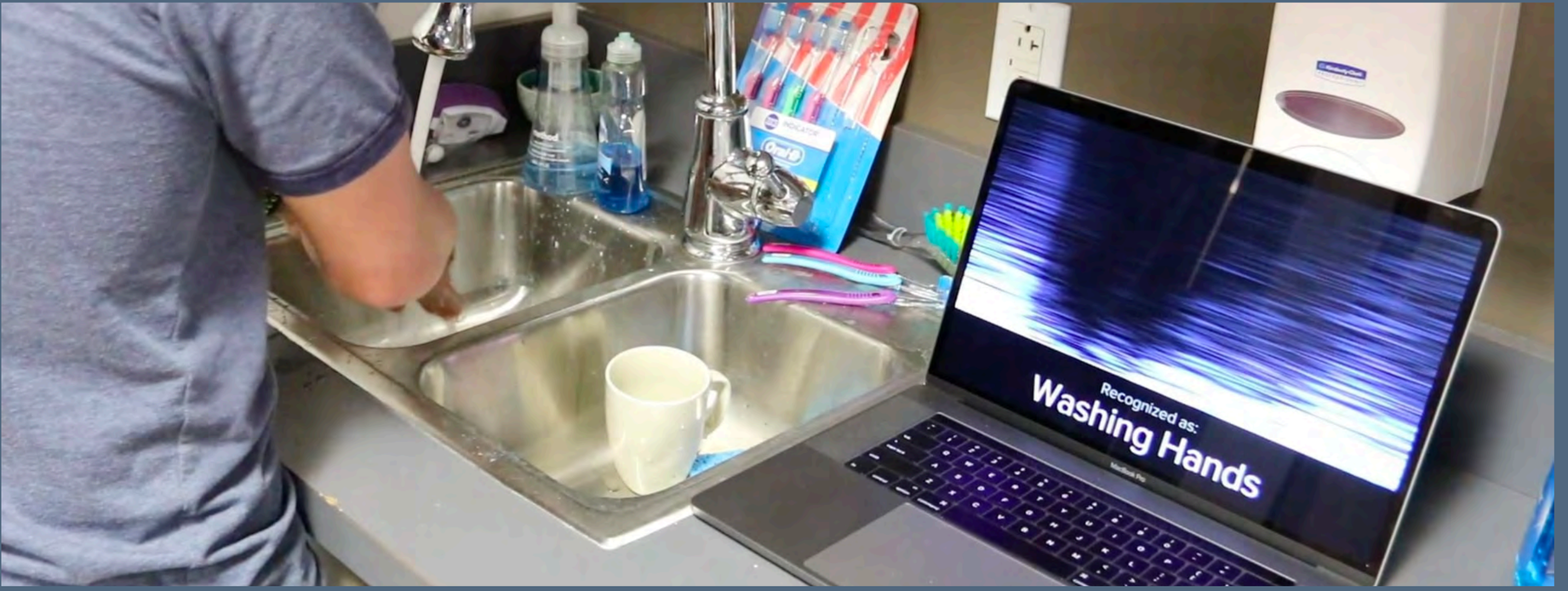
Zhai and Kristensson. 2003. Shorthand writing on a stylus keyboard.

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



Consolvo et al. 2008. Activity sensing in the wild: a field trial of UbiFit Garden.

Modern fitness trackers [image from Apple]

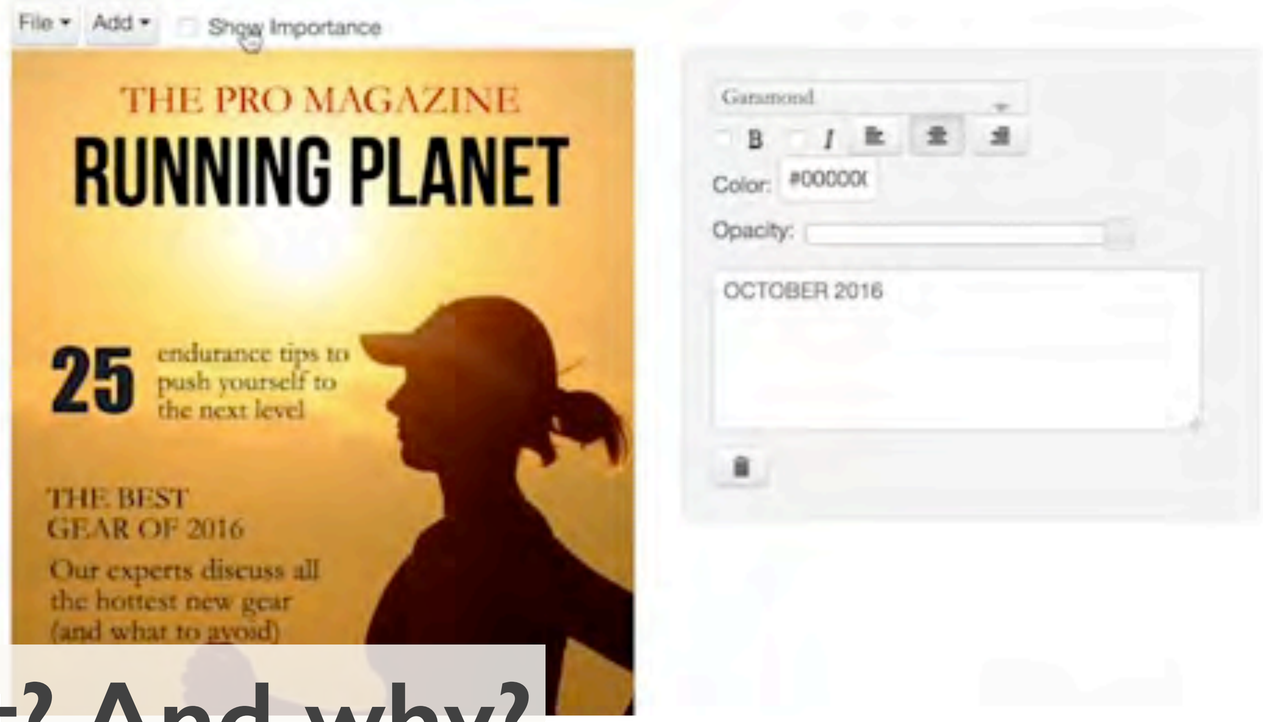


Laput et al. 2018. Ubicoustics: Plug-and-Play Acoustic Activity Recognition

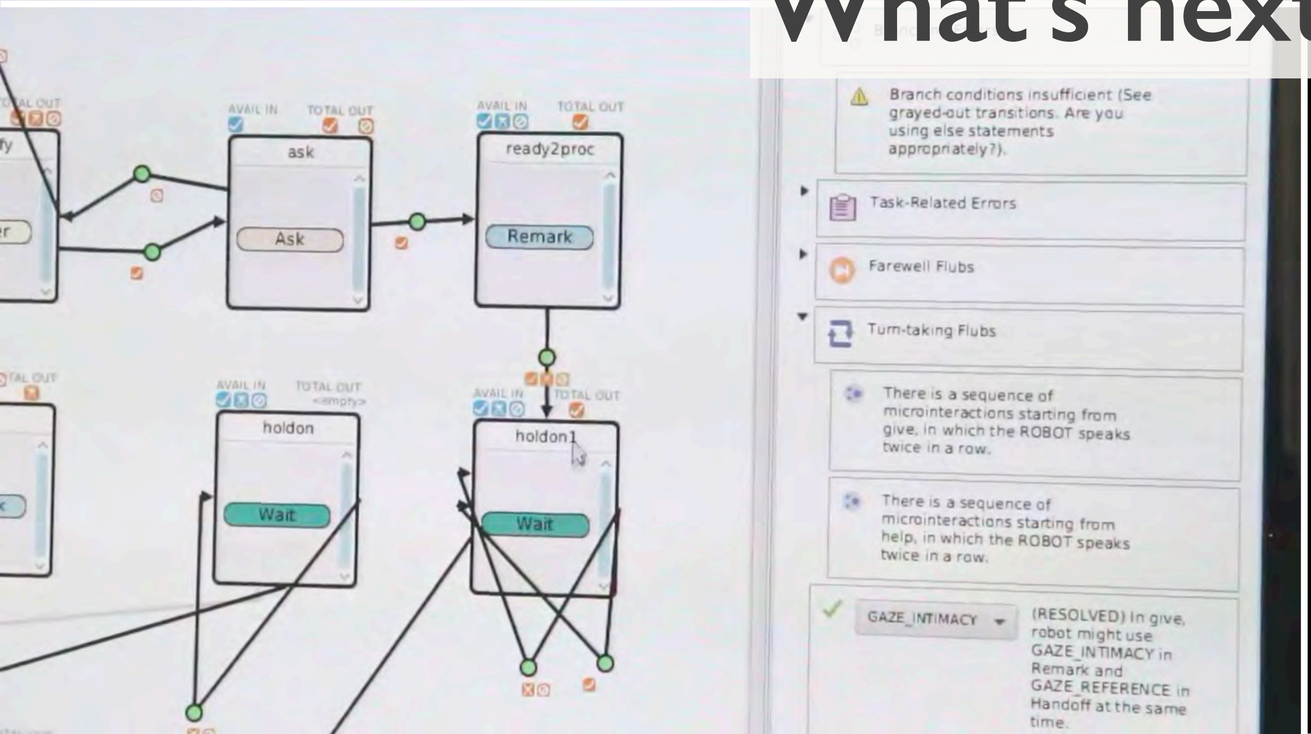
Apple Watch handwashing detection 2020

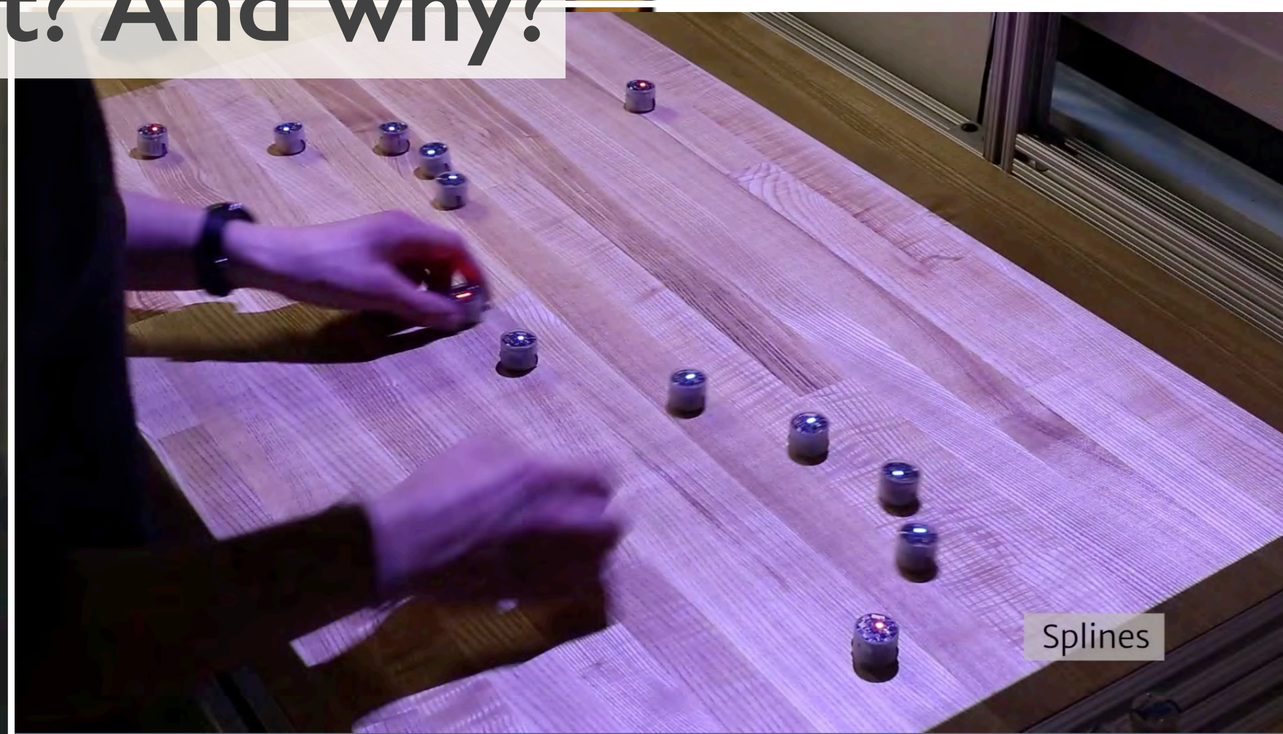
Zhang et al. 2021. AI-powered screen reader accessibility.

iOS Screen Recognition



What's next? And why?





"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."

Is this a good idea?

(ChatGPT 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 **design** 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


START

Ubiquitous computing

Unit 1

ubiquitous and tangible computing
input and output
activity, health, and behavior

Mobile phone's
model of a person

[O'Sullivan and Igoe 2004]

The future of interaction?

[Microsoft]

"…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”

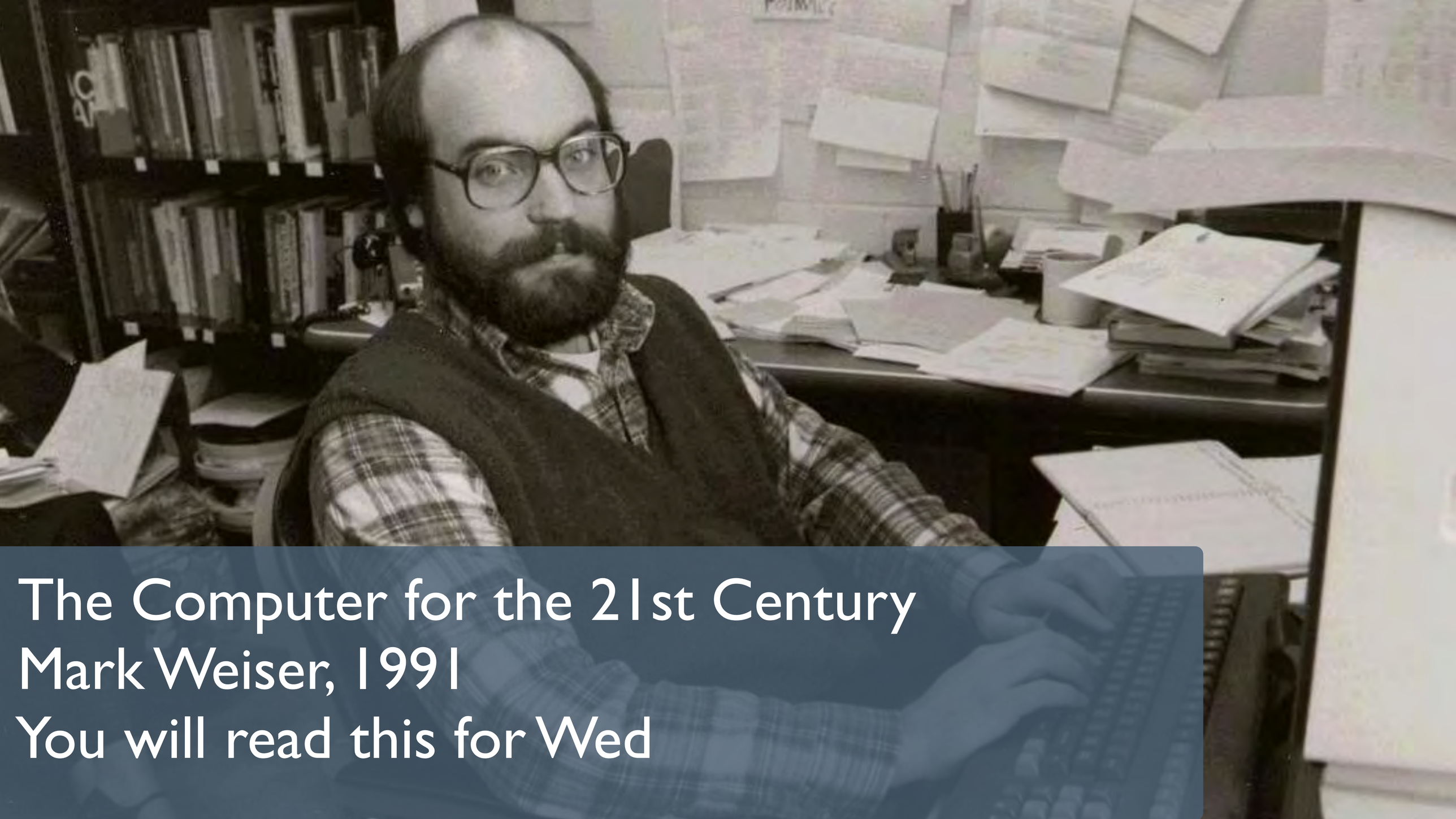
[Victor 2011]

Why is this so terrible?

[Hutchins 1995, 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



The Computer for the 21st Century
Mark Weiser, 1991
You will read this for Wed

“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]

Activity recognition [Laput et al. 2015]

Detecting ambient EM signals transmitted through body using 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]

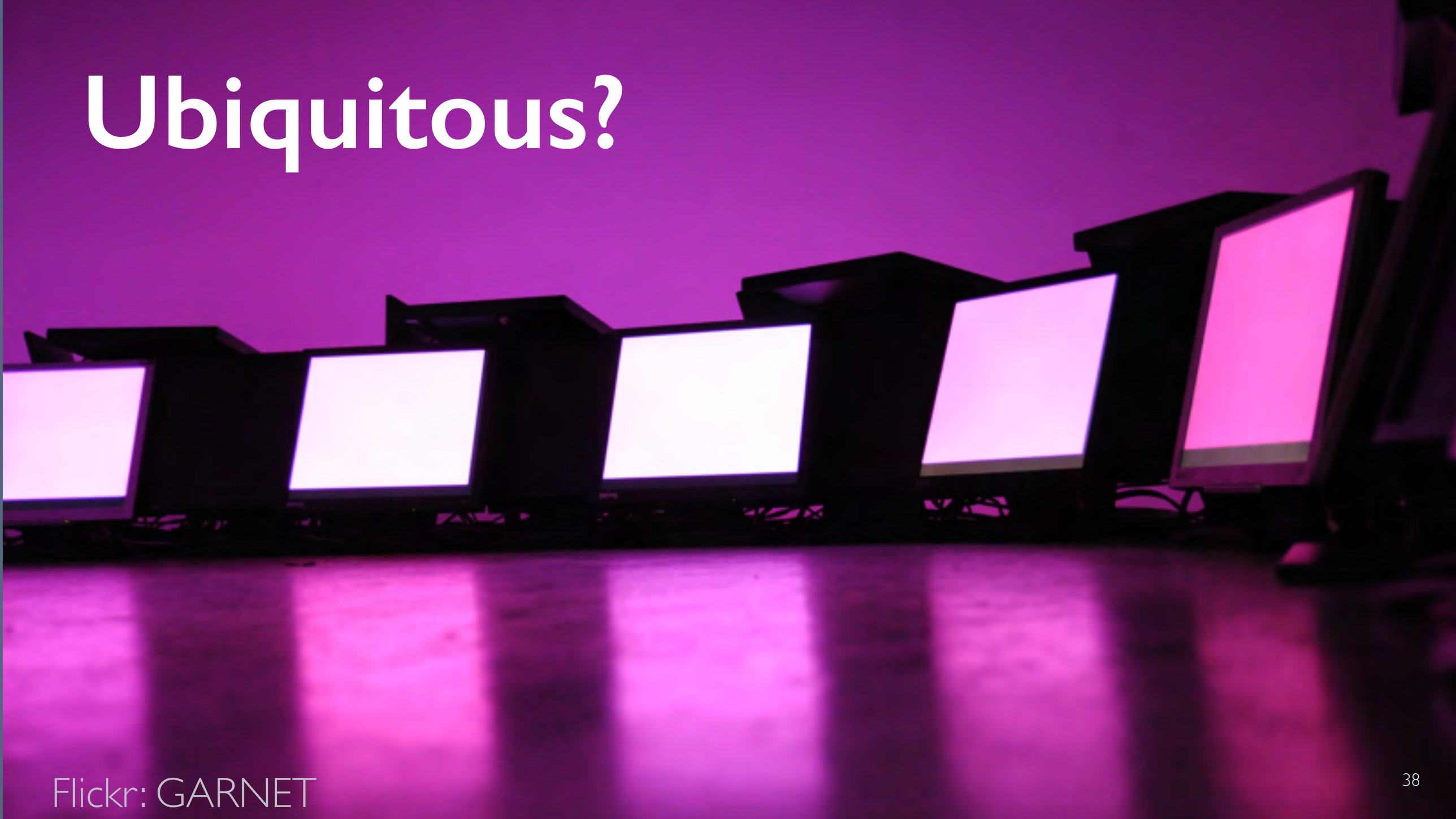
Photochromic inks change color when exposed to lights of a specific wavelength

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?



Flickr: GARNET

Ubiquitous?

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

Ubicomp is backgrounded

What Weiser calls one of the first "calm" technologies: Live Wire, a wire on a stepper motor, monitoring net traffic [Jeremijenko 1995]

Tabs

Weiser envisioned ubiquitous computing devices at three scales.

Boards

Pads

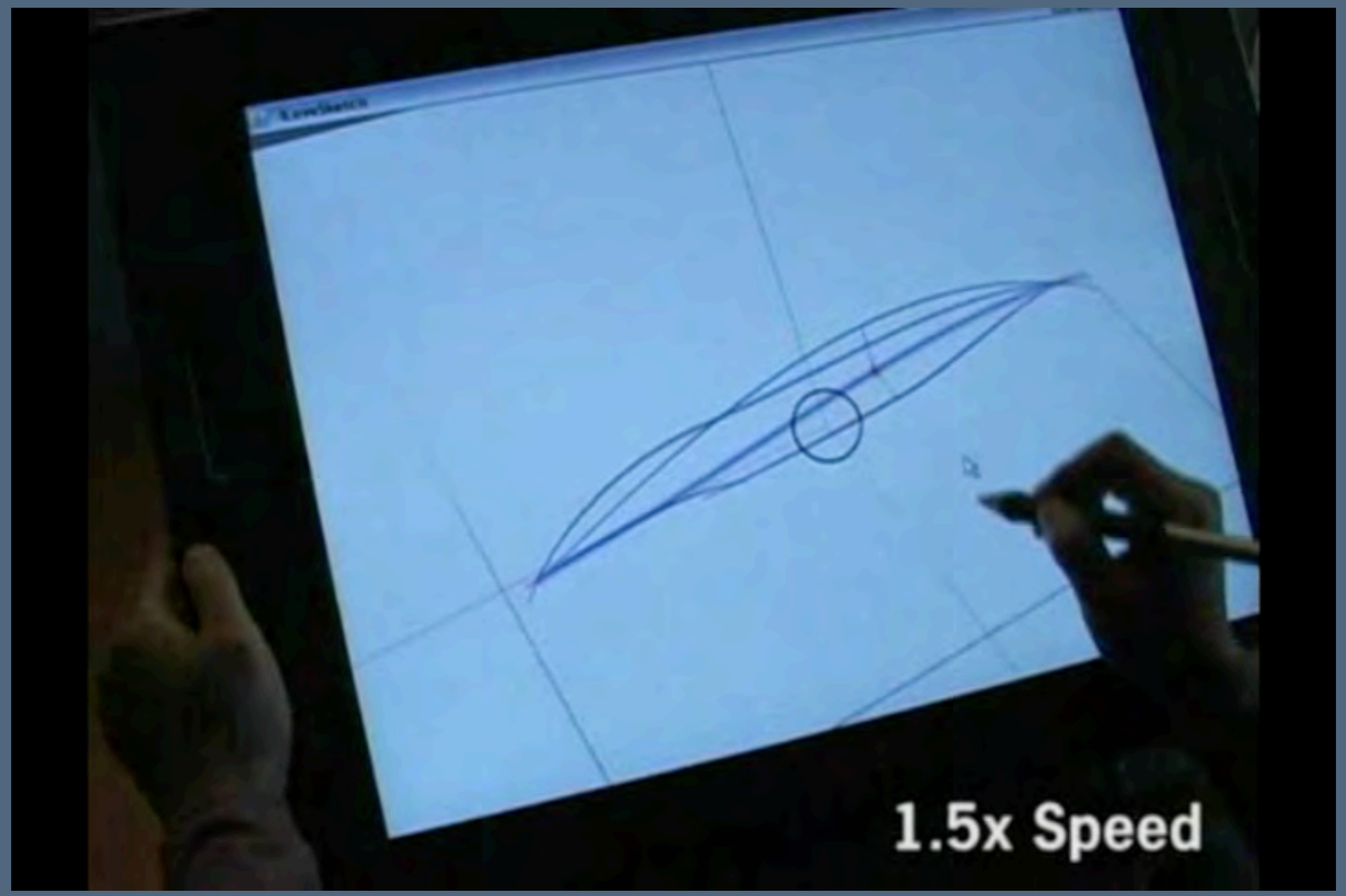
Tabs

Most similar to today's smart watches

Significant Otter: sharing biosignals with romantic partners [Liu et al. 2021]

Pads

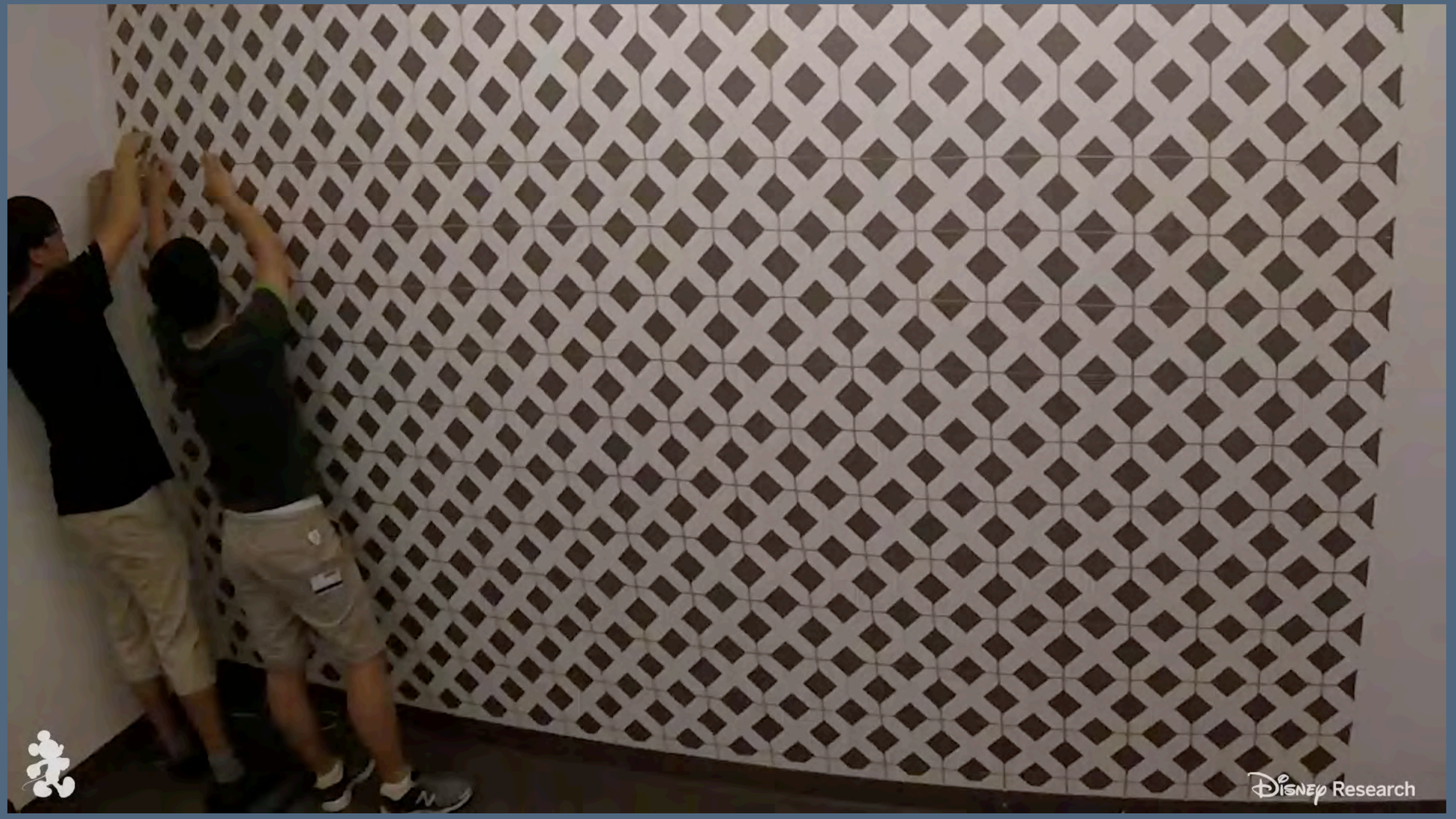
Most similar to today's tablets



[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

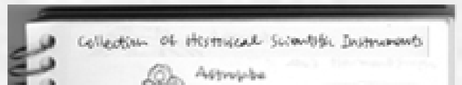
You will read this for Wed

Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms

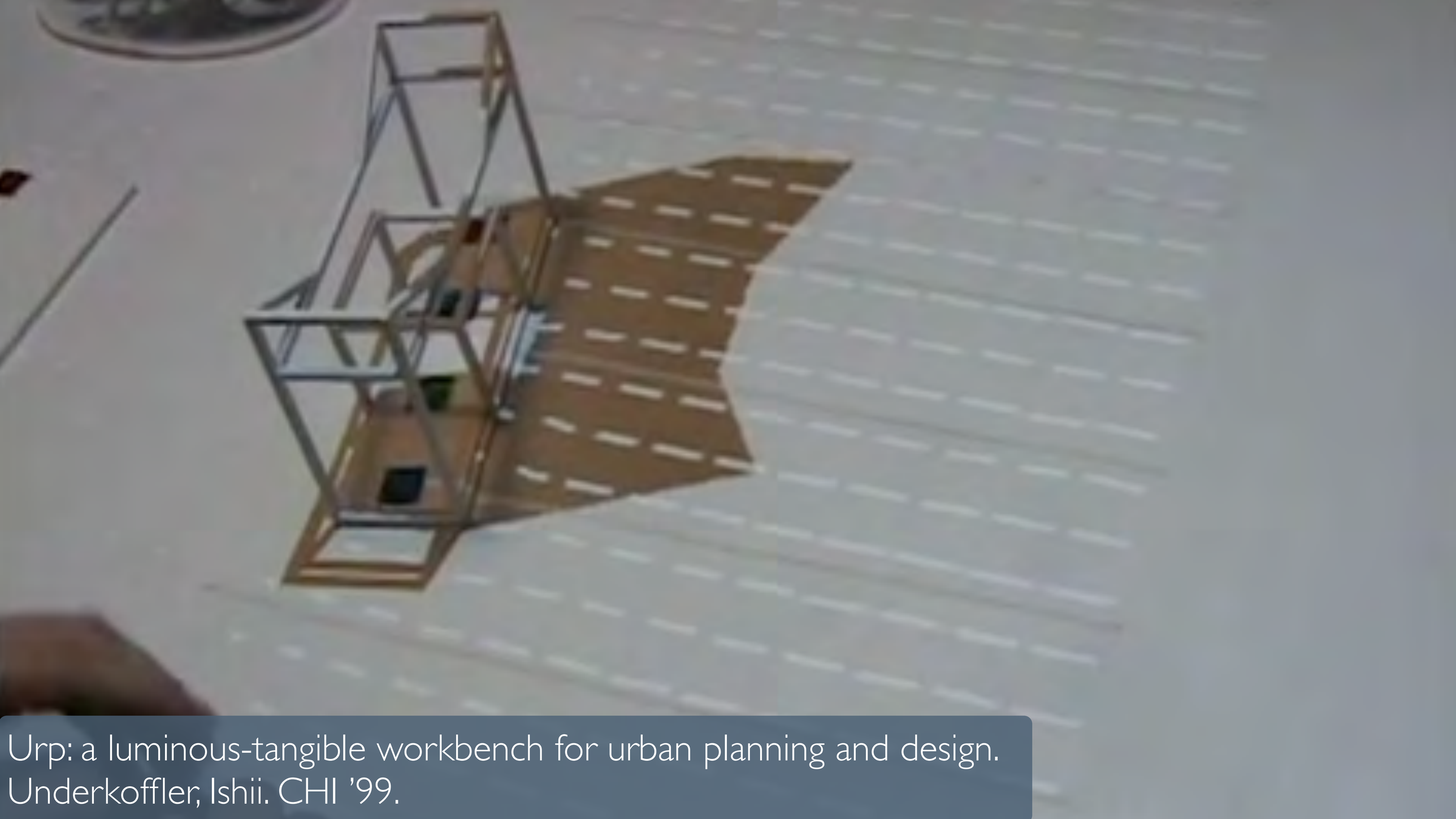
Hiroshi Ishii and Brygg Ullmer
MIT Media Laboratory
Tangible Media Group
20 Ames Street, Cambridge, MA 02139-4307 USA
{ishii, ullmer}@media.mit.edu

ABSTRACT
This paper presents our vision of Human Computer

BITS & ATOMS
We live between two realms:



Urp: a luminous-tangible workbench for urban planning and design.
Underkoffler, Ishii. CHI ’99.



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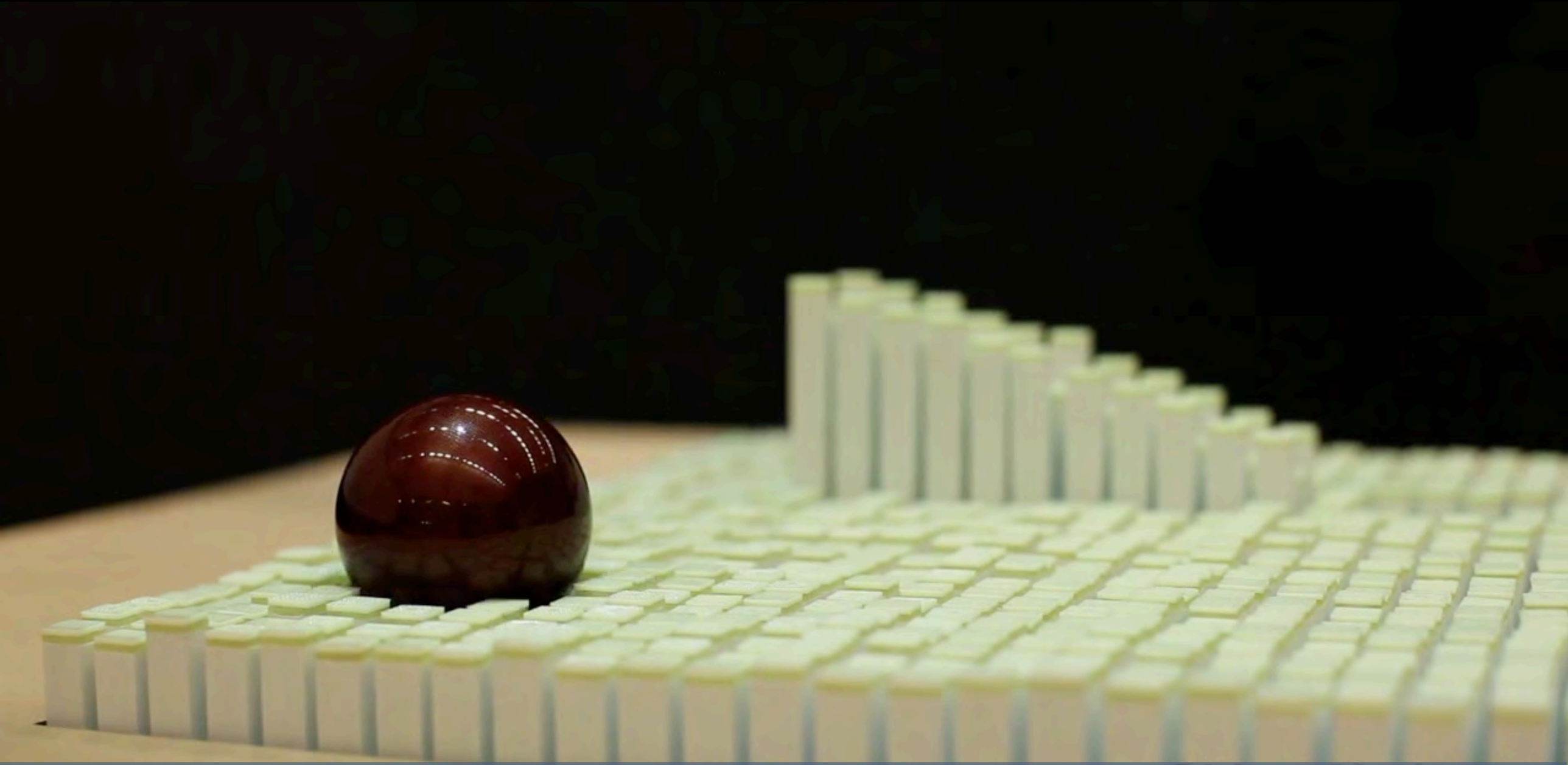

Follmer, Leithinger, Olwal, Hogge, Ishii. inFORM: Dynamic Physical Affordances and Constraints through Shape and Object Actuation. UIST '13.

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?

Yesterday's tomorrows

[Bell and Dourish 2007]

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	Ubicomp
week 2	Ubicomp/Design
week 3	Design
week 4	Social Computing and Collaboration
week 5	Human-Centered AI
week 6	Cognition/Visualization
week 7	Software Tools/Content Creation
week 8	Critical Theory/Simulating People
week 9	Methodology
week 10	History

How this class works

Class activity 1 of 3: 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 four lowest commentary grades at the end of class: meaning, you may drop four readings' worth of commentaries

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

Writing a strong commentary

Do: engage with the core contributions —

Step 1: What is the point that this paper is trying to make?

Step 2: How effectively does it convince you of that argument? How could the argument be even more persuasive, on its own terms?

Step 3: What are the implications of the argument? **What future frontier projects might be inspired by this work? What follow-up project would you work on?**

Don't: nitpick low-level details, harp on already-acknowledged limitations / future work, bring expectations from other HCI paper genres ("needs a user study!"), spend too much time summarizing, levy judgment ("I like this!") without digging into why or implications

~~“This paper has so many problems:”~~

“This paper inspired me to develop an idea:”

Example Length

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 Wednesday

The Computer for the 21st Century

Specialized elements of hardware and software, connected by wires, radio waves and infrared, will be so ubiquitous that no one will notice their presence

by Mark Weiser

The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.

Consider writing, perhaps the first information technology. The ability to represent spoken language symbolically for long-term storage freed informa- the limits of individual mem- technology is ubiqui- countries. Not is approachable only through complex jargon that has nothing to do with the tasks for which people use computers. The state of the art is perhaps analogous to the period when scribes had to know as much about making ink or baking clay as they did about writing. The arcane aura that surrounds personal computers is not just a "user interface" problem. My colleagues and I at the Xerox Palo Alto Research Center think that the idea of a "personal" computer itself is misplaced and that the vision of laptop machines, dynabooks "knowledge navigators" is only a toward achieving the

The idea of integrating computers seamlessly into the world at large runs counter to a number of present-day trends. "Ubiquitous computing" in this context does not mean just computers that can be carried to the beach, junnotebook computer, with access to a worldwide information network, still focuses attention on a single box. By analogy with writing, carrying a superportant book. Customizing this book, even writing millions of other books, does not begin to capture the real power of literacy.

Furthermore, although ubiquitous computers may use sound and vide in addition to text and graphics, make them "multimedia multimedia

PAPERS

Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms

CHI 97 * 22-27 March 1997

Hiroshi Ishii and Brygg Ullmer
MIT Media Laboratory
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{ishii, ullmer}@media.mit.edu

ABSTRACT
This paper presents our vision of Human Computer Interaction (HCI): "Tangible Bits." Tangible Bits allows users to "grasp & manipulate" bits in the center of users' attention by coupling the bits with everyday physical objects and architectural surfaces. Tangible Bits also enables users to be aware of background bits at the periphery of human perception using ambient display media such as light, sound, airflow, and water movement in an augmented space. The goal of Tangible Bits is to bridge the gaps between both cyberspace and the physical environment, as well as the foreground and background of human activities.

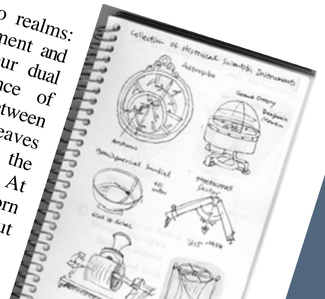
This paper describes three key concepts of Tangible Bits: interactive surfaces; the coupling of bits with graspable physical objects; and ambient media for background awareness. We illustrate these concepts with three prototype systems – the metaDESK, transBOARD and ambientROOM – to identify underlying research issues.

Keywords
tangible user interface, ambi
interface, augmented re
and periphery

BITS & ATOMS

We live between two realms: our physical environment and cyberspace. Despite our dual citizenship, the absence of seamless couplings between these parallel existences leaves a great divide between the worlds of bits and atoms. At the present, we are torn between these parallel but disjoint spaces.

We are now almost constantly "wired" so that we can be her (physical space) (cyberspace)



Class activity 2 of 3: Discussion

Yes, there is human-human interaction in a CS class.

You will join a weekly discussion section (starting week 2)

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

Discussions run Wednesdays, Thursdays and Fridays

Sections

Section 1 (Nava, Wednesday 4:30 - 5:20) : recommended for PhDs

Section 2 (Joon, Wednesday 5:30 - 6:20)

Section 3 (Yubin, Thursday 3:00 - 3:50)

Section 4 (Yubin, Thursday 4:30 - 5:20)

Section 5 (Dan, Friday 10:30-11:20)

Section 6 (Dan, Friday 11:30-12:20)

Section 7 (Joon, Friday 2:30-3:20)

Required section application

Submit the section 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 3: Quizzes

Five in-class quizzes

First 4 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 Monday

Final quiz is comprehensive and 2x in length (Wed of Week 10)

Closed-book, will ask you to recognize and apply the concepts from lecture

Course Timeline

week 1	
week 2	Quiz
week 3	
week 4	Quiz
week 5	
week 6	Quiz
week 7	
week 8	Quiz
week 9	
week 10	Quiz 2x

Prereqs and background

Most important: are you prepared to dive deep into foundational HCI theories and critique/discuss them?

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

30% Paper commentaries

60% First four quizzes 10%, Final Quiz 20%

10% Participation (discussant, section, class)

Introductions

Maneesh Agrawala

Professor of Computer Science

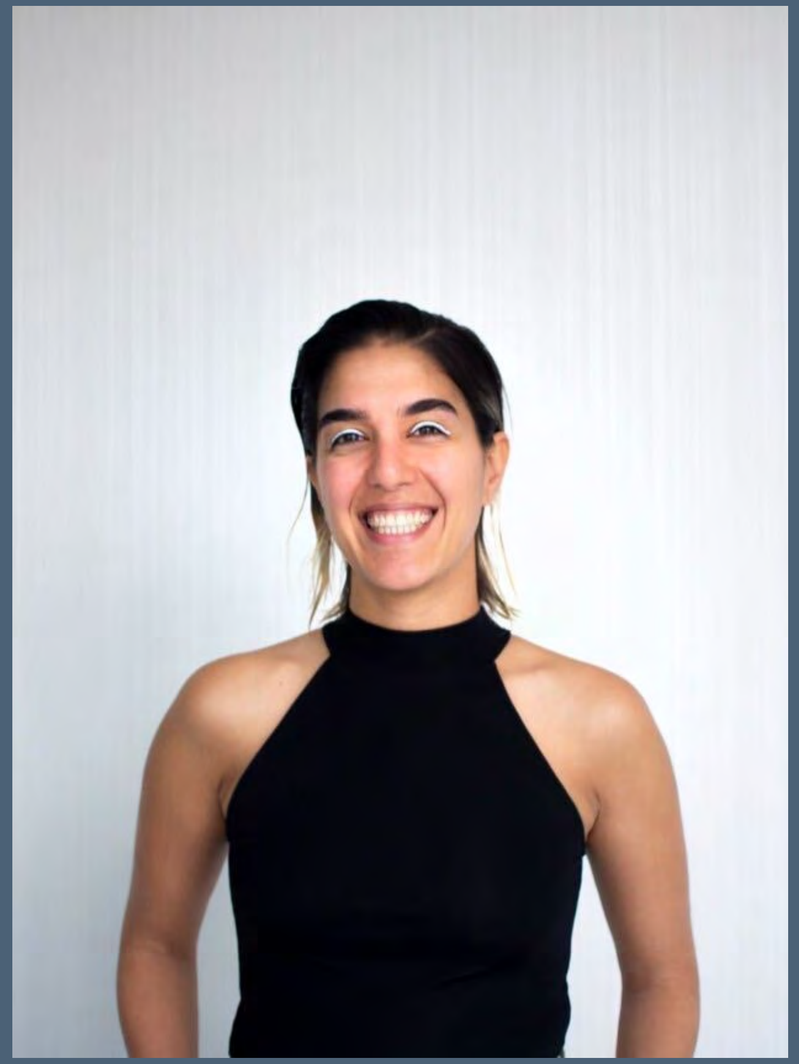
HCI/Graphics/Visualization

Office hours: Fri 9:30-10:30am,
Coupa Cafe Y2E2 & Zoom

TA: Nava Haghighi

PhD student in HCI

Office hours: Monday 4-5pm,
Location: Gates 3B Common Area



TA: Yubin Jee

BS in HCI, now MS student in AI

Office hours: Wednesday 1-2pm,
Location: Tressider

TA: Joon Sung Park

PhD student in HCI

Office hours: Friday 1:15-2:15pm,
Location: Gates 3B Common Area

TA: Daniel Wan Rosli

BS/MS student in HCI

Office hours: Wednesday 12:30-1:30pm,
Location: 2nd Floor Old Union

Contact us

Email: cs347@cs.stanford.edu

Readings, policies, entertainment: cs347.stanford.edu

Assignment submission: canvas.stanford.edu

UNDER CONSTRUCTION

Michael Bernstein and I are rejiggering CS 347 to focus on the big ideas (theories) of HCI and critical analyses of these ideas and their applications to real world problems.

We appreciate your enthusiasm for trying new things, your patience for bearing with things that don't quite work, and your sharing with us your opinions on what we should keep and change.

Questions?

References

Bell, Genevieve, and Paul Dourish. "Yesterday's tomorrows: notes on ubiquitous computing's dominant vision." Personal and ubiquitous computing 11.2 (2007): 133-143.

Bush, Vannevar. "As we may think." The atlantic monthly 176.1 (1945): 101-108.

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