Human-Computer Interaction

Mobile, Ubiquitous, & Tangible Computing

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Today's Agenda

» What's next?

» Topic overview: *Mobile, Ubiquitous, & Tangible Computing*

» Discussion

What's Next

Methods Focus

Read *Textbook Chapter 2*[13] + *Chapter 3*[14]

Project Timeline

» Oct 31 — Method

» Nov 21 — Data Collection

» Dec 5 — Data analysis

» Dec 8/10 — Final Presentation

» Dec 12 — Final paper

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[13] Lazar et al. (2017). Chapter 2 — Experimental Research. *Research methods in human-computer interaction*. Morgan Kaufmann.

[14] Lazar et al. (2017). Chapter 3 — Experimental Design. *Research methods in human-computer interaction*. Morgan Kaufmann.

Three Visions

Three visions that have shaped mobile and tangible computing research:

1. **Vision 1:** Communication will be mobile and ubiquitous, facilitated by networked small, handheld devices ↠ *Mobile Computing*

2. **Vision 2:** Computing will be pervasive and embedded within environments, facilitated by specialized, networked, and invisible computers ↠ *Internet of Things*

3. **Vision 3:** Computing will be physical, tangible, and manipulatable by people, facilitated by platforms and props that recognize human intent and expressions ↠ *Tangible Computing*

The Three Visions Contrasted

Dimension	Mobile Computing	Tangible Interaction	Ubiquitous Computing
Device Role	Central, personal	Peripheral, shared	Invisible, embedded
Interaction	Screen-tapping	Grasping, moving	Sensing, responding
Focus	Efficiency	Embodiment	Seamlessness
Mobility	Device mobility	Human mobility	Spatial diffusion

What is the history behind these visions?

Vision 1: **Mobile Computing**

Harold Osborne (chief engineer for AT&T) predicted in 1954:[1]

Let us say in the ultimate, whenever a baby is born anywhere in the world, he is given at birth a number which will be his telephone number for life. As soon as he can talk, he is given a watch-like device with ten little buttons on one side and a screen on the other. Thus equipped, at any time when he wishes to talk with anyone in the world, he will pull out the device and punch on the keys the number of his friend. Then turning the device over, he will hear the voice of his friend and see his face on the screen, in color and in three dimensions. If he does not see and hear him he will know that the friend is dead.

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[1] Harold Osborne

An illustration of Osborne's *watch-like mobile communication device.*[2]

[2] Ling, 2004, The Mobile Connection

*Where is the research in **mobile computing**?*

- **Example 1:** Wish You Were Here (Venolia et al., 2018)
- **Example 2:** Geocaching with a Beam (Heshmat et al., 2018)
- **Example 3:** Supporting Elder Connectedness (Kleinberger et al., 2019)

Vision 2: **Internet of Things**

(a.k.a. Ubiquitous & Pervasive Computing)

Mark Weiser (CTO of Xerox PARC) proposed in 1991:[3]

Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives.

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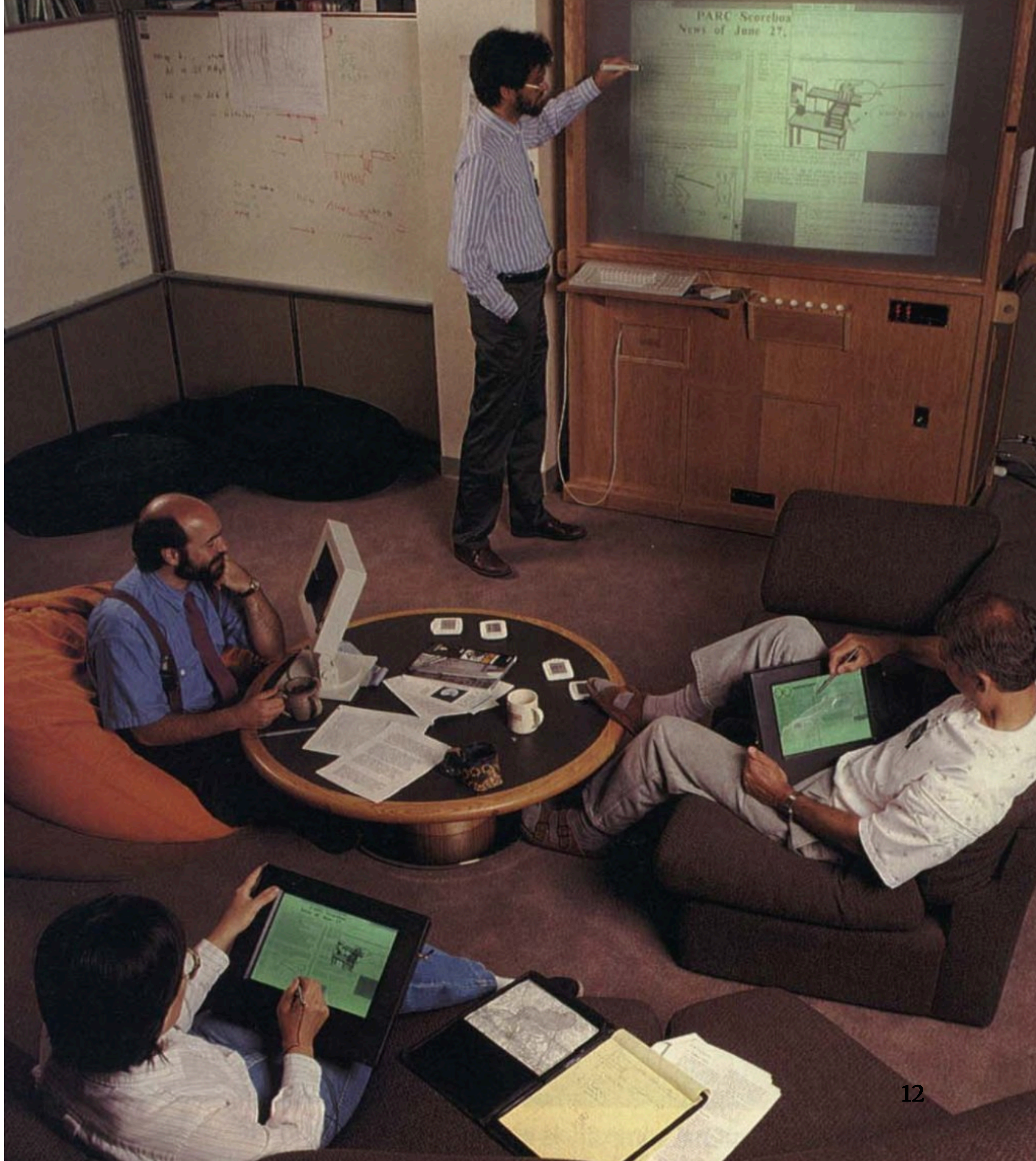
[3] Wikipedia: Mark Weiser

The Computer for the 21st Century:

Ubiquitous computing begins to emerge in the form of live boards that replace chalkboards as well as in other devices at the Xerox Palo Alto Research Center. Computer scientists gather around a live board for discussion. Building board and integrating them with other tools has helped researchers understand better the eventual shape of ubiquitous computing. In conjunction with active badges, live boards can customize the information they display.[4]



[4] Weiser, 1991, The Computer for the 21st Century

Weiser's Vision: Beyond the Mobile Device
"Ubiquitous computers will also come in different sizes...hundreds of computers per room." — Weiser (1991)

- Mobile computing focuses on *devices* you carry.
- Weiser[4] imagined a *fabric of computation*: tabs, pads, and boards embedded into environments.
- This vision *decentralizes interaction, and computing vanishes into the background.

[4] Weiser, 1991, The Computer for the 21st Century

Principles of Calm Technology[5]

1. Technology should require the smallest possible amount of attention
2. Technology should inform and create calm
3. Technology should make use of the periphery
4. Technology should amplify the best of technology and … humanity
5. Technology can communicate, but doesn’t need to speak
6. Technology should work even when it fails
7. Right amount of technology = minimum needed to solve the problem
8. Technology should respect social norms

[5] Calm Technology

*Where is the research in **pervasive/ubiquitous computing**?*

- **Example 1:** Wall ++ (Zhang et al., 2018)
- **Example 2:** Zensors (Laput et al., 2015)
- **Example 3:** Ubicoustics (Laput et al., 2018)

From Calm to Unremarkable
"Invisible in use" isn't just about shrinking devices or dimming displays.
It's about how technologies embed into everyday life — quietly, unobtrusively, and without comment.

» Tolmie et al.[8] critique techno-centric calm computing visions.

» Highlight: *Technologies are unremarkable when they become part of routines.*

» Example: An alarm clock doesn't disappear, it just becomes *expected*.

[8] Tolmie, P., Pycock, J., Diggins, T., MacLean, A., & Karsenty, A. (2002). *Unremarkable Computing*. CHI 2002.

What Makes Computing Unremarkable?
Routines are the glue of everyday life.
What matters is not perceptual visibility, but practical invisibility.

- » Unremarkable = no need to explain, justify, or notice.
- » Achieved through repeated, context-specific use.
- » Danger of tech: Turning the unremarkable into a performance.

Augmenting Routines, Not Artifacts
“Embed computation within life, not just in cups.” — Tolmie et al.

- Meaning isn’t in the door, it’s in the "knock."
- Tangibility ≠ naturalness unless you understand the social semantics.
- Design goal: Augment what’s “done in the doing” — not just what’s touched.

Vision 3: **Tangible Computing**

Hiroshi Ishii and Brygg Ullmer proposed in 1997:[6]

Humans have evolved a heightened ability to sense and manipulate the physical world, yet the GUI based on intangible pixels takes little advantage of this capacity. The TUI builds upon our dexterity by embodying digital information in physical space. TUIs expand the affordances of physical objects, surfaces, and spaces so they can support direct engagement with the digital world.

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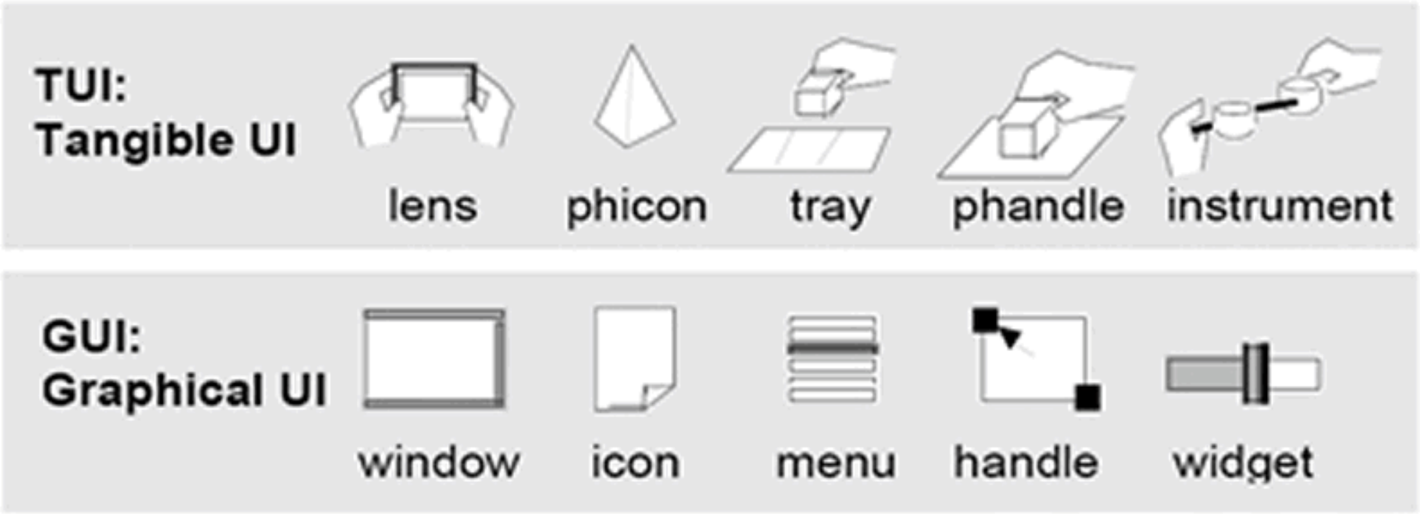
[6] Ishii & Ullmer, 1997, Tangible Bits

Physical instantiation of GUI elements in TUI[6]



metaDESK by Ishii and Ullmer[7]

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[6] Ishii & Ullmer, 1997, Tangible Bits

[7] YouTube

Four Themes in Tangible Interaction[10]

1. **Interaction with Tangible Representations** — Physical manipulation as direct interaction with data
2. **Embodied Facilitation** — Using space, gesture, and layout to scaffold activity
3. **Expressive Representation** — Tangibles as expressive or communicative artifacts
4. **Control, Feedback & Visibility** — Making system status and effects observable through physical change

[10] Shaer, O., & Hornecker, E. (2010). *Tangible User Interfaces: Past, Present, and Future Directions*. Foundations and Trends in Human–Computer Interaction, 3(1–2), 1–137.

Tangible ≠ Natural
“Tangibility is not inherently intuitive or effective.” — Shaer & Hornecker[10]

Tangible UIs often aim to be *natural*, but:

- Users may misinterpret mappings.
- Physical props require learning curves.
- Social context shapes interpretation.

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[10] Shaer, O., & Hornecker, E. (2010). *Tangible User Interfaces: Past, Present, and Future Directions*. Foundations and Trends in Human–Computer Interaction, 3(1–2), 1–137.

Thinking with the Body, Thinking in Space
Tangible interfaces support epistemic action, i.e., using the body to think.

Moving, grouping, and arranging objects helps users:

- Externalize cognition
- Offload memory
- Coordinate group work

The Tangible Interaction Framework (TIF)

Hornecker & Buur[12] offer a framework for describing and analyzing TUIs, including the components:

1. Physical artifacts — what users manipulate
2. Digital models — how the system interprets artifacts
3. Interactive surfaces — where interaction occurs
4. Coupling mechanisms — how physical & digital are linked

[12] Hornecker, E., & Buur, J. (2006). Getting a grip on tangible interaction: a framework on physical space and social interaction. CHI 2006.

Why Tangible Interaction Still Matters

Tangibility expands our expressive and social repertoire, by enabling:

» Physical collaboration[11]

» Spatial reasoning

» Embodied learning

Useful in education, scientific modeling, design tools

[11] Image: The Toy Insider

*Where is the research in **tangible computing**?*

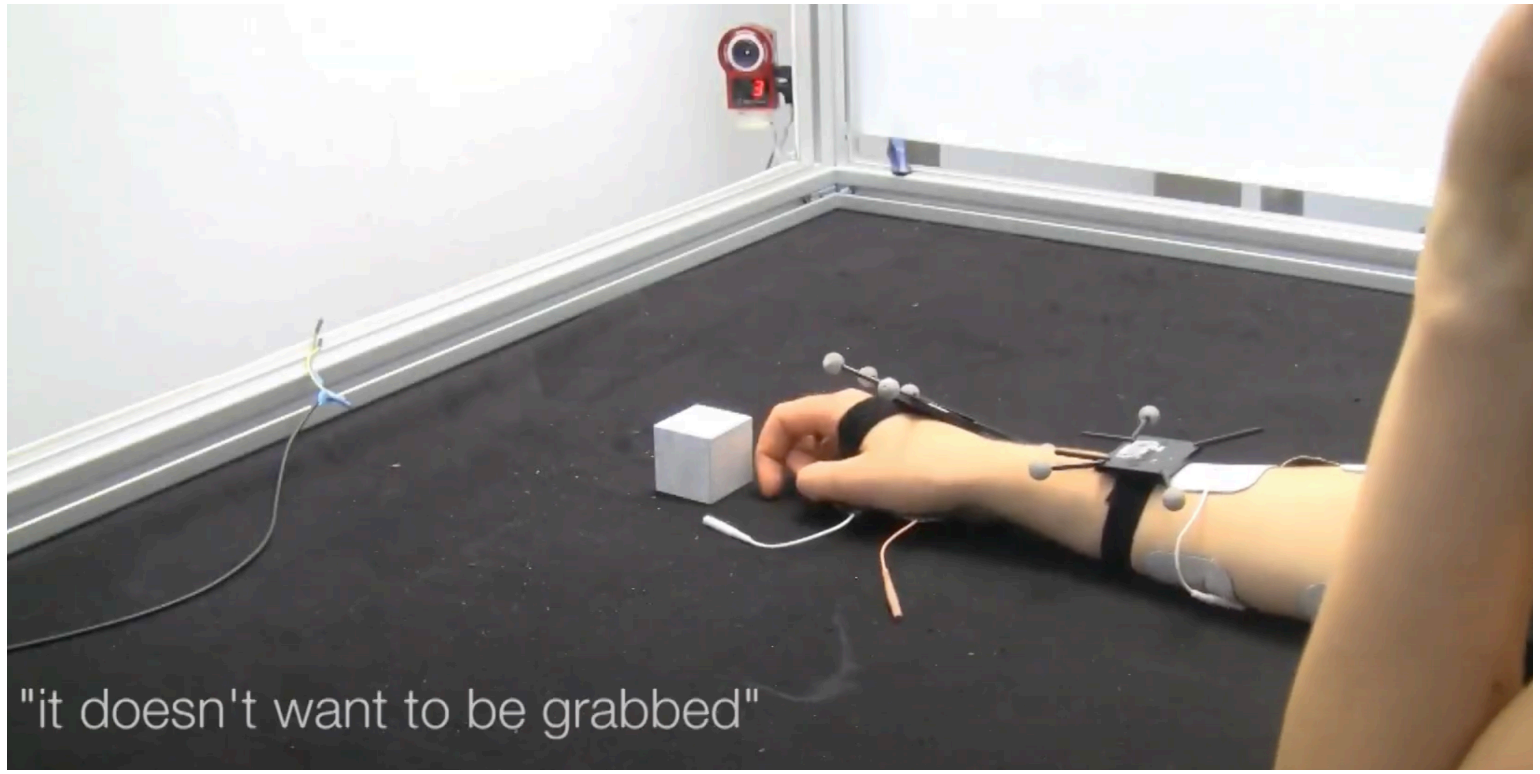
- **Example 1:** Affordance++, (Lopes et al., 2015)
- **Example 2:** Shape-shifting displays (Shape Lab)
- **Example 3:** Project Zanzibar (Microsoft Research)

Tangible Interaction = Embodied Virtuality?

» Weiser critiques virtual reality for replacing the real world; tangible interaction *augments* it.

» Tangible systems let people *manipulate digital information* via real-world objects.

» Tangible interaction embeds computation in physical space, aligns with Weiser's *embodied virtuality*.[10]



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[10] Shaer, O., & Hornecker, E. (2010). *Tangible User Interfaces: Past, Present, and Future Directions*. Foundations and Trends in Human–Computer Interaction, 3(1–2), 1–137.

Summary: Reframing UbiComp

Classic View	**Unremarkable View**
Invisible = Hidden	Invisible = Routine
Focus on artifacts	Focus on action sequences
Calm is a design goal	Calm is an *achievement* of practice
Embed tech in objects	Embed tech in everyday life

Discussion Format

- We'll let AI randomly pick 3-5 names
- In the selected order, students:
  - Present their provocation/critical artifact/policy or design recommendation (30 secs)
  - Lead class discussion (5-8 min)