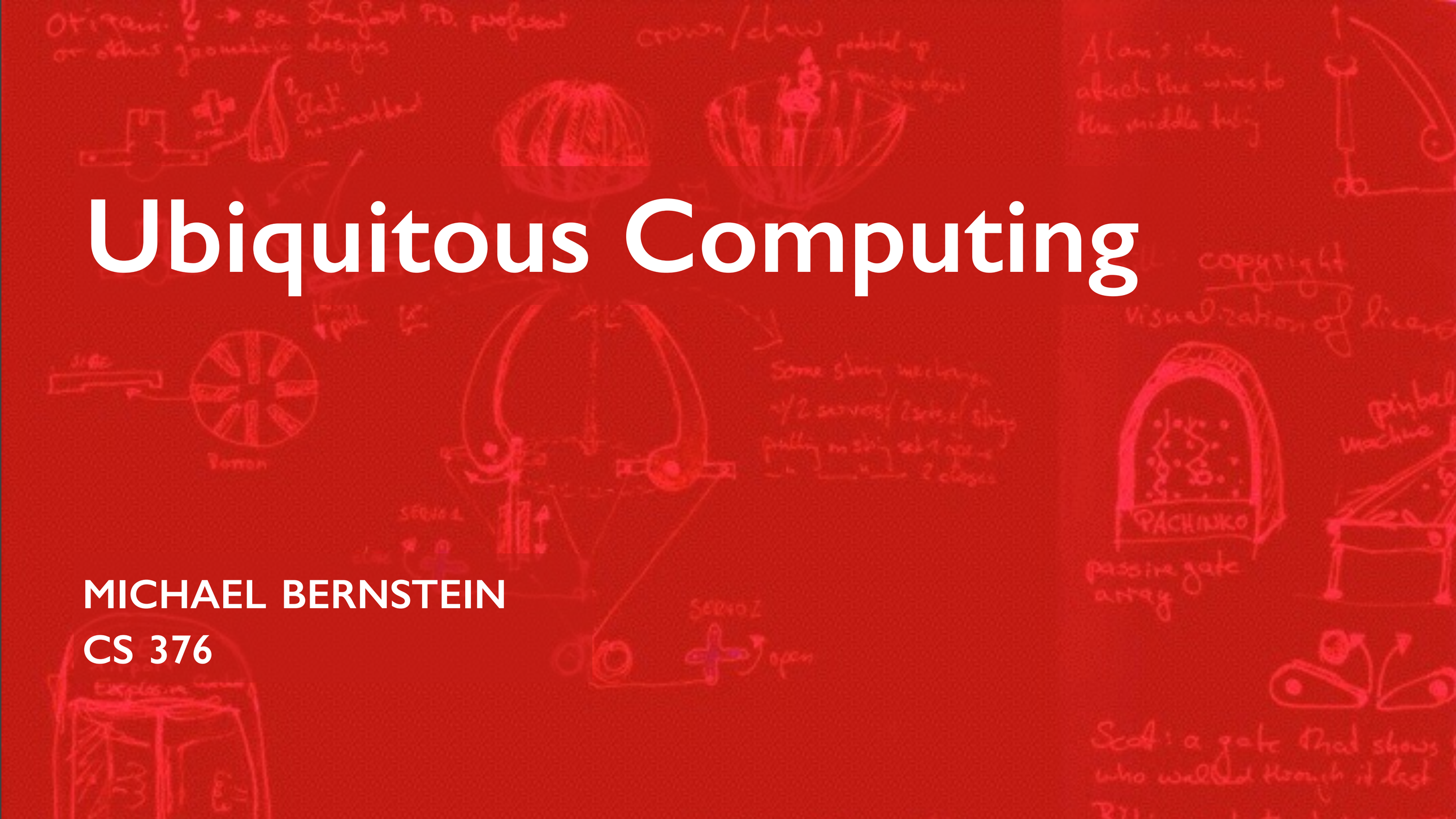
Ubiquitous Computing



MICHAEL BERNSTEIN

CS 376

Reminders

- First critiques were due this morning
- Idea Generation (Round One) due Friday
- Idea Generation (Round Two), with a team, due next Friday
- Next week:
  - Social computing
  - Design and creation

Ubiquitous?

Flickr: GARNET

Ubiquitous?

Flickr: GARNET

Ubicomp Vision

- ‘A new way of thinking about computers in the world, one that takes into account the natural human environment’ where computers will ‘vanish into the background’,
weaving ‘themselves into the fabric of everyday life until they are indistinguishable from it.’

Mark Weiser (late 80s/early 90s), quotes compiled by Daniel Fallman

Beyond Weiser

- Ubiquitous computing is a set of visions for distributing computation into the environment.
- These visions require interactive systems to become reactive, context-aware, ambient, and embedded in everyday activities.

Tangible Computing

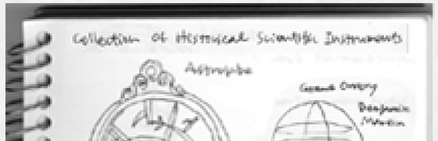
- Directly-manipulable physical interfaces to data and computation
- ‘Pure’ form of ubicomp in that there is no computer to be seen

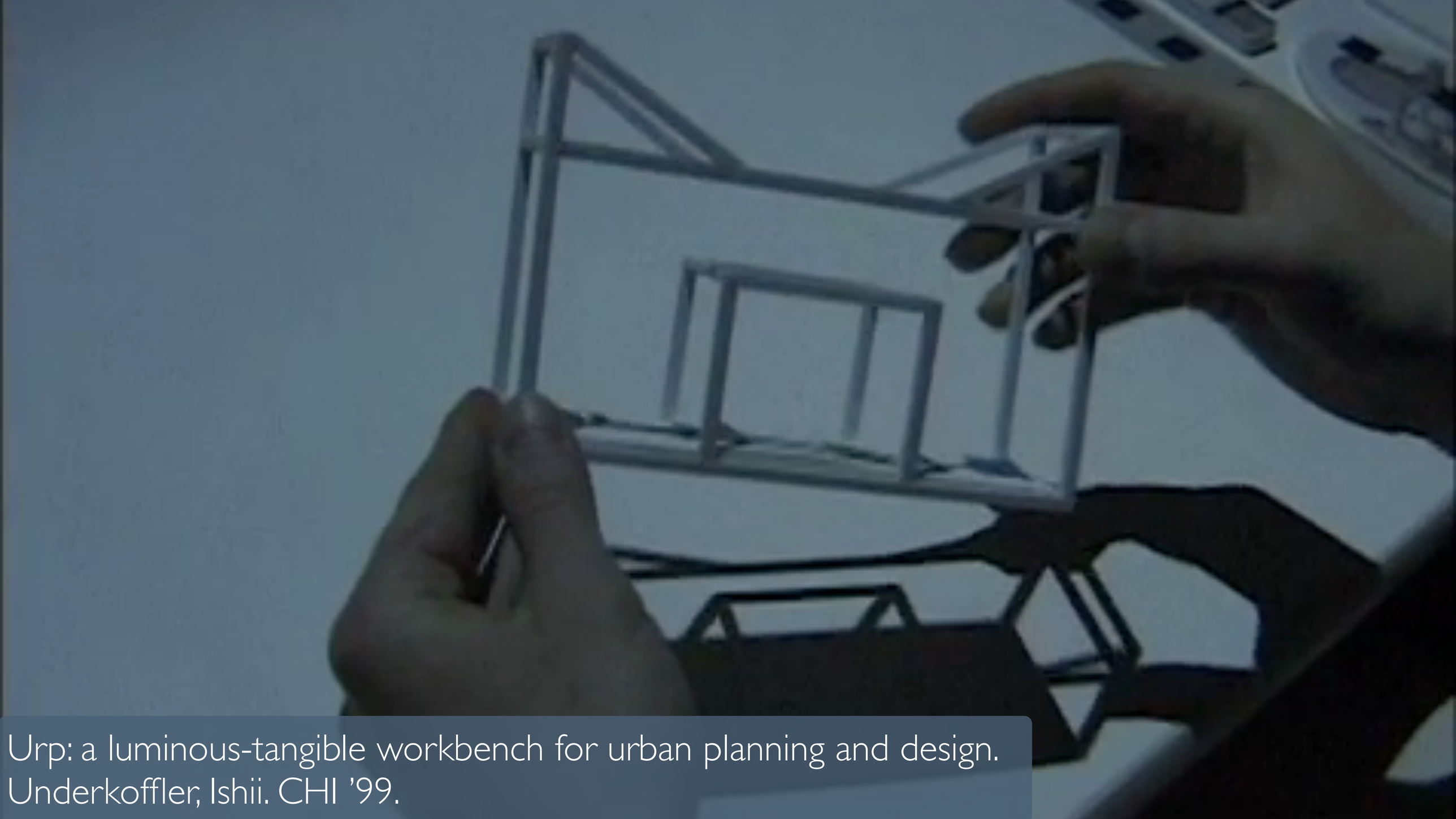
Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms

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 Interaction (HCI): "Tangible Bits." Tangible Bits allows

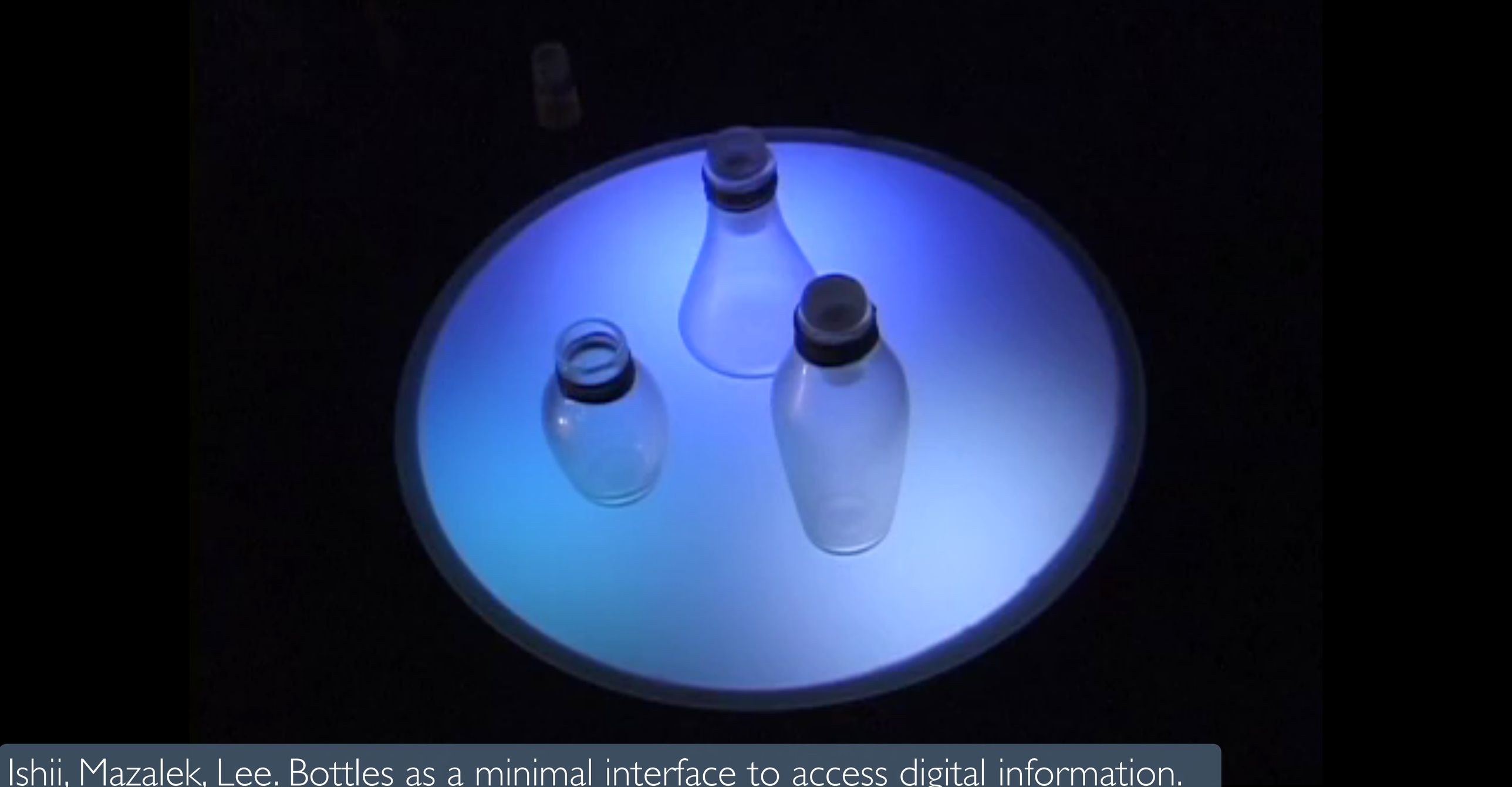
BITS & ATOMS
We live between two realms: our physical environment and





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.



Ishii, Mazalek, Lee. Bottles as a minimal interface to access digital information. CHI EA '01.

Ryokai, Marti, Ishii. I/O Brush: Drawing with Everyday Objects as Ink. CHI ’04.

Transforming data into physical form

- What Weiser calls one of the first calm technologies: Live Wire, a wire on a stepper motor, monitoring ethernet traffic
  [Jeremijenko ’95]

Themes of ubicomp research

- Activity sensing and monitoring
- Context-aware computing
- Input techniques

Activity recognition

- Sense the user's physical state by using minimally invasive sensors
- For example, wearing five 2d accelerometers and predicting tasks like walking, watching TV, reading, eating...

Activity Recognition from User-Annotated Acceleration Data

Ling Bao and Stephen S. Intille

Massachusetts Institute of Technology
1 Cambridge Center, 4FL

Activity recognition

- Detecting the user's state is powerful, but often involves invasive sensors.
- So, monitor the environment rather than the user: energy use, water use, activities of an aging population

Patel et al. At the Flick of a Switch: Detecting and Classifying Unique Electrical Events on the Residential Power Line. Ubicomp '07.

Environmental Sensors

- Monitor secondary signals in the environment: biosensors!

Nurturing Natural Sensors

Stacey Kuznetsov, William Odom, James Pierce, Eric Paulos
Human-Computer Interaction Institute
Carnegie Mellon University
Pittsburgh, PA, USA
{stace, wodom, jjpierce, paulos}@cs.cmu.edu

ABSTRACT
Sensing has played a significant role in the evolution of ubiquitous computing systems, enabling many of today's compelling interactive and ubiquitous experiences. In this paper, we argue for expanding the current landscape of sensing to include living organisms such as plants and animals, along with traditional tools and digital devices. We present a field study of ten individuals who routinely work with living organisms such as plants, fish, reptiles and bees, and rely on these organisms as well as analog instruments and digital sensors to infer environmental conditions and inform future actions. Our findings offer a new perspective

individuals who use *everyday biomarkers*- common biological organisms that express information about an ecosystem or its many parts. We present a field study of 10 participants who routinely work with living organisms such as plants, fish, reptiles or bees. While many people make inferences about the environment (*e.g.,* a cloudy sky suggests the possibility of rain), we expect our sample of participants to be more attuned to environmental processes as their work explicitly engages with living systems. Specifically, we focus on participants' use of digital devices, traditional tools and living organisms to infer environmental conditions and inform actions related to

Microsoft Research

SenseCam

Hodges, et al. SenseCam: A retrospective memory aid. Ubicomp '06.

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

Context-aware computing

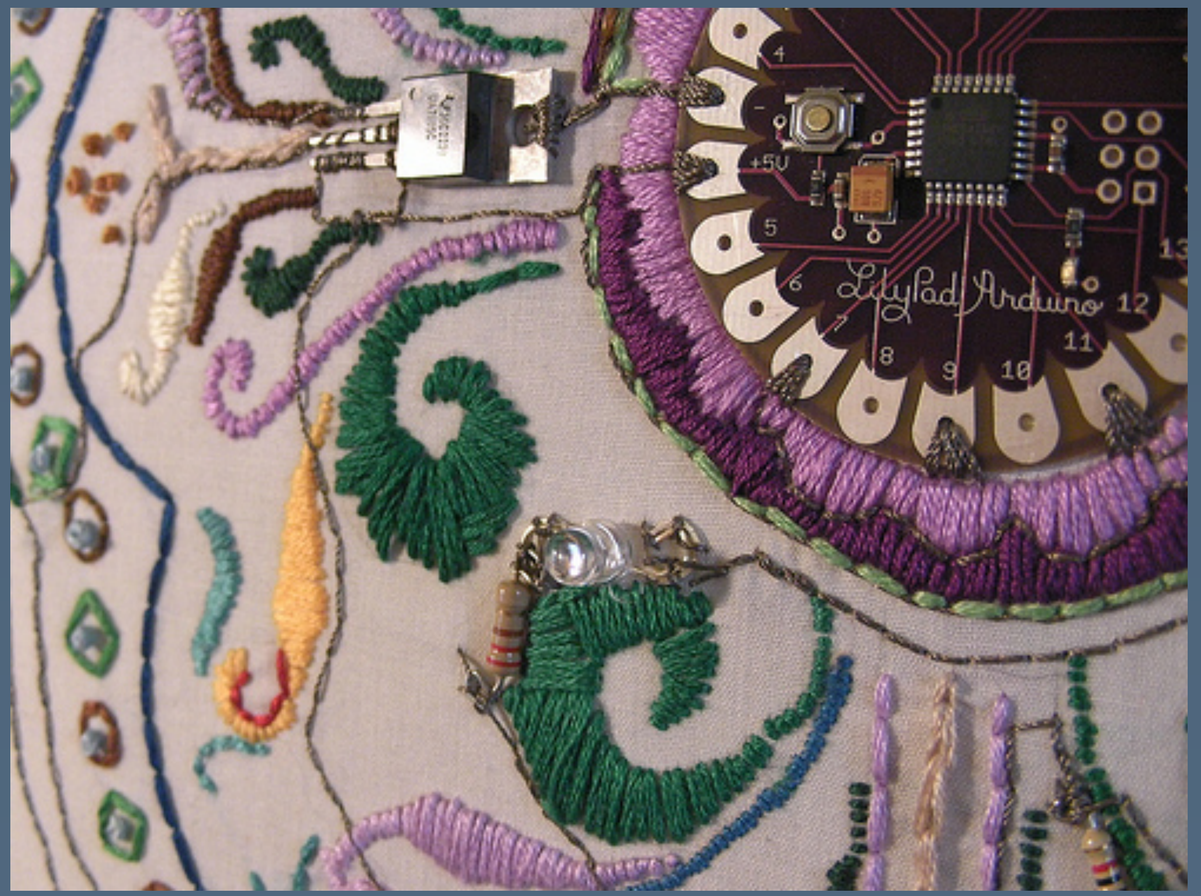
- Detection of context is typically the hardest problem
- Some successes:
  - **Localization using wifi access points**
    [LaMarca et al., Pervasive '05]
  - **Social networks using mobile phones**
    [Eagle and Pentland, Pers. Ubiq. Comp. '06]
  - **Google Now**

Wearable Computing

Steve Mann, MIT Media Lab

Wearable Computing

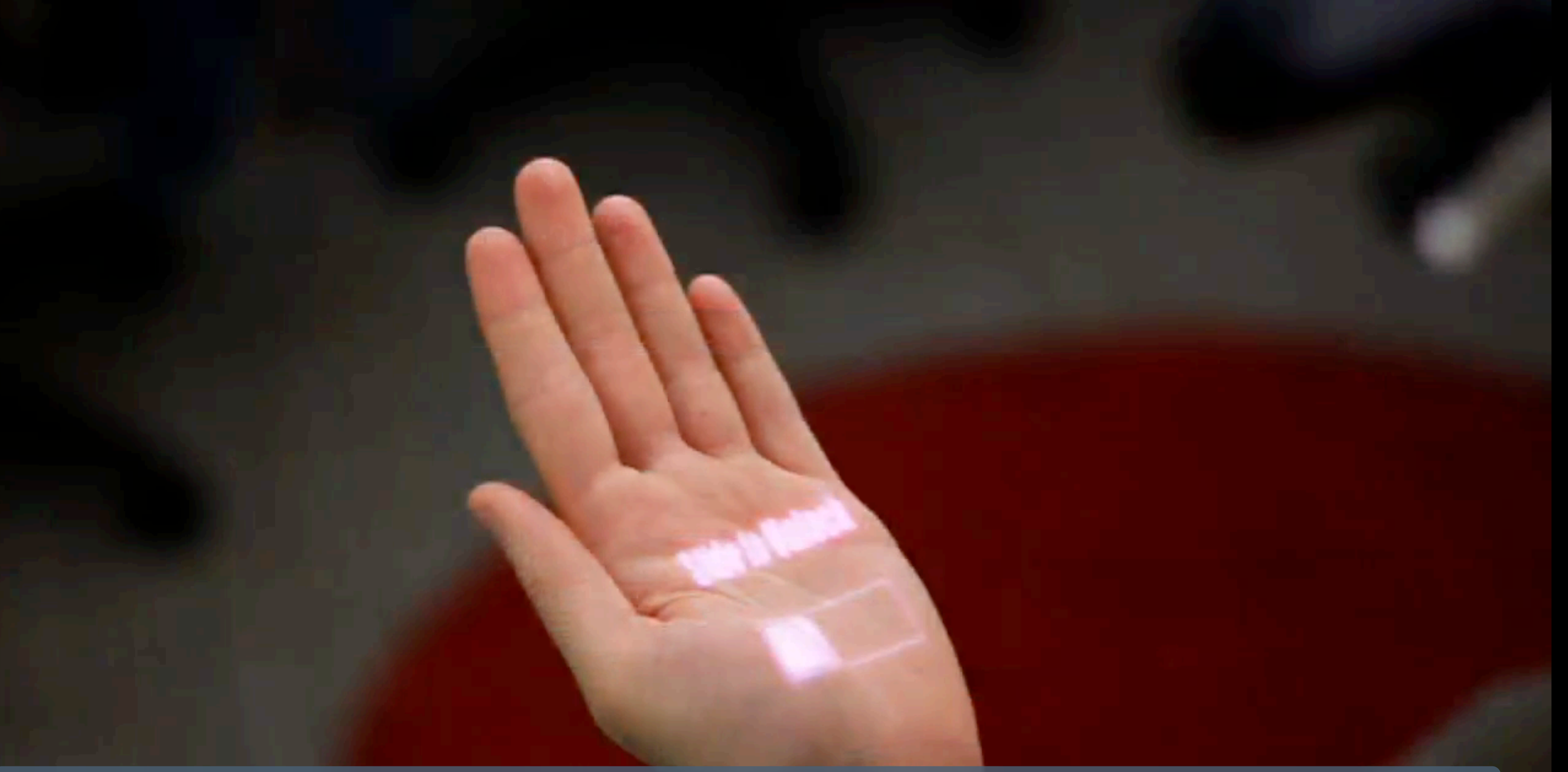
- **Lilypad Arduino**
  [Buechley et al., CHI '08]
- **And of course, Google Glass**



Input and interaction

- Effective control of ubiquitous computing systems without the traditional input channels
- Gesture, on-body, on-wall, on-floor: on any surface available

Harrison, Morris, Tan. Skinput: Appropriating the Body as an Input Surface. CHI '10.



Harrison, Benko, Wilson. Omnitouch: Wearable Multitouch Interaction Everywhere. UIST '11.

Yao et al.. PneUI: pneumatically actuated soft composite materials for shape changing interfaces. UIST ’13.

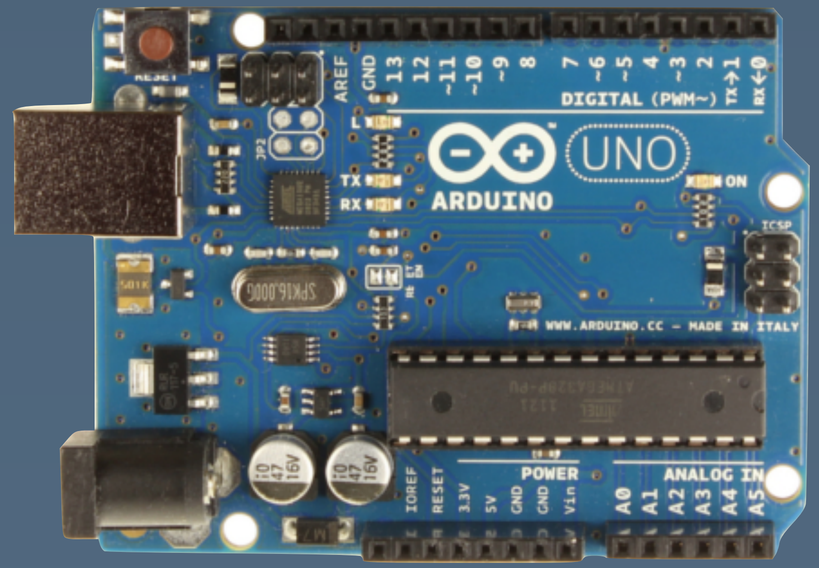
Follmer, Leithinger, Olwal, Hogge, Ishii. inFORM: Dynamic Physical Affordances and Constraints through Shape and Object Actuation. UIST '13.

What's difficult about ubiquitous computing research?

- Noisy inputs
- Sensor fusion
- Context is only a proxy for human intent [Dey, in Krumm 2009]
- Lack of standardization in interface patterns
- Privacy

What are open opportunities in ubiquitous computing research?

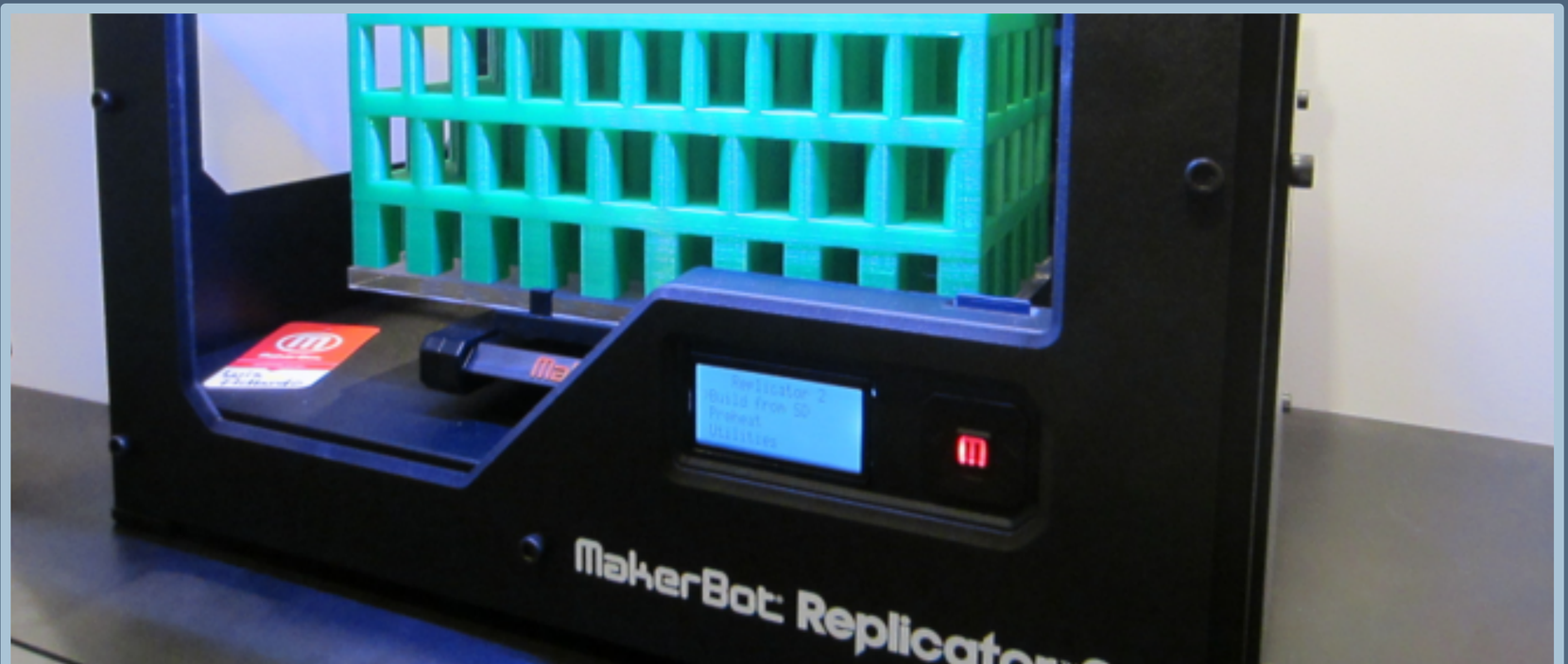
- The hardware is increasingly easy to find and to program



Arduino Uno

What are open opportunities in ubiquitous computing research?

- New I/O opportunities are coming out every year — from industry and from HCI researchers



Next ubicomp topics

- Pervasive
  - Infrastructure-mediated sensing and the humantenna
- Interaction
  - Muscle-computer interfaces and Skinput
- Global Citizenship
  - Avaaj Otalo: cell phone-based information networks
- Design tools
  - Midas: fabricating custom capacitive touch sensors to prototype interactive objects
- Intelligent User Interfaces
  - Predicting human interruptability with sensors