Ubiquitous computing
Announcements

Extra session: methods and stats
Led by Danaë today at 5 PM

If you don’t know

- how to do a t-test, one-way and two-way ANOVA, or chi square,
- how to write up the results and effect size for a paper,

join!
Announcements

Project abstract drafts due next Wednesday

Project Ideas feedback to come

You can iterate, pivot and ideate based on our feedback

Don’t feel compelled to go exactly with the ones we liked
Recall…

Mark Weiser’s ubiquitous computing vision: computing that fades into our attentional background.

Computing distributed through the environment at several scales: pads, tabs and boards.
Themes of ubicomp research

UI Technology was focused on end-user interactions, both software and hardware.

Ubicomp is focused more broadly on human activities, behaviors, and lives.

- Activity: How do we sense what people are doing?
- Context: In what environment are they doing it?
- Behavior: Health, wellness, elder care, mental health
- Theory: What is ubicomp, really? And why?

How do we do it? Why do we do it?
Activity sensing
Goal: what are you doing?

Visions of ubiquitous computing require an understanding of what the user is doing at a given point

Are they talking?
Are they exercising?
Are they sleeping?

Pioneering techniques from ubicomp are now seen in your Apple Watch, Fitbit, phone, and others
Foundational work

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
Infrastructure-mediated sensing

Rather than sensing the human, place sensors at critical points in the environment.

Resolves the tension of sensing quality vs. invasive per-human or per-room sensors.
Recall...

Sensing via HVAC

Whole-home gesture recognition

What applications can you imagine?

What challenges?
Acoustic activity sensing

A

B

C

D

“what was that sound?”

“that’s the microwave”
Context awareness
Context-aware computing

[Dey and Abowd 1999]

Apply information about the user’s situation and task to provide relevant information and services to the user.

- Finding restaurants or conference rooms near your current location
- Highlighting information that you might find useful for the current task
- Silencing your phone automatically when you’re in class

Some types of context: location, identity, time, activity

But beware overuse of the term ‘context’!
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
Sensing location using wireless signals [LaMarca et al. 2005]

Overcomes major hurdle in location-aware devices: location

GPS has mainly solved this outdoors, but wifi works indoors as well!

Spotters log visible signals to a shared DB (e.g., bluetooth, wifi, cell towers)

Trackers model location using the traces
Context-aware computing

If you’ve solved that, then: what is the relevant context to surface?

Location?
Music you’re listening to?
Email you looked at?
Friend nearby?
Behavior and society

How
Activity
Context
Behavior
Theory

Why
Health and wellness

Sleep tracking
[Bauer et al., CHI ’12]

Embedded assessment
[Morris, Intille, and Beaudin, Pervasive ’05]

“Our early studies indicated that to be tolerable to end users, assessment needed to be embedded not only with the environments of daily living, but also within accepted compensatory and preventive health strategies.”
Health and wellness

Ubifit: activity inference to produce an ambient display rewarding regular exercise [Consolvo et al. 2008]

The first system to show that these kinds of interventions could work with commodity sensors and readily-available glanceable interfaces over long periods.
Health and wellness

Can we detect opioid overdose — breathing cessation — with commodity smartphones? [Nandakumar 2019]

Use the phone as a sonar system: emit an inaudible frequency sweep (FMCW): red line. It bounces off the person and returns to the phone’s mic: blue line.
Health and wellness

Can we monitor blood pressure using commodity smartphones? [Wang et al. 2018]

Yes: measure the time between the heart pumping...

via phone accelerometer

...And the blood moving in an artery in your finger

via phone camera with flashlight on
Sustainable behavior

UbiGreen: semi-automatically record transit activity and make it visible on the user’s home screen [Froehlich et al. 2009]
Neurodiversity

Record and track care for people with autism and other conditions [Kientz et al. 2007]

Data capture is often difficult: so, lower the bar to capture!
Elder care  [Stanford 2002]

Noninvasive sensors can identify when seniors need assistance
Relieve caregivers from manual recordkeeping
Sensors: locator badge, weight sensors in apartments
Wearable Computing

[Mann 1997]

Tighter integration of tech and our bodies
Wearable Computing

Lilypad Arduino: integrate electronics into textiles
[Buechley et al., CHI ’08]

Buechley’s critique: why must electronics be any different than other forms of textile creation?

Current instantiations are still too tech-first rather than garment-first: Apple Watch, FitBit…
Theory

How
Activity
Context
Behavior

Why

Theory
Implications and theory of ubicomp

**Embodiment** as a core theme of tangible computing

Phenomenology as a guide for design: acting through our tools and infrastructure without reflection

- e.g., Heidegger
Space and place [Harrison and Dourish 2006]

Space is the structure of the world: the 3D environment, relative position and direction

Place is the understood reality, invested with understanding and meaning

Ex: hotel ballroom for a wedding vs. an academic conference
What we talk about when we talk about context

[Dourish 2004]

Ubicomp typically considers context via a positivist viewpoint, which aims to reduce complex phenomena to simple, stable patterns Amenable to engineering!

A phenomenological viewpoint would posit that context is emergent and evolving, not stable

Sitting in a classroom is relevant, but temperature is not, because it is just ordinary
Yesterday’s tomorrows
[Dourish and Bell 2006]

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?

Bell and Dourish's proposal: messiness
See you next week :) 

Action items

**Stats session**: today at 5 PM

**Project abstract**: due next Wednesday

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