Technology and sustainability: Sustainable HCI

People-Oriented Computing
2.12.2019

Agenda

- Announcements
- Introduction to sustainability and computing
- Sustainability in design
    - Approaches to designing technologies sustainably
- Sustainability through design
    - Approaches to addressing sustainable practices and lifestyles with technology

Announcements

- Lab on 5.12, exercise is posted on OLAT
- Course evaluation is ongoing - please fill it out if you have not already!
    - We will provide another informal survey in the last lecture for any additional feedback

Learning Objectives for this Lecture

- Basic understanding of the major environmental impacts of ubiquitous computing
- Clear understanding of the distinction between sustainability in design and sustainability through design
- Basic understanding of approaches to sustainable design and the fundamental concepts they embody
- Knowledge of technology approaches to supporting sustainable behaviors and practices
- Exposure to examples of various technology approaches to supporting sustainable behaviors and practices

Environmental Sustainability

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs

- UN World Commission on Environment and Development (1987)

Two negative effects of ubiquitous computing

- Energy/resource consumption
- Electronic waste

Technological Efficiency != Sustainability

- William S. Jevons published *The Coal Question* (1865)
- Argued that technological advances in coal use efficiency would not lead to an overall reduction in demand for coal, but instead to an increase
- Phenomenon has been repeated
  - E.g., when fuel is more available/efficient, people drive more
- Known as “Jevons Paradox” or “rebound effect”

Smart Vending Machine Example

- Entrepreneur proposed a business idea to put soft drink vending machines in small offices where few people worked
- Idea was viable because the proposed vending machines were very energy efficient
  - Efficient temperature forecasting and maintenance
  - Motion detectors for machine lighting
  - Intelligence to learn customer habits

Jevons Paradox and Technology

"Technological improvements increase the efficiency with which a resource is used; total consumption of that resource may increase rather than decrease." (Tainter, 2009)

Smart Vending Machine Example

- Decreased energy use made the machines more profitable
- Machines could be profitable in small offices with few customers
- Total power consumption of the “smart” vending machines exceeded power consumed by older, less efficient machines

E-waste

- E-waste – trash produced by the disposal of electronic devies
- Average number of consumer electronics per household (U.S.) grew from 2.8 (1980) to 25 (2010) and continues to grow
- Electronic waste production grew from 20 million tons (2005) to 42 million tons (2014)
- Growth continues despite regulation and take-back programs
- **Switzerland has the #2 highest rate of electronics disposal per capita (2015)**

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Obsolescence and Planned Obsolescence

- Rapid advancements in technology leads to technology obsolescence and frequent replacement of devices
- **Planned obsolescence** – the intentional design or engineering of technologies to become obsolete
  - E.g., software designed only to run on new devices
  - E.g., circuits designed to lose performance over time

What Happens to E-waste?

- Recommended video: Watchdog Group Tracks What Really Happens to Your Recycled Waste
- Recommended video: *The Digital Dump: Exporting Re-use and Abuse to Africa*
- Recommended video*: Exporting Harm: The High Tech Trashing of Asia*

Energy consumption and e-waste

- Complex problems without easy solutions
- No one party is responsible
    - Policy makers
    - Manufacturers
    - Consumers
    - Engineers
    - Designers
    - Governments
    - Etc.
- Why is this an important problem for computer science?

Energy Consumption and E-waste

- Advances in computer science have contributed greatly to these problems
- A very real impact of computing on society
    - Political, environmental, health, social, technological implications
- Computer science and related fields need to consider how to contribute to solutions

Design and Engineering

- Engineering technologies for efficiency alone is not enough to achieve sustainability
- Need to consider design, and how people interact with technologies
- How can design lead to more sustainable technology use?
- How can technologies themselves promote sustainable behaviors and practices?

Sustainable HCI

- Recent field of research in computing (since ~2007)
- Considers the relationship between humans and technology in the context of sustainability

Sustainable HCI

Two high level approaches:

Sustainability in design

Asks how technologies can be designed so that ***their use is sustainable***

Sustainability through design

Asks how technology can ***support sustainable behaviors*** or lifestyles

SUSTAINABILITY IN DESIGN

Sustainable Interaction Design

- Proposed by Eli Blevis (2007)
- The perspective that sustainability can and should be a first-class focus of design, like robustness, usability, etc.
- Blevis defines design as “an act of choosing among or informing choices of future ways of being”

Blevis's Rubric

- Rubric for understanding and assessing the sustainability of particular instances of design in terms of use, reuse, and disposal
- Approximately ordered from greatest to least negative impact

Blevis's Rubric

1. Disposal
2. Salvage
3. Recycling
4. Remanufacturing for reuse
5. Reuse as is
6. Achieving longevity of use
7. Sharing for maximal use
8. Achieving heirloom status
9. Finding wholesome alternatives to use
10. Active repair of misuse

1. Disposal

Does the design cause **the disposal of physical material**, directly or indirectly and even if the primary material of the design is digital material?

1. Disposal

- Does the design cause the disposal of physical material, directly or indirectly and even if the primary material of the design is digital material?
- Examples: Any single use technologies (cameras, phones), almost all devices eventually, printing software that has default cover pages

2. Salvage

Does the design enable **the recovery of previously discarded physical material**, directly or indirectly and even if the primary material of the design is digital material?

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- Does the design enable the recovery of previously discarded physical material, directly or indirectly and even if the primary material of the design is digital material?
- E.g., Technologies that run on waste oil, printers that can accept used paper

3. Recycling

Does the design make use of recycled physical materials or provide for the future recycling of physical materials, directly or indirectly and even if the primary material of the design is digital material?

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- Does the design make use of recycled physical materials or provide for the future recycling of physical materials, directly or indirectly and even if the primary material of the design is digital material?
- E.g., Devices made of recycled or recyclable plastics, devices designed to be easily separated into component materials

4. Remanufacturing for Reuse

Does the design provide for the renewal of physical material for reuse or updated use, directly or indirectly and even if the primary material of the design is digital material?

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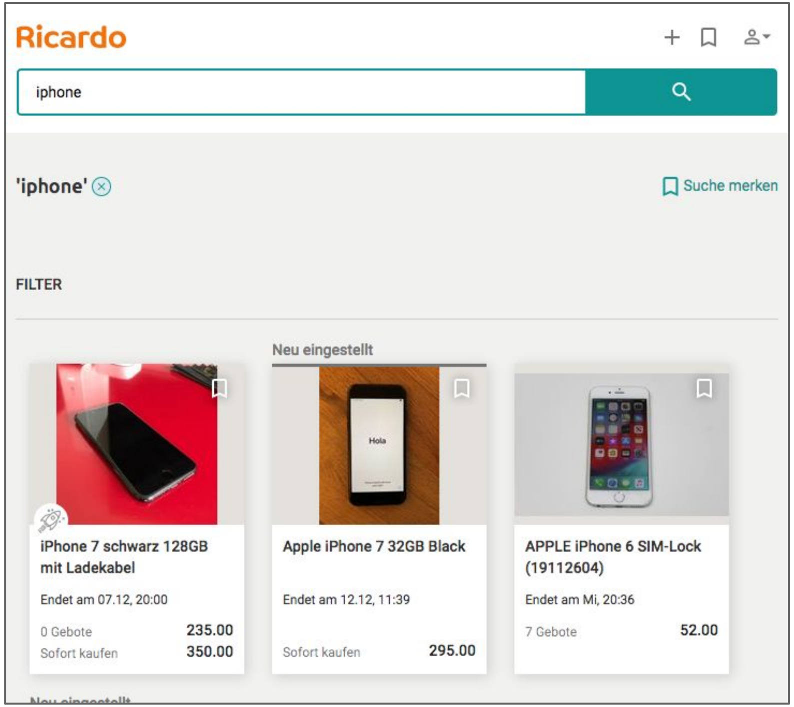
- Does the design provide for the renewal of physical material for reuse or updated use, directly or indirectly and even if the primary material of the design is digital material?
- Phones with replaceable exteriors, software upgrades to update older devices

5. Reuse as is

Does the design provide for the transfer of ownership, directly or indirectly and even if the primary material of the design is digital material?



5. Reuse as is

- Does the design provide for the transfer of ownership, directly or indirectly and even if the primary material of the design is digital material?
- E.g., Devices that are easy to wipe of old data and allow for “new user” configuration experience, websites for people to sell or give away used items

6. Achieving Longevity of Use

Does the design allow for long term use of physical materials by a single owner without transfer of ownership, directly or indirectly and even if the primary material of the design is digital material?

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- Does the design allow for long term use of physical materials by a single owner without transfer of ownership, directly or indirectly and even if the primary material of the design is digital material?
- E.g., Physically robust e-book reader that allows for regular upgrading of software and content

7. Sharing for Maximal Use

Does the design allow for use of physical materials by many people as a construct of dynamic ownership, directly or indirectly and even if the primary material of the design is digital material?

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- Does the design allow for use of physical materials by many people as a construct of dynamic ownership, directly or indirectly and even if the primary material of the design is digital material?
- E.g., car-sharing, bike sharing, or ride sharing websites and apps, shared payment devices in stores

8. Achieving Heirloom Status

Does the design create artifice of long-lived appeal that motivates preservation such that transfer of ownership preserves quality of experience, directly or indirectly and even if the primary material of the design is digital material?

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- Does the design create artifice of long-lived appeal that motivates preservation such that transfer of ownership preserves quality of experience, directly or indirectly and even if the primary material of the design is digital material?
- E.g., vintage game consoles, collector websites for rare electronics

9. Finding Wholesome Alternatives to Use

- Does the design eliminate the need for use of physical resources, while still preserving or even ameliorating qualities of life in a manner that is sensitive to and scaffolds human motivations and desires?

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- Does the design eliminate the need for use of physical resources, while still preserving or even ameliorating qualities of life in a manner that is sensitive to and scaffolds human motivations and desires?
- E.g., activity tracking apps on phones that reduce the need for separate tracking devices, digital readers that alleviate the need for paper

10. Active Repair of Misuse

- Is the design specifically targeted at repairing the harmful effects of unsustainable use, substituting sustainable use in its place?

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- Is the design specifically targeted at repairing the harmful effects of unsustainable use, substituting sustainable use in its place?
- E.g., apps that encourage and reward walking instead of driving, devices that generate and harness kinetic energy from everyday activities

Blevis's Principles for Design

- Linking invention and disposal
- Promoting renewal and reuse
- Promoting quality and equality
- De-coupling ownership and identity
- Using natural models and reflection

Linking Invention and Disposal

"Any design of new objects or systems with embedded materials of information technologies is incomplete without a corresponding account of what will become of the objects or systems that are displaced or obsoleted by such inventions."

Linking Invention and Disposal

- When designing a product or technology, it is as important to design what happens after it is out of use as it is to design how it will be used
- Why is this a concern for designers of digital content?
  - Software drives physical aspects, e.g. demand for new hardware, premature disposal of physical materials
  - New hardware prompts the invention of new software

Linking Invention and Disposal

- Take-back and recycling programs are insufficient given the rate of consumption
- What alternatives can be designed that change the way we use and discard things?
  - Incentives for shared use
  - Modularity or upgrade-ability
  - Construction from enduring materials

Promoting Renewal and Reuse

"The design of objects or systems with embedded materials of information technologies implies the need to first and foremost consider the possibilities for renewal and reuse of existing objects or systems from the perspective of sustainability."

Promoting Renewal and Reuse

- How can digital material (i.e. software) promote renewal and reuse?
- The use of software to upgrade and renew older devices
    - E.g. upgrading maps and directions on an older GPS device
    - Upgrading an older vehicle through the addition of a GPS device

Promoting Renewal and Reuse

- The use of technologies to promote renewal and reuse
  - E.g. freecycle.org – community based services that promote exchange and distribution of unwanted items
  - Websites for refurbishing and reselling computer equipment

Promoting Quality and Equality

- Looking at what can motivate people to reuse as is, achieve longevity of use, share for maximal use, and achieve heirloom status for objects

De-coupling Ownership and Identity

- Concerns issues of fashion, security and privacy, and sense of self in the construct of identity
  - These motivate relationship to objects of consumption
  - Hinder possibilities for sharing for maximal use

Using Natural Models and Reflection

- Promoting imitation of use of resources in nature and the design method for doing so
  - Connected to achieving longevity of use, sharing for maximal use, achieving heirloom status, finding wholesome alternatives to use, and active repair of misuse

Cradle to Cradle Design

- Proposed by McDonough and Braungart
- An alternate perspective on how things should be designed
- A counterargument to “doing less harm,” using fewer resources, or making do with less
- Argues against the tenets of “reduce, reuse, recycle and regulate”
- Argues against “cradle to grave” design

Cradle to Cradle Design

Considers the “cherry tree” metaphor

- Tree produces thousands of blossoms with the “goal” that one pit might grow a new tree
- Fruit nourishes birds, people, other animals
- Fallen blossoms decompose and re-nourish the soil
- “waste” equals “food”
- “eco-effective” vs. “eco-efficient”

Cradle to Cradle Design

- Conceives of design in terms of “nutrient flows” – all materials are nutrients that should go back into the system
- Two closed loop “metabolisms”
  - **Biological metabolism** – for biological nutrients; components that can biodegrade or be safely thrown away to be consumed again
  - **Technical metabolism** – for technical materials that can be reused in the same form (e.g., metals and high-quality plastics
- Avoidance of “monstrous hybrid” materials that prevent return of nutrients into the metabolisms

Cradle to Cradle Example

- Swiss textile company wanted new fabric for wheelchair seats
- Needed to be comfortable and colorfast, needed to avoid hazardous waste from incinerated scraps in factory
- Cradle to cradle designers eliminated chemicals, dyes, and materials that did not meet C2C standards
- Resulting product was more economical for the company
- Regulators could not detect any pollutants from manufacture – water leaving the factory was cleaner than water coming in

Cradle to Cradle Design

- Complicated to apply to technology design but promising
- Echoes Blevis's rubric about use of natural models and active repair of misuse

SUSTAINABILITY THROUGH DESIGN

Sustainable HCI

Two high level approaches:

Sustainability in design

Asks how technologies can be designed so that ***their use is sustainable***

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Sustainable HCI Technology Genres

- Ambient awareness
- Persuasive technology
- Pervasive and participatory sensing

Eco-Feedback Technologies

- A major area of technology development for promoting sustainable actions
- Technologies that present feedback about individual or group behavior with the intention of reducing environmental impact

Ambient Awareness

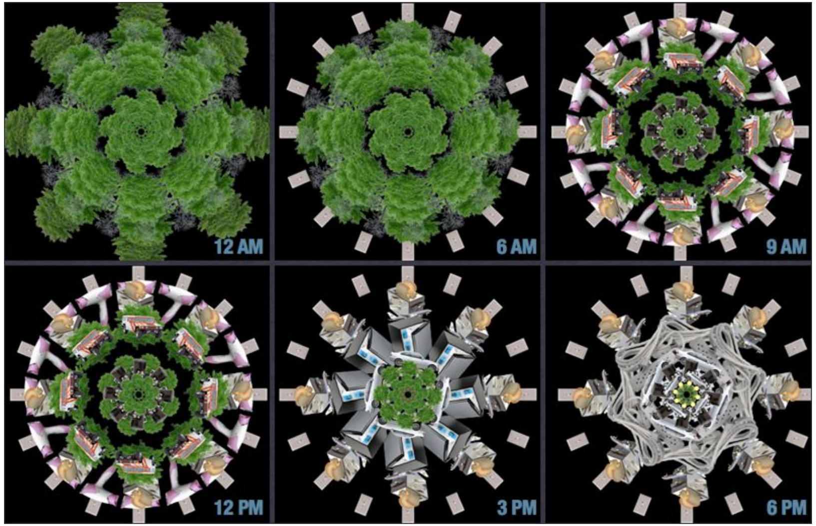
- Makes use of “calm computing” approaches
  - Technologies intended to reside in the background of your attention
- Intended to create awareness of the environment or behaviors
- Can make use of
  - Devices and physical artifacts
  - Visualizations
  - Instrumented environments
  - Intelligent agents

Power Aware Cord

- Reflects energy use of objects and appliances
- Intended to inform and provide information without requiring attention or interaction
- Changes based on current energy consumption

7000 Oaks and Counting

- Artistic piece by Tiffany Holmes
- Dynamic display of visualizations reflecting energy consumption in office building over time



Persuasive Technologies

- The predominant genre of sustainable HCI technologies
- Systems that attempt to convince users to behave more sustainably
- Vary in terms of whether the persuasion is passive or active
- Vary in terms of whether the user is intended to be conscious of the persuasion or not

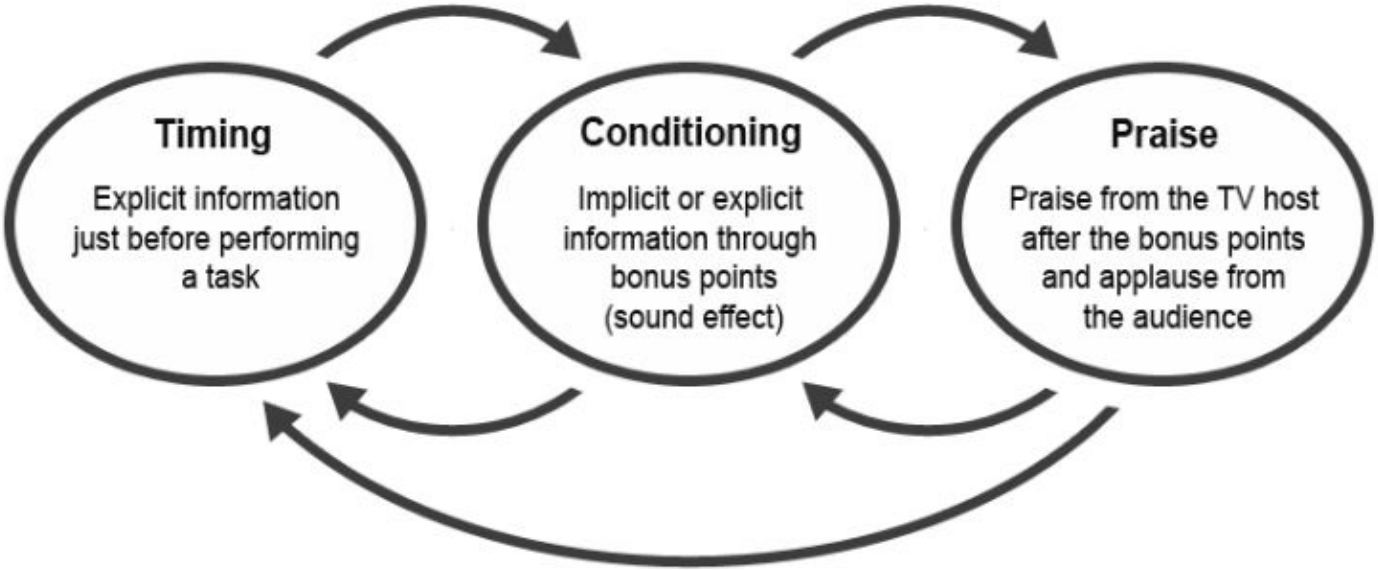
The PowerHouse

- Interactive game intended to teach teenagers about how to be more energy efficient in the home
- Intended to engage them and get them to think explicitly about saving energy
- Provides persuasion through suggestions, points, and praise
- Goal is to persuade teens to change their behavior in the real world through interaction with the virtual world


17:45
0436
Tony

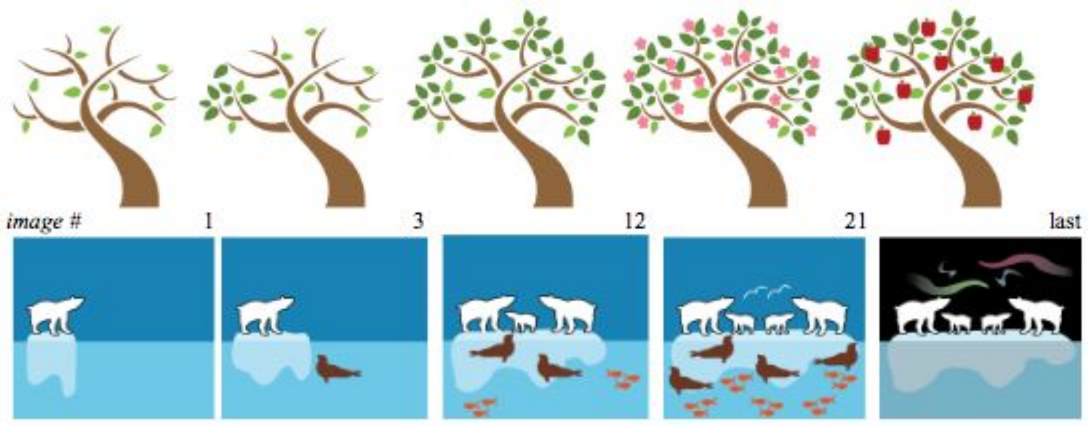

17:45
0436
Have you noticed the basket?
You can save up five times the energy if you put your lanudry here and run the machine when it´s full
Mathias

PowerHouse Persuasive Strategy



UbiGreen

- Tracked actual transportation practices using sensors on phone
- Update a visualization on phone to reward green transportation choices



UbiGreen


7:27 PM
T-Mobile
03/31/08
Start
Contacts
12:15 PM
11/05/08
Start
Contacts

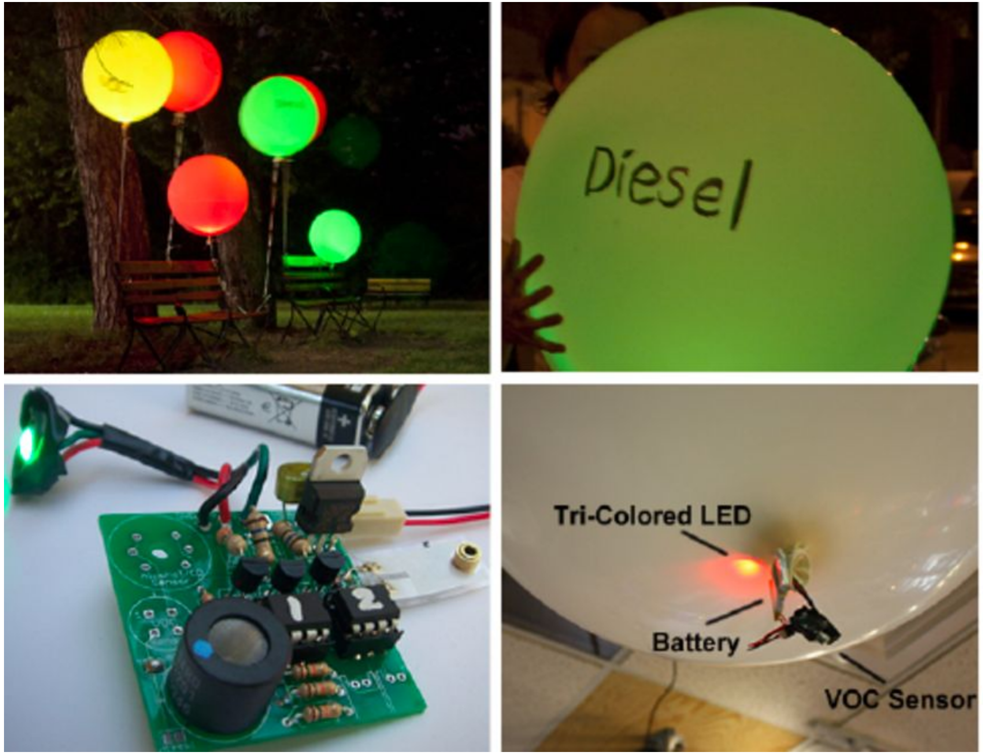
UpStream

- Displays affixed to home water taps to display a variety of feedback about water consumption
- Compared individual water use with household water use
- Had motivating effect on people to decrease water consumption

Pervasive and Participatory Sensing

- Sensors are increasingly being used to monitor and report on environmental conditions (e.g. air quality displays on highways)
- Participatory sensing involves non-experts in the collection of data
  - Also known as “citizen science”
- Intended to help collectively create a rich set of data
- Also intended to empower and inform non-experts

Spectacle Computing



Spectacle Computing

- Workshops teach citizens of a community to assemble sensor-augmented balloons to collect data about air pollutants
- Citizens deploy balloons in public places to monitor air quality and inform the public
- Balloons invite curiosity and engagement

Focus on Consumer vs. Focus on Designer

- Affecting consumer or end-user behavior is limited in impact
- Consumers may be motivated to change practices but technologies need to allow for more sustainable behaviors
- Currently ongoing work on how to motivate and support designers in incorporating sustainability into technology systems and products

Sustainability and Profitability

- Value of durable goods
- Shift from physical objects to services, software, content
- Reclaiming materials can save money

Sustainability is an Ongoing Problem

- Technologies and approaches presented are all problematic and unlikely to yield complete solutions
- Many proposed solutions potentially create new problems
- Problems of environmental sustainability, and negative environmental effects of ubiquitous computing cannot be solved by informatics alone
- Solutions are difficult to test and evaluate

Pervasive Healthcare (cont.)

Technology Approaches for Pervasive Health

Preventative Care	Hospital Care	Chronic Care

- Automated and selective capture and access of health information
- Persuasive technologies for self-monitoring
- Social health

Technology Approaches for Pervasive Health

Preventative Care | Hospital Care | Chronic Care

- Context-Aware Services and Awareness
- Pervasive Groupware and Collaboration Support
- Record-keeping and Note Taking
- Handling Multiple Activities and Supporting Rapid Context Switching

Technology Approaches for Pervasive Health

Preventative Care | Hospital Care | Chronic Care

- Pervasive Monitoring
- Social Connectedness and Communication Support
- Assisted Navigation and Wayfinding Support
- Prompting and Reminders

SUCCESS AND CHALLENGES FOR PERVASIVE HEALTHCARE

How to Assess Success?

- Improved health metrics
- Improved quality of life
- Less time in hospital
- Fewer readmissions to hospital
- More/better information for clinicians
- Better understanding of own health
- More independence
- Low burden
- Greater efficiency
- Lowered need for treatment
- Etc.

Ongoing Challenges for Pervasive Health

- Privacy of sensitive health information
- Reliability of sensor-based technologies
- Overhead of introducing new systems and reluctance to move from analog to digital technologies
- Difficulties of testing and evaluating the effects of technologies on health and wellness

Development and Evalution

- Many approaches from CSCW and UbiComp are appropriate
  - Participatory Design
  - Contextual Inquiry
  - Distributed Cognition
  - Activity Theory
  - Cultural Probes
  - Etc.
- ... but concrete measures of effectiveness remain a challenge

Evaluation of Health Technologies

- Difficult to measure behavior change
- Difficult to measure effects of social factors
- Ethical challenges of deploying experimental technologies that affect health
- Long-term empirical studies with measurable results are challenging to deploy
    - Legal and safety compliance
    - Cooperation of health organizations

Next week

- Mini lecture on ethic and computing
- Course survey follow-up
- Topic review for exam