Multimodal User Interfaces 2019

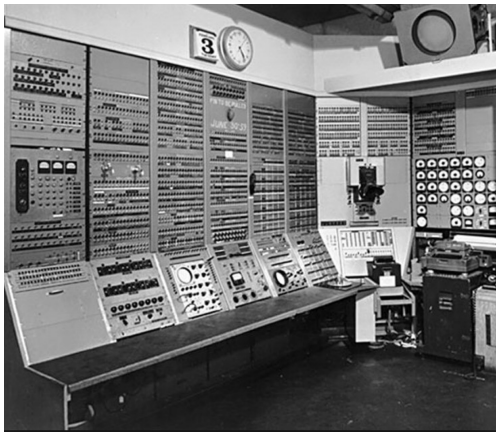
[5] Ubiquitous and Wearable Computing

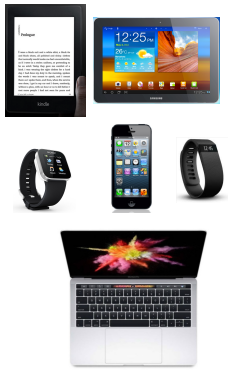
Agnes Lisowska Masson
(with slides from Denis Lalanne)

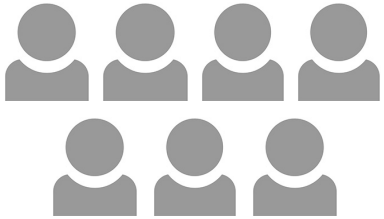
19.03.2019

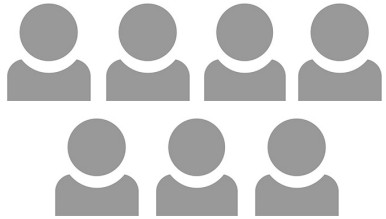
Paradigm shift

MMI2019
UbiComp &
Wearables









2019

Time

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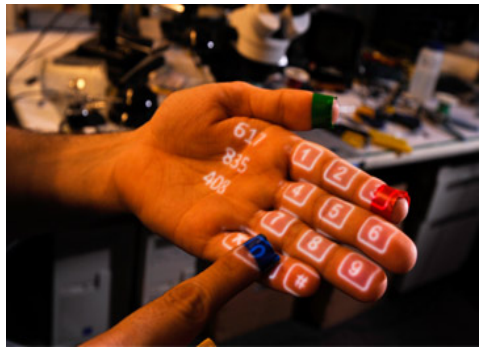
Enablers

- Moore's Law
- Communication technologies
- Material technologies
- Sensors and actuators
- Smart, cheap, fast processors

Overview

- Ubiquitous computing
  - what it is
  - a bit of history
  - application scenarios
  - challenges
- Wearable Computing
  - what it is
  - history
  - where its worn
  - types and contexts
  - design considerations
  - interaction
  - building your own
  - challenges



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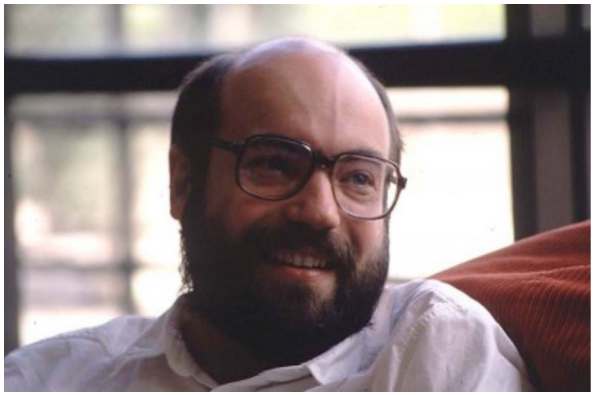
Ubiquitous Computing

'In the 21st century the technology revolution will move into the everyday, the small and the invisible…'

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

- 'The Computer for the 21st century', Scientific American, 1999



Marc Weiser (1952-1999) Xerox Parc

Ubiquitous Computing – What it is

- Also called *UbiComp* and *pervasive computing*
- Focus on *invisible computing* and *calm technology*
- Can be *in environment, in objects,* and *on the body*
- It implies…
  - human-computer interaction moving away from desktops
  - a mapping shift
    - ✓ one human-to-one computer -> one human-to-many computers
  - an enriched environment
    - ✓ sensors etc.
  - a paradigm shift
    - ✓ explicit interaction -> implicit interaction
      - – based on contextual information
  - humans at the center of the system

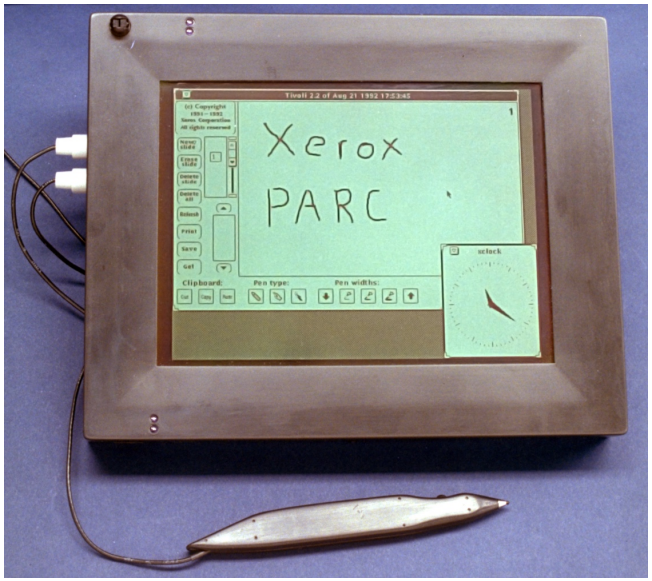
UbiComp - Example

(Ericsson)

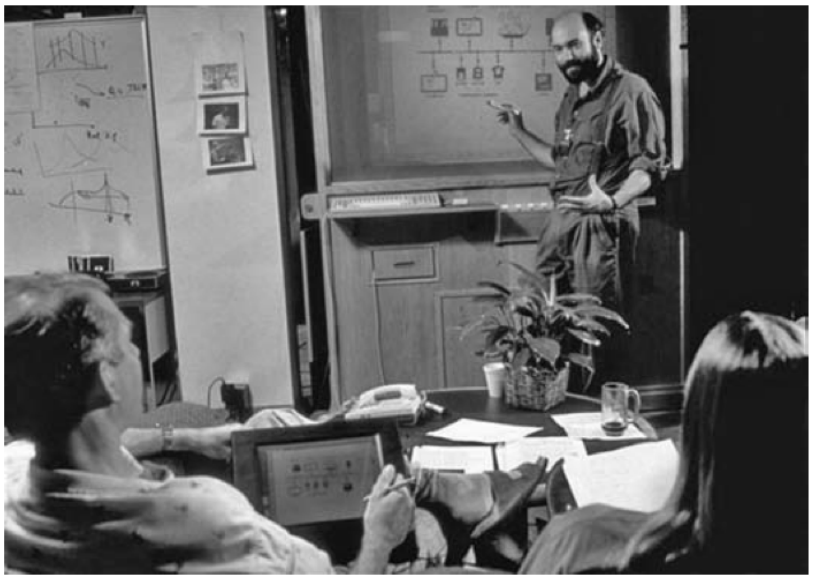
UbiComp - A bit of history…

- Xerox PARC (early 1990s)
  - scales of human interaction
    - ✓ inch, foot, yard
    - ✓ mixed-reality ecosystem

ParcTab



ParcPad



LiveBoard

UbiComp - A bit of history…

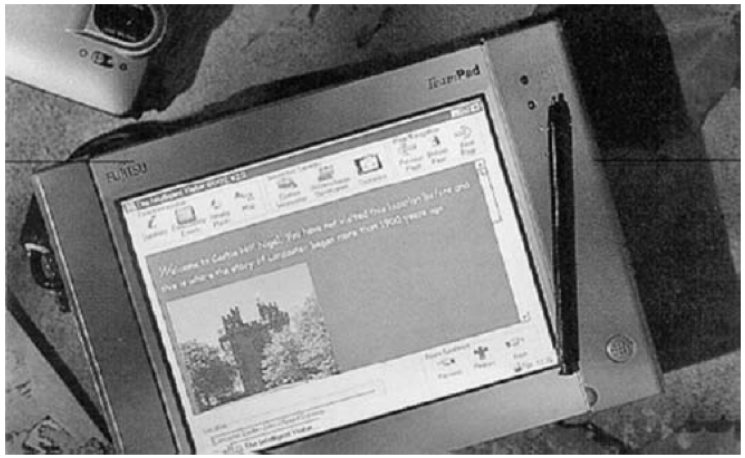
- Olivetti (early 1990s)
  - automated indoor location
  - 3D-positioning

- IBM (mid 1990s)
  - pervasive computing
    - ✓ less focus on calm and invisible
    - ✓ more of a commercial/business focus
  - check-in using mobile phones
    - ✓ IBM Zurich + SwissAir in 1999!

UbiComp - A bit of history…

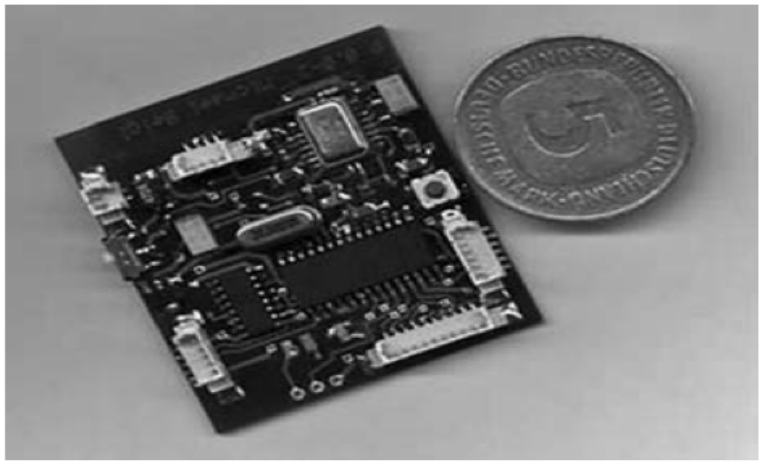
- UC Berkley (mid 1990s)
  - architecture and system-level issues
  - ubiquitous access to real-time media on mobile computers (InfoPad)
  - indoor environment

- Lancaster (mid 1990s)
  - location-based services in the wild
    - ✓ E.g. tourist guide around the city



UbiComp - A bit of history…

- University of Karlsruhe (late 1990s)
  - Cups and Smart-Its
    - ✓ general purpose tool for experiments with pervasive concepts
    - ✓ 'small embedded computers with communication and sensing components that can be integrated with everyday objects'



UbiComp - A bit of history…

- Georgia Tech (late 1990s)
  - living Labs
  - Classroom 2000
  - AwareHome

- MIT (around 2000)
  - wearable computing
  - researchers living w/ their concepts on a daily basis

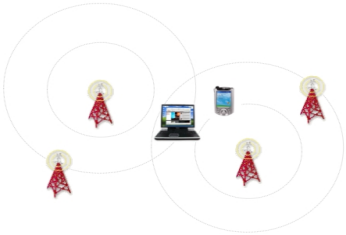
UbiComp - A bit of history...

- Intel (early 2000s)
  - detection of mobile devices
  - sensor networks
  - Place Lab
    - ✓ Sandbox for experimenting with location-based services on mobile platforms

Usage Model

Urban areas have dense WiFi coverage

Client devices cache snapshots of WiFi Beacon Databases

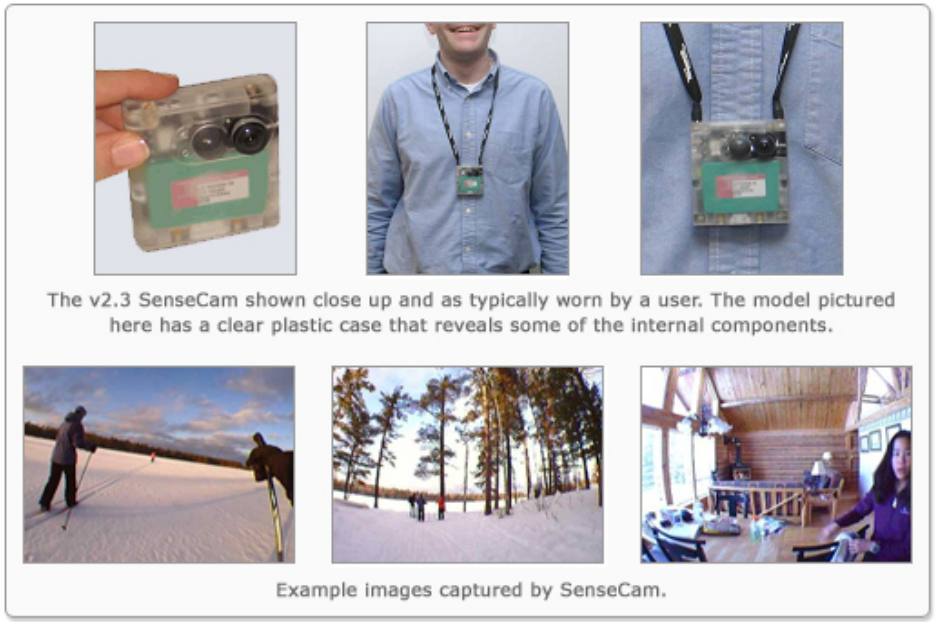


Devices that hear WiFi beacons estimate location locally & privately. New beacons get added to user-contributed database

Applications use location to provide customized, dynamic content and services

UbiComp - A bit of history…

- Microsoft (around 2000)
  - prosthetic memory aids
    - ✓ Sensecam
    - ✓ MyLifeBits
  - smart room for work and play
    - ✓ EasyLiving
      - – computing sessions follow people, control of lights and music



The v2.3 SenseCam shown close up and as typically worn by a user. The model pictured here has a clear plastic case that reveals some of the internal components.

Example images captured by SenseCam.

UbiComp - A bit of history…

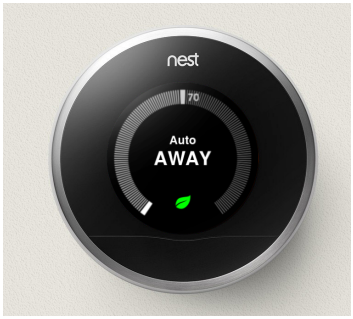
- HP Cooltown (late 1990s, early 2000s)
  - linking real-world objects to web
  - can configure and interact with networked systems
  - access to context, inference about activities

UbiComp - A bit of history…

- Internet of Things (around 2000s)
  - first example around 1982…a coke machine at Carnegie Mellon
  - contributions from embedded systems, wireless sensor networks, control systems, automation etc.
  - notion of unique addressability (tag, IP address, URI…)
  - early starts with RFID, now tagging using NFC, barcodes, QR codes, digital watermarking
  - applications: media and marketing, environmental monitoring, infrastructure management, manufacturing, energy management, medical and health care systems, building and home automation, transportation…

UbiComp - A bit of history…

- Smart Everything (around 2000s)
  - phones
  - cars
  - watches
  - clothes
  - meters
  - cities
  - health
  - homes
  - cards
  - heating
  - buildings
  - …



UbiComp – Application scenarios

- Smart objects
  - objects enriched with information processing capabilities
  - can have a memory
  - can exhibit context sensitive behaviour
    - ✓ may have sensors
    - ✓ location, situation or context awareness
  - can have communication capabilities
    - ✓ wired or wireless
    - ✓ spontaneous networking interaction
  - can be responsive and/or proactive
    - ✓ Communicate with environment
    - ✓ Networked with other objects
  - can have sensors and actuators

ComfortBox (Human-IST)

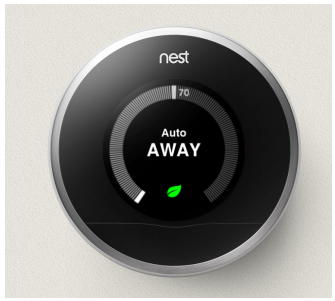

Kartoz (Nabaztag)


Tamagotchi

Adapted from slides by Denis Lalanne

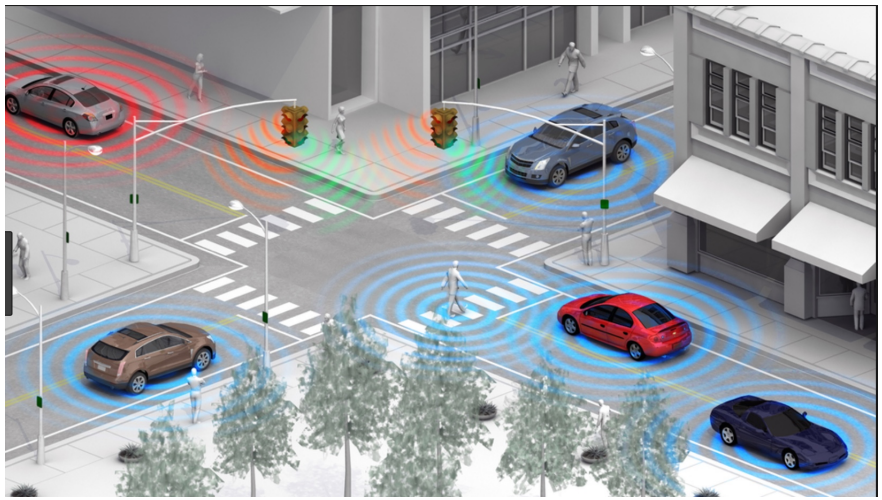
UbiComp – Application scenarios

- Smart Living and Smart Homes
  - sensors and actuators
  - awareness
  - smart
    - ✓ energy use
    - ✓ ventilation
    - ✓ lighting
    - ✓ heating
    - ✓ appliances
    - ✓ …



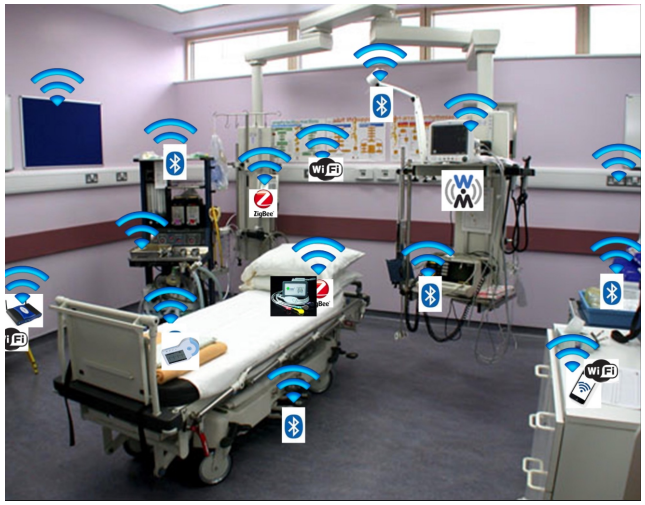
UbiComp – Application scenarios

- Automotive computing
  - self-driving cars
  - intelligent routing
  - car-to-car interaction
  - location-based services
  - congestion avoidance



UbiComp – Application scenarios

- Health and well-being
  - biological monitoring
  - eldercare
  - medical devices



- Education
  - Classroom 2000
  - tangible interaction

Challenges for UbiComp

- No longer have a constrained environment/context of use
  - device moves into new context
  - context around a device changes
  - adaptive scenarios
- User activity is continuous
  - rarely a clear beginning and end
  - interruptions are expected
  - multiple activities happen at once
  - same information used from different perspectives
- Context awareness
  - activity recognition
  - social situation recognition
  - face detection and tracking

Challenges for UbiComp

- Localization
- Device and infrastructure heterogeneity
- Reliability
  - of sensing
  - of knowledge
  - of inferences
- Ambiguity
- Power management
  - intelligently switch modes
  - battery size and life span
- Privacy

Interaction challenges for UbiComp

- Interface needs to…
  - allow different types of input
    - ✓ haptic, tangible, kinetic
  - allow different types of output
    - ✓ graphic, auditory, haptic, …
  - be usable
    - ✓ by different types of people
    - ✓ in different contexts
    - ✓ in different environments
  - allow for passive or active interaction

Interaction challenges for UbiComp

- Technology more transparent/invisible
  - how will user know that it's there?
  - how will user know what he/she can do?
  - how will user know what system does or can do?
  - how will system get input and give feedback (notifications, error messages)?
  - how will user get help in decision making?
- Role of the user

A bit of perspective...

"In order to understand the impact of ubicomp on everyday life, we navigate a delicate balance between **prediction** of how novel technologies will serve a **real human need** and **observation** of authentic use and subsequent **co-evolution** of human activities and novel technologies."

Dix et al. pg. 731

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Wearables

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Wearables – What are they?

- Computers or technologies that are always with a user and in their intimate space

- Also called
  - body-borne computers
  - bearable computing

- Characteristics
  - portable while operational
  - hands-free
  - equipped with sensors
  - always on (or asleep)
  - attention getting

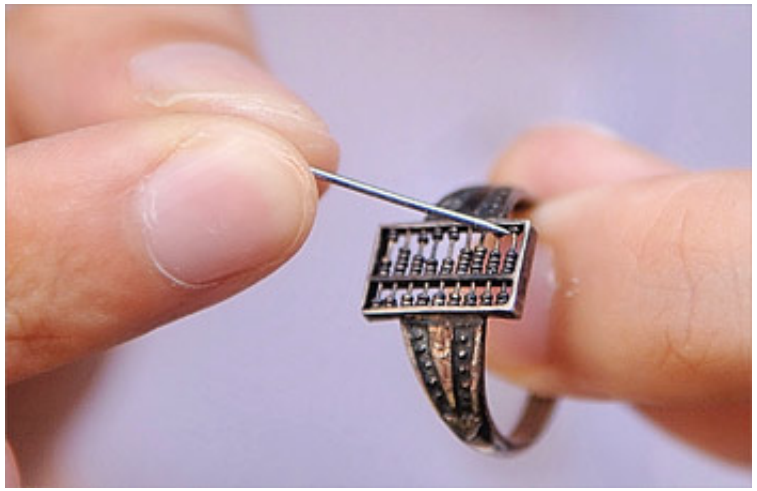
- Can be…
  - controllable
  - communicative
  - attentive

- Extends HCI concept
  - additional sensory modalities
  - extended cognition

Adapted from slides by Denis Lalanne

Wearables - History

"The Nuremberg Egg", pocket watch 1510.



1600: portable abacus

1920: first digital watch

Borrowed from Denis Lalanne

Wearables – Steve Mann

- Father of wearable computing

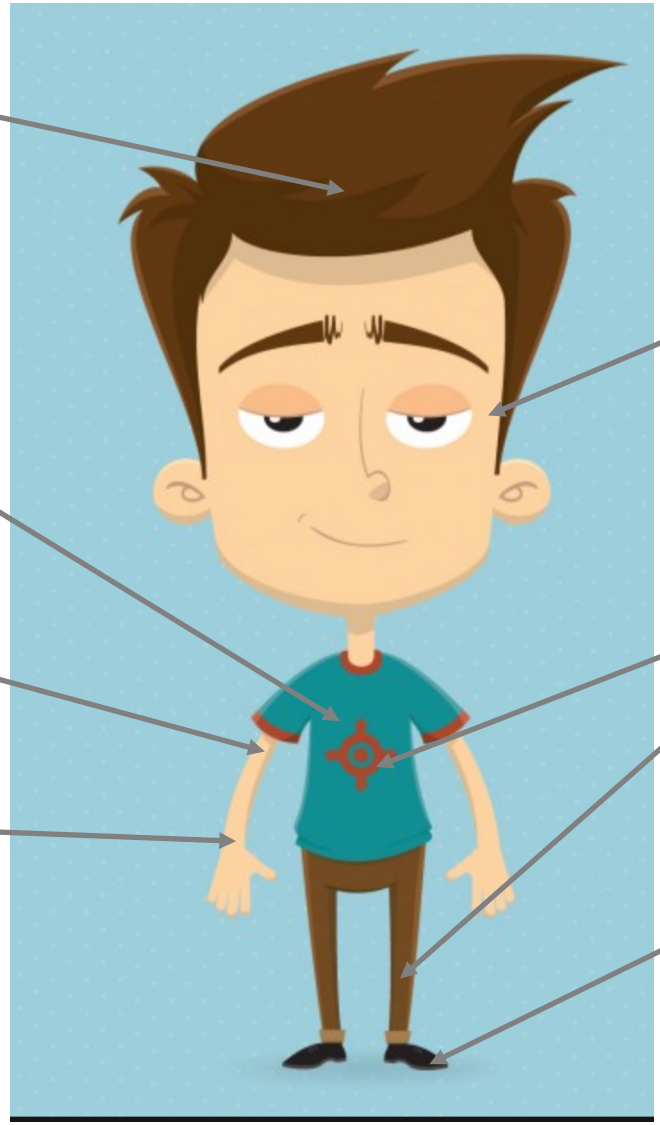
Steve Mann's "wearable computer" and "reality mediator" inventions of the 1970s have evolved into what looks like ordinary eyeglasses.

Mid 2000s

- Currently at the University of Toronto, Canada

Adapted from slide by Denis Lalanne

Wearables – Where do you wear them?



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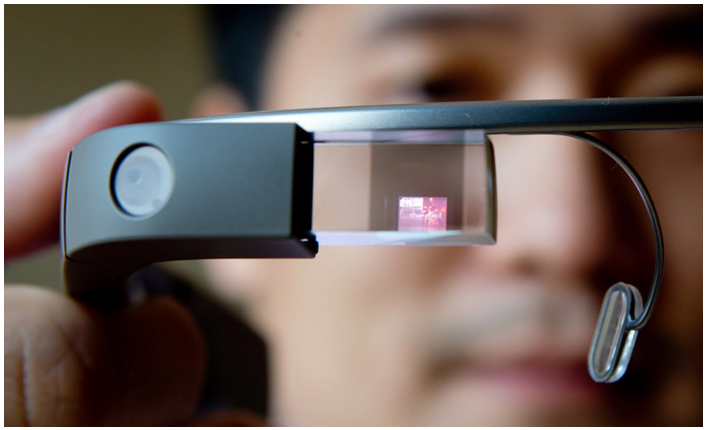
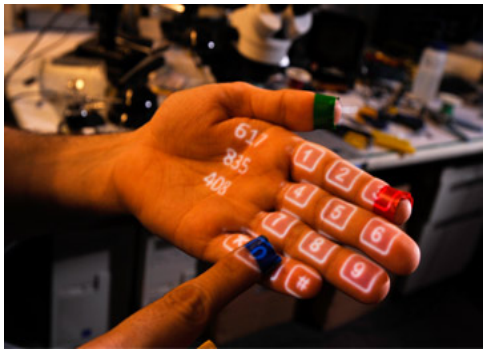
Wearables – Everyday life





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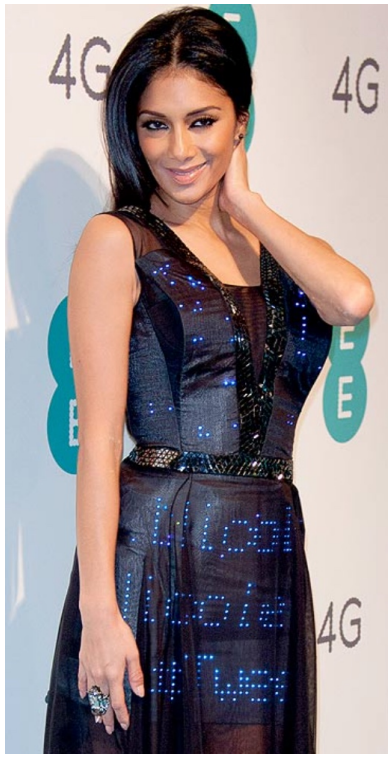
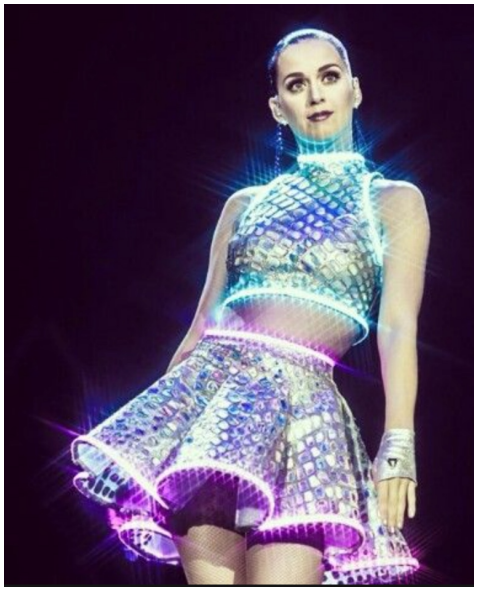
Wearables - Clothing





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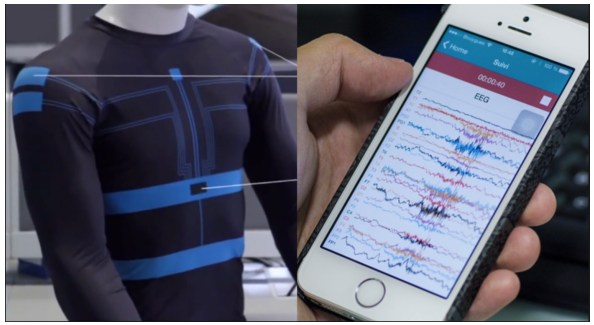
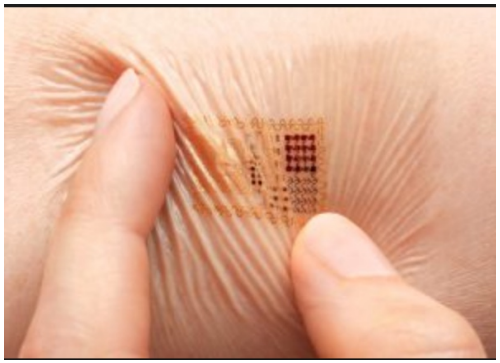
Wearables - Health





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Wearables – Monitoring and Assistance

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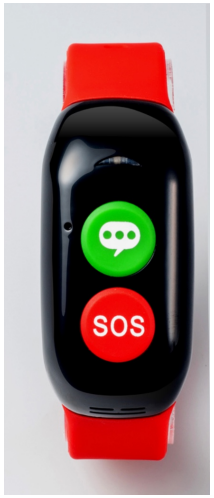

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Wearables – Fitness and Sports

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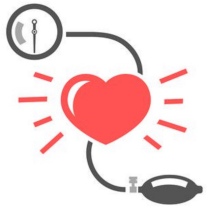
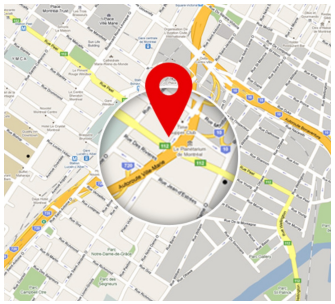
Wearables – What can be detected

- Heart rate
- Blood pressure
- Calories burned
- Breathing rate
- Temperature
- Skin conductance
- Motion (accelerometer)
- Sleep quality
- Location
- …





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Wearables – Design considerations

- Placement
  - where on body – size across populations, low movement, large surface area?
- Humanistic Form Language
  - work with human form to ensure fit
- Human Movement
  - allow for movement – design around joints, create spaces into which body can move
- Human Perception of size
  - form should stay within intimate space
- Size variations
  - fit many types of users
- Attachment
  - comfortable – wrap around body rather than single fastener

From slide by Sieworek et al.

Wearables – Design considerations

- Contents
  - sufficient volume to house tech
- Weight
  - weight should not hinder movement or balance
- Accessibility
  - test comfort and accessibility before purchase
- Interaction
  - passive and active interaction should be simple and intuitive
- Thermal
  - body sensitive to products that create, focus or trap heat
- Esthetics
  - culture and context affect shape, material, texture colour etc.

From slide by Sieworek et al.

Wearables - Interaction

- Input/output modalities
  - sound
    - ✓ usually as output

  - language
    - ✓ input or output
    - ✓ spoken or written

  - sight
    - ✓ usually as output
    - ✓ colours, images, text …

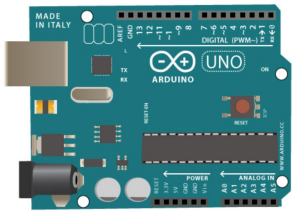
  - haptic/tactile
    - ✓ input or output
    - ✓ pressure, vibrations

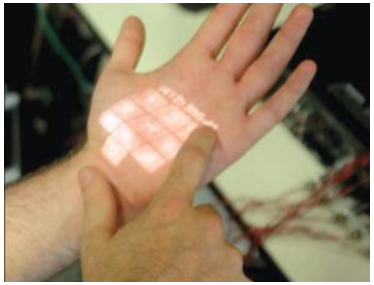
  - gestures
    - ✓ usually as input
    - ✓ direct or mediated
  - taste and smell?

- Passive vs. Active
  - tech gives information to owner, to others
  - tech requires user input to carry out actions

Wearables – Build your own

- What you need
  - A powerful portable computer
    - ✓ laptop or tablet
    - ✓ Arduino
    - ✓ Raspberry Pi
    - ✓ smartphone
    - ✓ …
  - Portable output systems
    - ✓ screen
    - ✓ speakers
    - ✓ actuators
    - ✓ …
  - Portable input systems
    - ✓ command interfaces
    - ✓ sensors
    - ✓ …





Adapted from slides by Denis Lalanne

Wearables – Challenges

- Power – battery
  - cost, size, weight, type
  - supply constancy
- Heat dissipation
  - cooling is expensive
- Hardware robustness
  - shock and waterproof
  - reparability
- Data management
  - storage location
  - duration
  - granularity

Adapted from slides by Denis Lalanne

Wearables – Challenges

- Networks
  - types
    - ✓ Off-body communication (mobile to fixed)
    - ✓ On-body communication (bluetooth)
    - ✓ Communicating with nearby objects (RFID, NFC)
  - wireless connection types
    - ✓ WaveLAN, IEEE802.11B, GPRS or UMTS (3G), Bluetooth, Infrared, ZigBee…

- Privacy
  - own - right to control use of personal information
  - privacy of others
  - barriers
    - ✓ Physical (personal screen, ear-plugs etc)
    - ✓ Encryption and biometric identifiers
    - ✓ Laws regarding use and distribution of data

Adapted from slides by Denis Lalanne

References and Acknowledgements

- Most images from Wikipedia and Google
- Some slides borrowed and adapted from Denis Lalanne's course slides.
- References
  - *Wearable Computing.* D. Sieworek, A. Smailagic, T. Starner. The Human Computer Interaction Handbook, 3rd Edition, Chapter 12. Ed. J. Jacko. CRC Press, 2012.
  - Human-Computer Interaction, 3rd edition. A. Dix, J. Finlay, G. Abowd and R. Beale. Prentice Hall, 2004.