PA198
Augmented Reality Interfaces

Lecture 8

Wearable Augmented Reality

Fotis Liarokapis

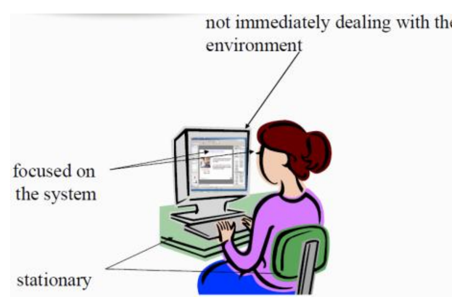
14th November 2016

Introduction

Intro to Wearable Computing (WC)

- Technology which allows for the human and computer to <u>interact</u>, <u>process data</u>, and <u>perform tasks</u> as one unit
- The concept of wearable computers attempts to bridge the 'interaction gap' between the computer and a human
- Wearable computing promotes devices that should be as natural to the user as wearing sunglasses or clothes

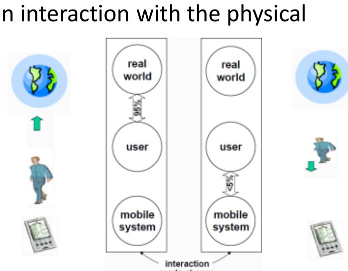
Conventional Computer



Roadmap: Wearable Computing 2020, Wear it at work.

Today's Mobile Interaction

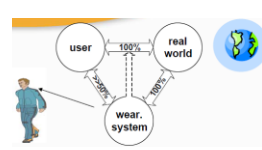
- Unusable when interaction with the physical world needed



Roadmap: Wearable Computing 2020, Wear it at work.

The Wearable Vision

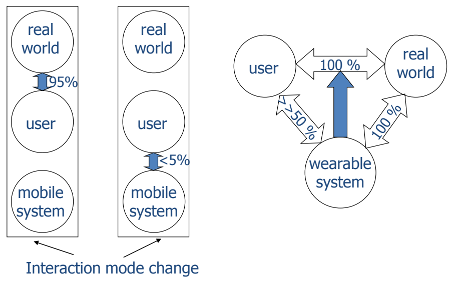
- Non disruptive interaction
- Environment oriented
  - Context recognition
  - Augmentation
- Physically unobtrusive
- Seamlessly connected



Roadmap: Wearable Computing 2020, Wear it at work.

Wearable vs. Mobile Computing

- Focus on the interaction of user/system

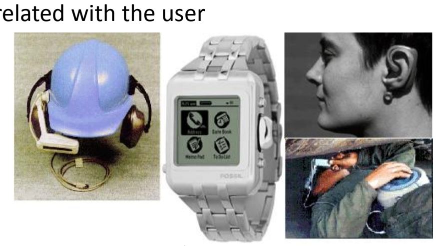


What is a Wearable Computer?

- A computer that is subsumed into the personal space of the user
- Controlled by the user, and always with the user – it is always on and always accessible
  – Operational and interactional consistency

Wearable Computer Definition

- A wearable computer offers all the features of a regular computing system, but is also totally related with the user



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Fundamentals of Wearable Computing

- Humanistic Intelligence (HI)
- Human-Computer Interaction (HCI)
- Mediated Reality

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Humanistic Intelligence (HI)

- HI is the intelligence that arises when a human is part of the feedback loop of a computational process in which the human and computer are linked
- This creates a far more powerful entity than the individual parts

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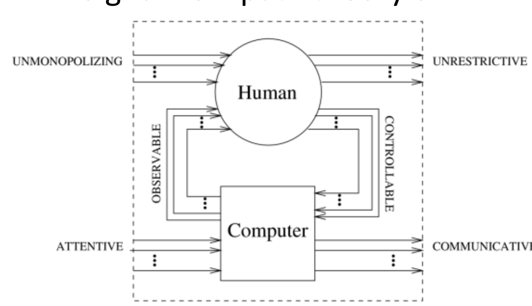
Signal flow path theory of HI



HCI

- HCI typically treats the human and computer as 2 separate entities
- Wearable computing extends the HCI concept
  - The computer can be regarded as a second brain, with it's sensory modalities and additional senses adding to the wearer's (paradigm shift)
- Idea is to <u>move</u> the tools of <u>augmented intelligence</u> and <u>communication</u> directly onto the <u>human body</u>

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Mediated Reality

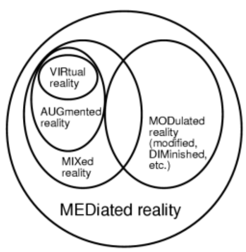
- Refers to the ability to <u>add</u> to, <u>subtract</u> information from, or otherwise <u>manipulate</u> one's perception of reality
  - Through the use of a wearable computer or hand-held device
- Typically, it is the user's visual perception of the environment that is mediated

Displays what's really there and then this allows a computer to be inserted into the "reality stream" to modify it

https://en.wikipedia.org/wiki/Computer-mediated_reality

Mediated Reality .

- Mixed reality and augmented reality are special cases of mediated reality



https://en.wikipedia.org/wiki/Computer-mediated_reality

Goal of Wearable Computing

- Main goal of the wearable computing paradigm is to produce a symbiotic relationship between the human and computer
  - Rather than attempting to emulate human intelligence
- The computer simply performs tasks at which it is much better and faster at doing

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Communications

- Wireless communication is an integral part of wearable computing
  - Extremely important!
- Nowadays WC's use communication protocols such as:
  - 802.11x
  - Bluetooth
  - Infra-red

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Hardware

- Small size and light-weight
  - Getting better and better
  - Innovative design of components
- Functionality is decided by where on the body it is worn
  - Head-mounted are the most common
- Multiple standard connectors
  - i.e. USB
- Innovative power use
  - Batteries are still a problem

Software

- Common Operating Systems:
  - Windows
  - Linux (popular)
  - MS-DOS
- GUIs are typically minimal
- Installed applications depend on the function of the device
- Use of Agents is mandatory, not optional
  - i.e. Remembrance agent, context-aware agent, etc

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Why Use Wearables

- Since they are wearable they are always with you
  - Difficult to loose
- Instant access, information anywhere and at anytime
  - Laptops require preparation time
  - PDAs require both hands
- Can become very personal items
  - Transparent use

Who Uses Wearables

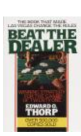
- Researchers
  - i.e. Augmented reality
- Field workers
  - Access to information given by remote experts
- Technicians
  - Blueprints
- Military
  - Soldiers monitoring health and equipment

Characteristics of Computing Devices

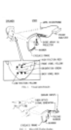
Device Type	Form Factor	Highest Degree of Mobility	Mode of Interaction	Modularity
Desktops	Large	Fixed	Stationary only	Fully modular input/output mechanisms
Laptops	Medium	Transportable	Stationary only	Single unit device with optional external output mechanisms (audio)
Palmtops	Small	Transportable	Stationary, with minor exceptions	Single unit device with optional external output mechanisms (audio)
Handhelds	Medium to small	Fully mobile	Mobile interaction enabled	Single unit device with optional external input/output mechanisms
Wearables	Small	Fully mobile	Mobile interaction enabled	Fully modular input/output mechanisms

[L. Gorlenko and R. Merrick, No wires attached: Usability challenges in the connected mobile world]

Brief History


1961


1966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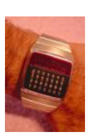
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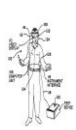
1981


1991


1991


1992


1993


1993


1996

Evolution of Wearable Computers

Father of Wearable Computing

https://www.youtube.com/watch?v=jhTchUYEIdU

Wearable Devices

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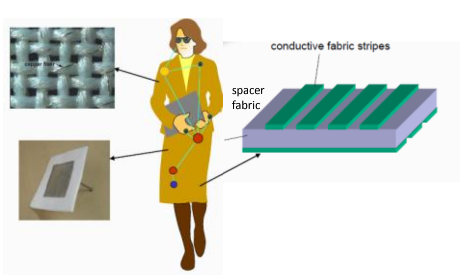
Architecture

Key Architecture Question

- What does integration with the outfit mean ?
- Observation:
  - Clothing is a heterogeneous, distributed, dynamically reconfigurable system
    - Function
    - Technology
    - User expectation
- Solution:
  - 4 layers of integration reflecting relation between clothing and electronic

Roadmap: Wearable Computing 2020, Wear it at work.

Layer 1: Functional Textiles



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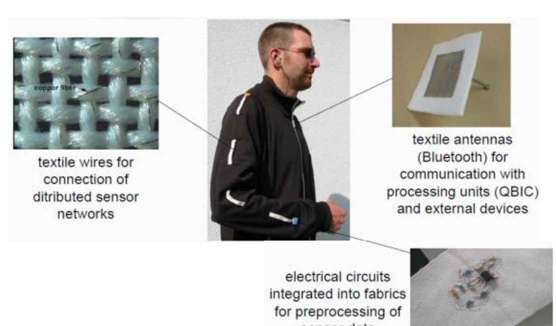
Simple Functions in Textiles



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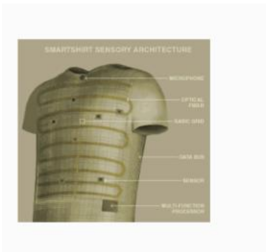
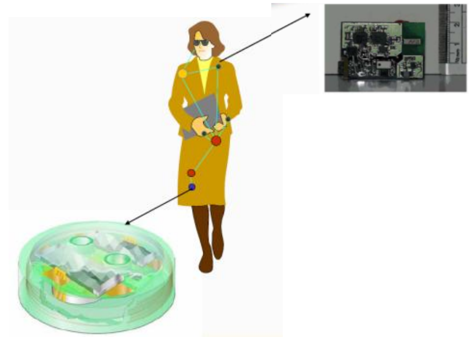
Smart Shirts

- Wearable Motherboard, Smart Shirt (GATECH)



Roadmap: Wearable Computing 2020, Wear it at work.

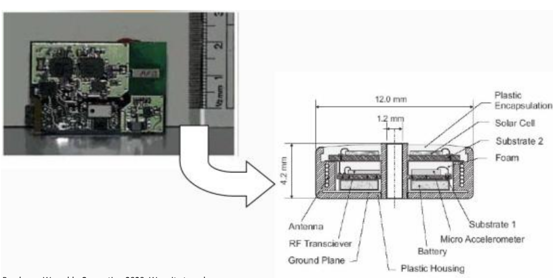
Layer 2: Embedded Microsystems



Roadmap: Wearable Computing 2020, Wear it at work.

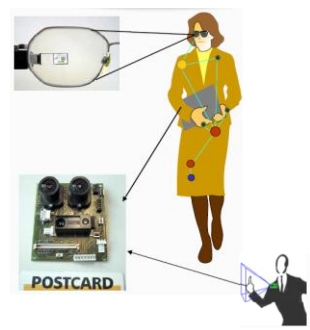
Miniaturized Sensors

- (Bharatula, Ossevoort, Lukowicz, Tröster, 2004)



Roadmap: Wearable Computing 2020, Wear it at work.

Layer 3: Attachable Peripherals



Roadmap: Wearable Computing 2020, Wear it at work.

Augmented Reality

Roadmap: Wearable Computing 2020, Wear it at work.

Billinghurst, M. Designing for Wearables, AWE Asia 2015.

Sensor Based Interfaces

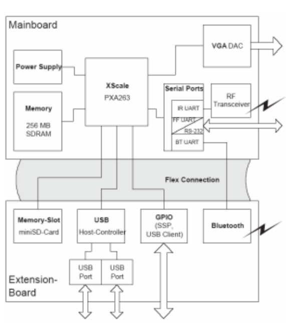
Roadmap: Wearable Computing 2020, Wear it at work.

ETH QBIC: Belt Integrated System

- Buckle as computer housing
- Belt as peripheral bus
  - Connectors
  - Batteries
  - Wireless adapter, storage etc

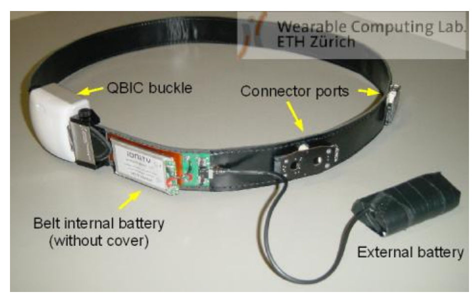
Roadmap: Wearable Computing 2020, Wear it at work.

QBIC



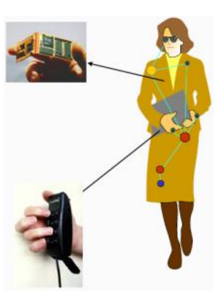
Roadmap: Wearable Computing 2020, Wear it at work.

ETH QBIC



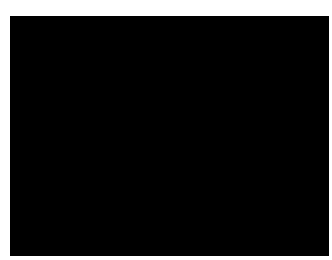
Roadmap: Wearable Computing 2020, Wear it at work.

Layer 4: Carry On Devices



Roadmap: Wearable Computing 2020, Wear it at work.

Wearable Computer New Scientist



https://www.youtube.com/watch?v=9DNXLAogM7Q

Design Guidelines

How To Design This?

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Universal Design Principles

- Flexibility
- Equitable use
- Easy to perceive
- Simple and intuitive
- Low physical effort
- High tolerance for error

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Designing for Wearables

- Wearables are intimate on-body devices, so interface design for wearables, means:
  - Designing for Attention
  - Designing for Interruption
  - Designing for User Experience
  - Designing for Social Interaction

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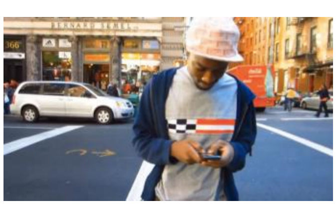
Micro-Interactions

- Using mobile phone people split their attention between the display and the real world



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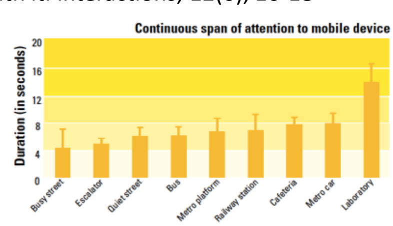
Time Looking at Screen

- Oulasvirta, A. (2005). The fragmentation of attention in mobile interaction, and what to do with it. interactions, 12(6), 16-18



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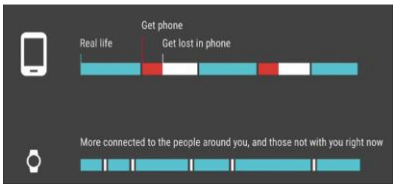
Using Micro Interactions

- Quick micro-interactions reduce divided attention and allow people to spend more time in real world



Billinghurst, M. Designing for Wearables, AWE Asia 2015.

Like A Rear View Mirror

- Don't overload the user
- Stick to the absolutely essential
  - Avoid long interactions
- Be explicit

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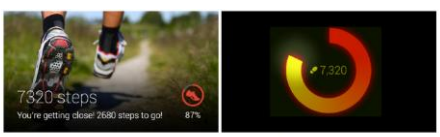
Make it Glanceable

- Seek to rigorously reduce information density
- Successful designs afford for recognition, not reading



Bad Good

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Reduce the Number of Info Chunks

- Designing for recognition, not reading
- Reducing the total # of information chunks will greatly increase the glance ability of the design

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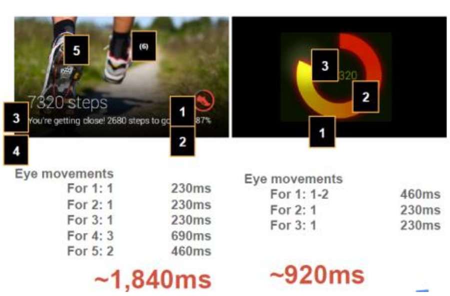
Design Single Interactions < 4 sec



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Test the Glanceability of Your Design

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Design for Micro-Interactions

- Design interactions less than a few seconds
  - Tiny bursts of interaction
  - One task per interaction
  - One input per interaction
- Benefits
  - Use limited input
  - Minimize interruptions
  - Reduce attention fragmentation

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Important Note

- Design for limited attention/micro-interactions
- No more than 4 seconds to complete a given step in the interaction

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Designing for Interruptions

- Assume user is engaged in critical real world task
- Use context to filter interruptions
  - Is it necessary?
- Interrupt in way that consumes least attention
- Allow user to dismiss interruption with minimal effort
- Progressively disclose information and increase interaction

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Interruptions on Glass Example

- Receiving SMS on Glass
  - Gradually increase engagement and attention load
  - Respond to user engagement

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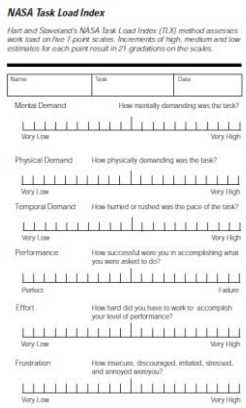
Important Note

- Design carefully for interruption
- Low cognitive load that can be increased as needed
  - i.e. NASA TLX

NASA TLX

- A subjective workload assessment tool
- Allows users to perform subjective workload assessments on operator(s) working with various human-machine systems
- A multi-dimensional rating procedure that derives an overall workload score based on a weighted average of ratings on six subscales

http://humansystems.arc.nasa.gov/groups/tlx/


NASA Task Load Index

Hart and Staveland's NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales.

Name	Task	Date

Mental Demand — How mentally demanding was the task?
Very Low — Very High

Physical Demand — How physically demanding was the task?
Very Low — Very High

Temporal Demand — How hurried or rushed was the pace of the task?
Very Low — Very High

Performance — How successful were you in accomplishing what you were asked to do?
Perfect — Failure

Effort — How hard did you have to work to accomplish your level of performance?
Very Low — Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed wereyou?
Very Low — Very High

Consider Your User

- Wearable User
  - Probably Mobile
  - One/no hand interaction
  - Short application use
  - Need to be able to multitask
  - Use in outdoor or indoor environment
  - Want to enhance interaction with real world

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How To Take A Note?

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Glass Pictures Example

- On Glass there are three ways to take a picture
  - Voice commands – "Ok Glass, Take a Picture"
  - Touch navigation through menu
  - Winking with right eye
- Which you use depends on context
  - Riding a bike outdoors – voice commands
  - During a meeting – winking

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Important Note

- Provide many different ways of accessing functionality
- Each person is different!

Design For Device

- Simple, relevant information
- Complement existing devices

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Glass User Interface

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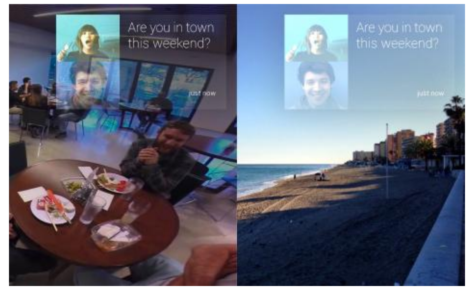
Test Indoors & Outdoors



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Design for Context

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Design for Ecosystem of Wearables

- User have multiple devices
  - Phone, watch
  - Fitness band, HMD
- Each device should be used when it's most relevant and when it's the easiest interaction available

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Interface Guidelines

- Design for device
- Use multiple input options
- Do one thing at a time
- Consider user context
- Design for indoor and outdoor use
- Design for device ecosystem

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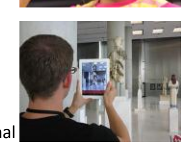
Social Acceptance

- People don't want to look silly
  - Only 12% of 4,600 adults would be willing to wear AR glasses
  - 20% of mobile AR browser users experience social issues
- Acceptance more due to social than technical issues
  - Needs further studies
    - Ethnographic, field tests, longitudinal



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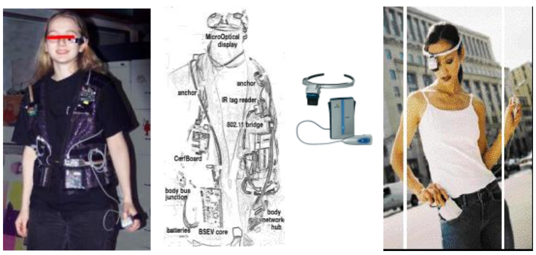
Social Implications

- Freak or Trendy?



Social Implications Questions

- Will the use of wearable computers become a symbol of elitism or will they become accepted as part of the daily routine?
- Is the integration of computer equipment into the body more acceptable than a wearable computer module?

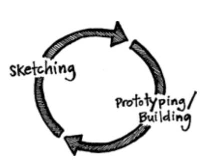
Prototyping

Main Goal

- How can we quickly prototype wearable computing applications with little or no experience
- Understand the market and user needs first

Why Prototype?

- Quick visual design
- Capture key interactions
- Focus on user experience
- Communicate design ideas
- Learn by experience



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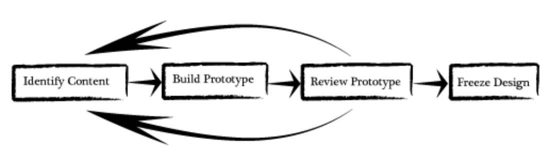
Prototype Design Process



Typical Development Steps

- Sketching
- Storyboards
- UI Mockups
- Interaction Flows
- Video Prototypes
- Interactive Prototypes
- Final Native Application

Static
Low fidelity

Increased Fidelity & Interactivity

Interactive
High fidelity

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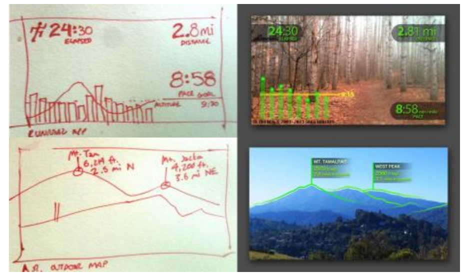
Sketched Interfaces

- Sketch + Powerpoint/Photoshop/Illustrator



Billinghurst, M. Designing for Wearables, AWE Asia 2015.

Paper Prototype

- Use sketched interface in template

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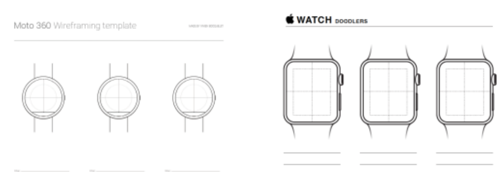
Smart Watch Templates

- https://dribbble.com/jaysuthar/buckets/260235-watch



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Wearables Today

Application Areas

- Warehouse picking
- Inspection
- Maintenance
- Repair
- Medical
- Security
- Military

A Prototypical Wearable Device

- Hearing aid computer
- Permanently useful
- Augments user's perception
- Situation sensitive
  - Adjusts amplification to the situation
- Virtually unnoticeable

Roadmap: Wearable Computing 2020, Wear it at work.

Consumer Applications

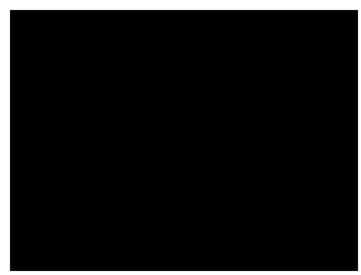
- Fossil has created the wrist PDA, it uses the Palm OS, and has almost all the functionality of a standard Palm Pilot

- Accenture Technology Labs has created a device that uses two small microphones, and a camera to assist in remembering a persons name

Consumer Applications .

- MIT Media Lab has developed handbags that alert you when you leave
  - Things behind, your wallet, or an umbrella if you need one
- Oakley has developed the first digital music eyewear
  - The Oakley Thump, comes equipped with a solid state hard drive, for skip free listening

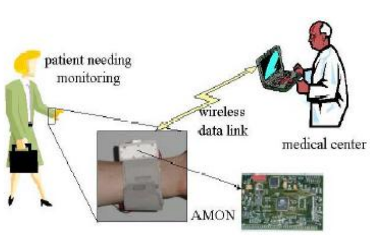
Intel Wearable Video



https://www.youtube.com/watch?v=iwSpn7H7vKg

Medical Applications

- Wrist worn medical monitoring devices



Medical Applications .

- The C-Leg
  - Uses the C programming language to do all of the calculations required to function, hence "C"-leg
  - Sensors from the foot and ankle get load information, sensors from the knee get the precise angle of the leg and swing speed, this is all sent to a microprocessor for processing

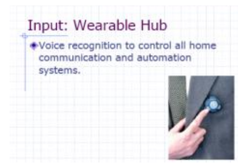
Ottobockus.com

C-Leg Video

https://www.youtube.com/watch?v=F0bpXmzCw7A

Personal/Recreational Use

- Web surfing
- Email/Text/Video Messaging
- Note taking
- Audio/Video Entertainment



Hiris Video

https://www.youtube.com/watch?v=VF9Qkt89u30

Military Wearables

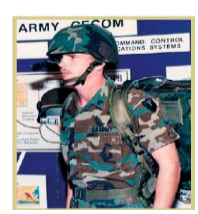
Early Years - The Soldier's Computer

- James Schoening, Matt Zieniewicz 1989, John Flatt, Sal Barone, and Almon Gillette, 1990
- Schoening:
  - small wearable computer, integrated with a wireless link and HMD
- Matt Zieniewicz:
  - wireless data transmission, image capture, integrated Global Positioning System (GPS) receivers, and menu-driven software

Zieniewicz, M.J., Johnson, D.C., Wong, D.C., Flatt , J.D. The Evolution of Army Wearable Computers, Research, Development, and Engineering Center, US Army Communications Electronic Command

Army Material Command's - First Trade Show

- Agilis bricktype 386-based computer
- Software:
  - Creating reports, displaying battlefield situation maps
  - Could enter and transmit simple reports to other units
- HMD:
  - 14-inch monochromatic display
- Interaction:
  - Trackball for input



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The SIPE project

- Spring of 1990
  - Led by Carol Fitzgerald
- New digitized battlefield concept:
  - portable, wearable battery-powered computer
- Computer needed to include:
  - Image capture
  - Integrated radio
  - Portable display unit

Zieniewicz, M.J., Johnson, D.C., Wong, D.C., Flatt , J.D. The Evolution of Army Wearable Computers, Research, Development, and Engineering Center, US Army Communications Electronic Command

SIPE Requirements

- Challenges
  - Integrate these components into a lightweight package
  - Bring computing devices to the individual soldier
- None of the functions were commercially available
- Software:
  - Developed in C

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SIPE Functionality

- The new system aimed to digitize basic battlefield operations to help soldiers
  - Read maps, navigate, and maintain situation awareness
  - Receive, prepare, and send written field reports
  - Capture and transmit color still images for reconnaissance purposes
  - Access battlefield operations reference material

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SIPE System Architecture

- Computer processor with memory
- GPS receiver and a digital compass
- Data radio
- Video capture system
- A miniature color camera
- A video controller subsystem
- An HMD
- A power supply subsystem
- Wiring harnesses and packaging

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Feedback From Soldiers

- Operate longer on a set of batteries
- Computer-radio-GPS:
  - 18 pounds
- HMD into helmet
  - nearly 8 pounds
- CRT display
  - 15 pounds
- Drawback
  - Delay in capturing and sending a still video image

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Land Warrior Project

- Land Warrior requirements:
  - Integrate small arms with high-tech equipment
  - Provide communications and command and control at the infantry soldier level
  - Look at the individual infantry soldier as a complete unit rather than as a segment of a larger force
- Cancelled in 2007, but restarted in 2008

https://en.wikipedia.org/wiki/Land_Warrior

Major Subsystems and Components

- Computer subsystem
- Helmet subsystem
- Control and communications subsystem
- Weapons subsystem
- Navigation system

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Helmet Subsystem

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Computer Subsystem

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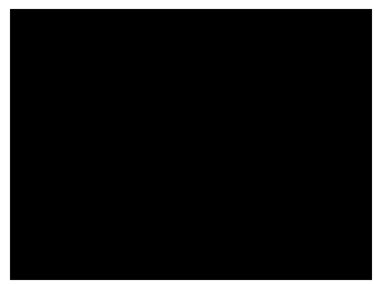
Land Warrior Video



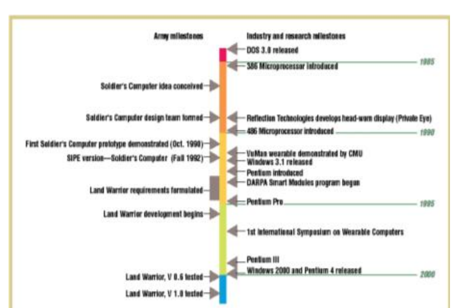
https://www.youtube.com/watch?v=dDrvZzfmuk4

21st-Century Soldier

- 21st-Century Soldier (Czech: Voják 21. století) is a Czech Future Soldier military project
- The agreement of Czech Ministry of Defence and VOP-026 Šternberk about the future soldier program was signed in 2004
- A functional prototype was created at the end of 2005
  - Expected to be operation in 2012

https://en.wikipedia.org/wiki/21st-Century_Soldier

Timeline of Army's Wearable Systems



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Military Suit & Suspended Armor

https://www.youtube.com/watch?v=Ix_KVBLrEdo

Conclusions

- Wearables mainly used by Universities
  - Industrial applications are catching up
- Major obstacles
  - Power, cooling, processing power, lightweight components, displays, graphics
- Future:
  - A single wearable will replace all separate devices we carry and use on a daily basis

Questions