Human-Computer Interaction

from natural interaction to ubicomp
“The details are not the details. They make the design.”

Charles Eames
How about interacting with “special” devices offering natural interfaces?
## sensorial experience

<table>
<thead>
<tr>
<th>Sense</th>
<th>Relevant information</th>
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<tbody>
<tr>
<td>Audio</td>
<td>Speech, Identity, Intonation, Precision (timing)</td>
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<tr>
<td>Vision</td>
<td>Identity, Facial expression, Body language, Gesture, Accuracy (spatial)</td>
</tr>
<tr>
<td>Tactile/somesthetic</td>
<td>Tabs/pads/devices, Texture, Precision (timing), Accuracy (spatial)</td>
</tr>
<tr>
<td>Scent</td>
<td>Atmosphere, likability</td>
</tr>
<tr>
<td>Taste</td>
<td>Clarification, enjoyment</td>
</tr>
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</table>
sensorial experience

The interpretation of sensorial data depends on user expectations.
sensorial experience

sensorial experience

Also, the interpretation of sensorial data depends on specific input devices (K. Hinckley, ‘08)
sensorial experience

Also, the interpretation of sensorial data depends on specific input devices (K. Hinckley, ‘08)

mouse, trackball, isometric joystick, touchpad, touchscreen, pen-operated device, watch, camera, microphone, indirect table,...
natural interaction

Haptic • Gesture • Locomotion
Auditory & Voice • Tangible
natural interaction

Haptic UI
(O’Malley & Gupta, 2008)

based on tactile sensations to provide information
natural interaction

Haptic UI
(O’Malley & Gupta, 2008)

based on tactile sensations to provide information

typical examples:
  haptic screen for “touching” objects
  natural output – e.g., vibrations (via tactons)
natural interaction

Haptic UI

cutaneous touch *versus* kinesthetic touch
natural interaction

Haptic UI

used in various contexts and domains:
  CAD (Computer-Aided Design)
  design prototyping
  product evaluation
  simulation of exceptional situations
  remote task execution (tele-operation)
  mobile & wearable computing
natural interaction

Haptic UI

usually, a haptic environment is defined by a formal model
example:
virtual wall – used in 3D games/simulations
natural interaction

Haptic UI

fixed haptic interfaces

haptic joysticks
pen-based haptic devices
floor- and ceiling-mounted interfaces
M. O’Malley, A. Gupta, “Haptic Interfaces”,
in P. Kortum (Ed.), *HCI Beyond the GUI*, Elsevier, 2008
natural interaction

Haptic UI

portable haptic interfaces

exoskeletons
natural interaction

Light Exoskeleton (L-Exos) described by Frisoli et al. (2005)
PowerArm HCI project: Arduino, Android & Unity3D
Dan-Gabriel Bratu, Daniel Vicol, Sergiu Recean (FII, 2013)
profs.info.uaic.ro/~stefan.negru/studentprojects/powerarm.html
natural interaction

Haptic UI

tactile interfaces

could detect heat, pressure, vibrations, pain

the feedback is usually provided by the user fingers
natural interaction

Haptic UI

tactile interfaces

vibrotactile interfaces

wearable tactile interfaces
natural interaction

Haptic UI

tactile interfaces

vibrotactile interfaces
wearable tactile interfaces

useful in the context of user accessibility
Moose haptic interface (O’Modhrain & Gillespie, 1995)
ccrma.stanford.edu/files/papers/stanm95.pdf
AHNE – Audio-Haptic Navigation Environment (SOPI Research Group, Aalto University, 2011) user tracking via Kinect + OpenNI & OSCeleton vimeo.com/28447850
natural interaction

Haptic UI

aspects regarding human factors:
understanding bio-mechanical, sensorial-motor,
and cognitive abilities of users (Tan et al., 1994)
natural interaction

Haptic UI

accuracy of movement measurement
(position, velocity, acceleration)
<table>
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<tr>
<th>Feature</th>
<th>Specification / Group</th>
<th>Maturity</th>
<th>Current Implementations</th>
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</table>
| Touch-based interactions | Touch Events  
Web Events Working Group |          | Shipped: |                    |
|                      | Pointer Events  
Pointer Events Working Group |          | Shipped: |                    |
|                      | touch-action in Pointer Events  
Pointer Events Working Group |          | Shipped: |                    |
| Vibration            | Vibration API (Second Edition)  
Devices and Sensors Working Group |          | Shipped: |                    |
| Notification         | Web Notifications  
Web Notification Working Group |          | Shipped: |                    |

in the mobile Web context, see HTML5 APIs e.g., Touch, Vibration, Screen Orientation, Gamepad, Media Capture

www.w3.org/2019/04/web-roadmaps/mobile/
natural interaction

Haptic UI

design principles:

base your mechanical design on the inherent capabilities of the human operator
natural interaction

Haptic UI

design principles:

consider human sensitivity to tactile stimuli
natural interaction

Haptic UI

design principles:

use active rather than passive movement
natural interaction

Haptic UI

design principles:

minimize confusion and control instabilities
natural interaction

Haptic UI

design principles:

ensure realistic display of environments with tactile devices
natural interaction

Haptic UI

specific uses:

(tele-)medicine
  e.g., laparoscopic surgery simulator, palpation simulator
  3D surface modeling
learning the interaction with touchscreen devices
digital art
using hand tracking data, VRgluv employs predictive physics algorithms to calculate the size and stiffness of virtual objects and recreates them in your hands.

vrgluv.com
natural interaction

Pseudo-Haptic UI

(software) emulation of a haptic device
natural interaction

Pseudo-Haptic UI

gensorial substitution (Lenay et al., 2003)

a haptic stimulus is substituted by another sense (e.g., an audio signal simulating the contact with virtual objects)
natural interaction

Pseudo-Haptic UI

offering pseudo-haptic feedback (Anatole Lecuyer, 2007)

simulation of stiffness via a combination of the interaction with the input device & the visual feedback

pseudo-haptic simulation of textures
Simulation-based Palpation using Pseudo-haptic Feedback (Min Li et al., 2012)

www.youtube.com/watch?v=OclczYCUkmc
natural interaction

Gesture interaction

inspired by non-verbal interactions between people
natural interaction

Gesture interaction

inspired by non-verbal interactions between people

alternative or complementary to traditional interactions

“tap is the new click”
natural interaction

Gesture interaction

“While natural gestures are often subtle, gesture interfaces rely on emphasized gestures.”

M. Nielsen et al., 2008
natural interaction

Gesture interaction

types:
hand gestures for pointing out objects or controlling a mouse-like pointer
One Finger
- Tap to Click
- Dragging
- Drag Lock
- Secondary Click

Two Fingers
- Scroll
- Rotate
- Pinch Open & Close
- Screen Zoom
- Secondary Tap

Three Fingers
- Swipe to Navigate

Four Fingers
- Swipe Up/Down for Exposé
- Swipe Left/Right to Switch Applications
natural interaction

Gesture interaction
types:

motion-tracking interfaces

used by several game consoles or laptops
natural interaction

Gesture interaction

types:
facial gestures

useful in detection of reactions and emotions
natural interaction

Gesture interaction

usually, based on specific input devices

mechanical/magnetic – e.g., mouse, data glove, Wii,...

single/multi-point touch
examples: smart phones, tablets
natural interaction

Gesture interaction

could be “invisible” for the user

detecting gestures via computer vision:
segmentation – extracting the relevant fragments
tracking – detecting the movements of interest
classification – obtaining the desired information
(e.g., via machine learning, neural nets,...)
general architecture of a gesture-based interactive system (Moustakas et al., 2006)
natural interaction

Gesture interaction

gesture classification:

semantic – the meaning of a gesture
functional – what the gesture does in an interface
descriptive – how the gesture is performed
natural interaction

Gesture interaction

functionally, gestures can signify:
command – Quit, Undo, Configure
pointing – e.g., selecting an item of interest
manipulation – example: scaling/rotating an image
control – emulates the control over an entity
natural interaction

dynamic + spatial-temporal “classical” gestures performed via an input device: mouse, stylus,...
Material Design – types of gestures:

- **Navigational**
  - (tap, scroll & pan, drag, swipe, pinch)

- **Action**
  - (tap, long press, swipe)

- **Transform**
  - (double tap, pinch, compound gestures, pick up & move)

[material.io/design/interaction/gestures.html](material.io/design/interaction/gestures.html)
natural interaction

Gesture interaction

the interaction vocabulary should be limited

we must assure an optimal interaction space (spatial zone)
natural interaction

“special” interactive zones having specific semantics
natural interaction

Gesture interaction

technology- *versus* human-based gestures

causes of discomfort:
stressful/fatigue producing for the user
nearly impossible for some people to perform
illogically imposed functionality
some gestures easily recognizable by software meanings/actions difficult to be understood/performed by the human users:
T0: without signification (residue)
T1: select
T2: copy & paste
T3: delete
T4, T5: menu/release
natural interaction

Gesture interaction

a gesture-based UI must:
be intuitive
take into consideration the user mental model
be easy to learn & deployed (ergonomics)
natural interaction

Gesture interaction

practical design advices:
be tolerant to human errors
beware of cultural factors
consider the context
provide positive feedback
natural interaction

Gesture interaction

patterns for touchscreens & interactive surfaces
(Dan Saffer, 2009)

tap to open/activate
tap to select
drag to move object
slide to scroll, spin to scroll
natural interaction

Gesture interaction

patterns for touchscreens & interactive surfaces (Dan Saffer, 2009)

slide and hold for continuous scroll
tap to stop
pinch to shrink and spread to enlarge
two fingers to scroll
natural interaction gesture notation (Luke Wroblewski, 2010)
natural interaction

Gesture interaction

patterns for free-form interactive gestures
(Dan Saffer, 2009)

move body to activate
point to select/activate
wave to activate
place hands inside to activate
natural interaction

Gesture interaction

patterns for free-form interactive gestures
(Dan Saffer, 2009)

rotate to change state
step to activate
shake to change
tilt to move
device specific gesture notation – for example: Kinect
natural interaction

locomotion design
natural interaction

Locomotion interfaces

interfaces that both enable users to move around in real or virtual spaces and make users feel as if they are moving

Mary C. Whitton & Sharif Razzaque, 2008
natural interaction

Locomotion interfaces

could be virtual, not only physical
natural interaction

Locomotion interfaces
could be virtual, not only physical

main problem:
to capture the user’s intent using data that can be derived from sensing the pose (position and orientation) and movement of the user’s body
discussion
natural interaction

Locomotion interfaces

perceiving self-motion

each sensorial channel (visual, auditory, vestibular,...) is used in detection of user or surrounded objects movement

Dichgans & Brandt, 1977
natural interaction

Locomotion interfaces

detection of pose and motion

artificial sensors (trackers)
optical motion capture
mechanical solutions
Master on Software Engineering :: Human-Computer Interaction

trackers

optical motion capture

exoskeleton

Dr. Sabin-Corneliu Buraga – profs.info.uaic.ro/~busaco/
case study

360° FREERIDE EXPERIENCE

interactive climbs
project360.mammut.ch
natural interaction

Locomotion interfaces

providing feedback to user(s)

visual information:
head-mounted displays (HMDs)
surround-screen displays
natural interaction

Locomotion interfaces

walking simulation

treadmills (Brooks, 1998; Hollerbach et al., 2000)

walking-in-place (WIP) interfaces
natural interaction

Locomotion interfaces

design principles (Whitton & Razzaque, 2008):

making the interface feel natural

higher-fidelity reproduction of human way of walking

avoiding simulator sickness – cybersickness

a VR treadmill allowing users to maneuver a scene using their feet (Nick Randolph, 2018)

medium.com/uxxr/the-user-experience-of-virtual-reality-c464762deb8e
natural interaction

Locomotion interfaces

issues that can be detected in the testing phase:

realism + preservation of spatial understanding

cognitive distraction

break-in-presence (BIP) events
an action that causes **break-in-presence** (virtual scene ➔ physical location)

details in A. Steed, A. Brogni, V. Vinayagamoorthy, “Breaks in Presence as Usability Criteria”, *HCII 2005*

www0.cs.ucl.ac.uk/staff/v.vinayagamoorthy/pdf/hcii2005.pdf
natural interaction

Locomotion interfaces

advice:
match the locomotion metaphor to the interface goals

walking metaphor versus vehicle metaphor
natural interaction

Locomotion interfaces

practical considerations:

Is viewing direction independent of motion direction?
Are hands used for locomotion?
Able to move in any direction and change direction easily?
Can walking speed or step length be set for each user?
natural interaction

Locomotion interfaces

practical considerations:

Are tracker sensors immune to other signals in the room?
Are wireless trackers used?
What parts of body will have sensors/markers on them?
Cables – if any – interfere with user’s motion?
case study

motion studies in the context of modern art

Hype Cycle: Machine Learning
When will machines achieve human agility?

Universal Everything – universaleverything.com

other examples: prostheticknowledge.tumblr.com/tagged/motion
auditory & vocal interactions
natural interaction

Auditory interfaces

using non-speech audio information for interaction

for details, see (S. Camille Peres et al., 2008)
natural interaction

Auditory interfaces

motivations and uses:
- presenting information to visually impaired people
- providing an additional information channel
- alerting people to error or emergency states of a system
- providing information via devices with small screens
natural interaction

Auditory interfaces

why an audio interaction?

reducing visual overload
reinforcing visual messages
when eyes are elsewhere
when audio is more informative
conveying emotion – e.g., for electronic games
natural interaction

Auditory interfaces

sonification = using non-speech sound to render data

the simplest method is audification
natural interaction

Auditory interfaces

representational
auditory icons

abstract
earcons

Stephen Brewster (2008)
natural interaction

Auditory interfaces
natural interaction

Auditory interfaces

problems regarding the audio interaction:
  annoyance
  privacy
  auditory overload
  interference/masking
  low resolution
  lack of familiarity
natural interaction

Auditory interfaces

aspect of interest:
the tasks performed by the user via an audio interface
natural interaction

Auditory interfaces

aspect of interest: what (kind of) information could be exclusively represented by sounds?
natural interaction

Auditory interfaces

aspect of interest:
the suitable format audio – lossless vs. lossy – to be used

FLAC, PCM, WAV versus AAC, OGG, MP3
natural interaction

Auditory interfaces

aspect of interest:
producing the sound

thinking about sound as information

designing the sound – consider auditory content as a kind of sound ecology (Walker & Kramer, 2004)
What if the things in the night didn't just go bump? *BlindSide* is a terrifying new audio-only adventure game, set in a fully-immersive 3D world you'll never see. Put on your headphones, close your eyes, and explore the darkness. Listen as the world rotates around you!

You play as Case, an assistant professor who wakes up blind, to find his city destroyed and mysterious creatures devouring people. Will you and your girlfriend be able to find your way without sight? How will you escape? Run for your life, navigate the darkness, and uncover the mystery of the apocalypse— all in the dark!

*BlindSide* was inspired by co-creator Aaron Rasmussen’s temporary blindness as a result of an explosion in high school chemistry.

**Available on the App Store**

[www.audiogames.net](http://www.audiogames.net)
natural interaction

Voice user interfaces

facilitating the conversation between software and user
natural interaction

Voice user interfaces

important aspect: speech recognition
natural interaction

Voice user interfaces

user perceptions regarding a VUI are fragile
  ▸ lack of trust (Susan Hura, 2008)
natural interaction

Voice user interfaces

users interact generally via prompts

“Hello, you have to choose from the following options...”
natural interaction

Voice user interfaces

several discourse makers are needed for:

confirmation – “yes, of course”, “alright”
changing the topic of conversation
emphasizing a statement – “as we previously said...”
narrative sequences – “so,...”
natural interaction

Voice user interfaces

problem: the lack of concision

“I can help you with the following five options. You can interrupt me and speak your choice at any time. Please, select one of the following: sign up for new service, add features to my service, move my existing service, problems with my satellite service, or ask a billing question.”
natural interaction

Voice user interfaces

problem: dealing with errors

“I’m sorry. I did not understand your response. I can help you with the following five options...”

› inducing the feeling of user culpability
natural interaction

Voice user interfaces

problem: increasing the user discomfort

“Please say or enter your account number!”

the user cannot control the interface
natural interaction

Voice user interfaces

problem: using the same message (in different contexts)

“Attention! I don’t understand! Please, indicate the correct answer!... Attention! I don’t understand! Please, indicate the correct answer!... Attention! I don’t understand! Please, indicate the correct answer!...”
natural interaction

speech recognition – main phases (Cohen et al., 2004)
natural interaction

Voice user interfaces

design guidelines:

present menu options in a way that makes them comprehensible and easy to retain
natural interaction

Voice user interfaces

design guidelines:

consider error sources when writing error-handling prompts
natural interaction

Voice user interfaces

design guidelines:

provide context

VUI: You can say: account balances, last contribution, transfers, allocations, or life insurance.

User: Transfers.

VUI: Transfers. You can say: hear pending transfers or make a transfer.
natural interaction

Voice user interfaces

design guidelines:

use hints and reminders

“Next time, you can say ‘order status’ at the main menu to get here quicker.”

“You can speak your account number or key it in.”
natural interaction

Voice user interfaces

design guidelines:

favor models over instructions

learning by doing
natural interaction

Voice user interfaces

design guidelines:

use discourse markers liberally

using in conversation common expressions like “all right”, “next”, “thanks”,...
natural interaction

Voice user interfaces
design guidelines:
allow for conversational repair
natural interaction

Voice user interfaces

design guidelines:

be careful with terminology
natural interaction

Voice user interfaces

recent examples – mobile, Web & smart home contexts:

cloud-based voice services + devices

Amazon Alexa, Amazon Echo, Apple HomePod
natural interaction

Voice user interfaces

recent examples – mobile, Web & smart home contexts:

Apple Siri (iOS, watchOS)
developer.apple.com/sirikit/
natural interaction

Voice user interfaces

recent examples – mobile, Web & smart home contexts:

Google Assistant

developers.google.com/assistant/sdk/
natural interaction

Voice user interfaces

recent examples – mobile, Web & smart home contexts:

Microsoft Cortana in conjunction to Azure Bot Service
developer.microsoft.com/cortana
azure.microsoft.com/services/bot-service/
case study

A home assistant able to announce who is home by using facial recognition (Juan Perez & Robin Cole, 2018)

image data captured via Webcam and processed locally with Facebox – [machinebox.io/docs/facebox](http://machinebox.io/docs/facebox) – or on cloud by using Amazon Rekognition or Google Vision

announcement speaker uses Google Text-To-Speech service, integrated into Home Assistant – an open-source home automation platform: [www.home-assistant.io](http://www.home-assistant.io)

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Zygote Tetraedro Prototype</td>
<td>Testing floatation of a possible new addition to the Zygote family.</td>
</tr>
<tr>
<td>Lasers</td>
<td>DMX controlled lasers test, 10x6 &amp; counting.</td>
</tr>
<tr>
<td>Morula Prototype</td>
<td>Approx 2m diameter inflatable with 32 faceted panels containing RGB LEDs.</td>
</tr>
<tr>
<td>Light Columns</td>
<td>A sound reactive and fast deployable light system for performances, events</td>
</tr>
<tr>
<td></td>
<td>and venues. 8 feet tall. 100 LEDs per column.</td>
</tr>
<tr>
<td>Pixel Box</td>
<td>Pixel Box 1. 2x5 pixel grid. Programmed in Quartz Composer</td>
</tr>
<tr>
<td>House Number</td>
<td>A DIY, aluminum, low consumption, illuminated house number. Contains a</td>
</tr>
<tr>
<td></td>
<td>photocell that turns it on at night and off during the day.</td>
</tr>
<tr>
<td>Pixel Urchin</td>
<td>Sound reactive LED lights test.</td>
</tr>
<tr>
<td>Halo Lamp Prototype</td>
<td>A controllable venue lighting system. This is the first iteration of Halo -</td>
</tr>
<tr>
<td></td>
<td>60cm in diameter with 50 controllable RGB LEDs inside. Depending...</td>
</tr>
<tr>
<td>Faceted Furniture</td>
<td>Faceted furniture prototypes.</td>
</tr>
<tr>
<td>Flex and ArtNet over Wi-Fi</td>
<td>Testing wireless ArtNet.</td>
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<tr>
<td>Playground</td>
<td>Real time interaction for Android and iOS. No apps needed. Now all devices</td>
</tr>
<tr>
<td></td>
<td>can play together.</td>
</tr>
</tbody>
</table>

Idea are nothing more than ideas, until we make them happen.

tangible interfaces
natural interaction

Tangible interfaces

digital information ➔ physical form (representation)
Hiroshi Ishii

digital content could be directly perceived & manipulated
natural interaction

Tangible interfaces

key components:
control – permits users to manipulate the content
external representations – perceived by human senses
natural interaction
natural interaction
<table>
<thead>
<tr>
<th>Tangible Manipulation</th>
<th>Spatial Interaction</th>
<th>Embodied Facilitation</th>
<th>Expressive Representation</th>
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<tr>
<td>haptic direct manipulation</td>
<td>inhabited space</td>
<td>embodied constraints</td>
<td>representationnal significance</td>
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<td>lightweight interaction</td>
<td>configurable materials</td>
<td>multiple access points</td>
<td>externalization</td>
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<tr>
<td>isomorph effects</td>
<td>visual access</td>
<td>tailored (adaptive) representations</td>
<td>perceived coupling</td>
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<td></td>
<td>full body interaction</td>
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<td></td>
<td>performative action</td>
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</tr>
</tbody>
</table>

Eva Hornecker (2010)

see also [www.ehornecker.de/TangiblesFramework.html](http://www.ehornecker.de/TangiblesFramework.html)
Does shifting stuff (or your own body) around have meaning?

Tangible Interaction Conceptual Framework

responding to key design questions via cards
Can users grab, feel and move “the important stuff”? Do people and objects meet and invite into interaction? Can you create a meaningful place with atmosphere? Are representations legible, meaningful, and expressive?
natural interaction

Tangible interfaces

for other resources + demos, consult:

Eva Hornecker, Tangible Interaction (2015)
www.interaction-design.org/encyclopedia/tangible_interaction.html

Tangible Interfaces discipline – mas834.media.mit.edu

Tangible Media Group @ MIT – tangible.media.media.mit.edu
multimodal interaction
multimodal interaction

Processing two or many inputs – voice, gestures, tactile, etc. – in a coordinated manner in order to obtain a complex output (e.g., multimedia, 3D) or to perform a task

Sharon Oviatt, 2008
Paulo Barthelmess & Sharon Oviatt, 2008
multimodal interaction

“The situation where the user is provided with multiple modes for interacting with a system.”

Abdo El Ali, 2011

www.slideshare.net/Abd0/multimodal-interaction-an-introduction
multimodal interaction

Diverse contexts are considered
from mobile interfaces to collaborative systems
virtual and/or augmented reality
multimodal interaction

Advantages:

error reduction via mutual disambiguation

increasing user performance
multimodal interaction

Issues to be resolved:

linguistic factors

redundancy & complementarity

choosing the “right” multi-/mono-modal input

cognitive load
designing multimodal interaction for info kiosks
designing multimodal interaction for info kiosks

aspects of interest (M. C. Maguire, 1999):
choosing a suitable location
encouraging use
providing instructions for using the system
user privacy
multiple input methods: touch, speech, keypad
proper output: language, color, images, feedback,...
navigation possibilities

ui4all.ics.forth.gr/UI4ALL-97/maguire.pdf
ubiquitous computing

www.macadamian.com/2015/03/20/design-iot-product/
ubiquitous computing

“Invisibly enhancing the world that already exists.”
(Mark Weiser, 1988)
ubiquitous computing

“Invisibly enhancing the world that already exists.”
(Mark Weiser, 1988)

ubicomp

pervasive computing

ambient intelligence (AmI)

physical computing

everyware
ubiquitous computing

“Invisibly enhancing the world that already exists.”
(Mark Weiser, 1988)

can occur using any device,
in any location,
and in any format

computers disappear in the environment
ubiquitous computing

Related topics of research:

context awareness

distributed & mobile computing

Internet of Things (IoT) + wireless sensor networks
Using (semantic) Web technologies to specify & interact with IoT components
describing IoT for machines/users via Web of Things specifications (W3C, 2018): [www.w3.org/WoT/](http://www.w3.org/WoT/)
developing applications by using WebThings Framework (Mozilla), a collection of re-usable software components to build Web things via Web Thing API (2019): [iot.mozilla.org/wot/](http://iot.mozilla.org/wot/)
ubiquitous computing

Scales of devices

Mark Weiser’s initial proposals (1991)

tabs – centimeter-sized devices: PDAs, voice recorders, smart-phones, smart-watches,...

vision: individuals own many of them and they can all communicate with each other and environment
interacting with a smart-watch via widgets


ubiquitous computing

Scales of devices

Mark Weiser’s initial proposals (1991)

pads – handheld decimeter-sized devices: tablets, laptops, e-readers, etc.

vision: an individual owns several, but it is not assumed to be always with them
ubiquitous computing

Scales of devices

Mark Weiser’s initial proposals (1991)

**boards** – meter-sized interactive devices: mounted walls, e-tables, smart info kiosks,…

vision: buildings or institutions own them and lots of people used them
Virtual Reality
term coined by Jaron Lanier (1989)

a computer-based simulated 3D environment intended for its users to inhabit and to interact via avatars

an interface between the “physical” reality and a virtual environment
Virtual Reality – desktop

1st wave (1995) – expensive hardware
HMD (Head Mounted Display)

2nd wave (since 2010)
MxR (Mixed Reality Lab), Oculus Rift

consumer-ready HMDs (2016)
Oculus Rift, Sony Morpheus, HTC/Valve Vive

for further information, study the Mark Billinghurst’s presentations:
www.slideshare.net/marknb00/presentations
Augmented Reality
term coined by Thomas Caudell (1990)

the use of technology which allows the perception of the physical world to be enhanced or modified by computer-generated stimuli perceived with the aid of special equipment

generation of virtual objects merged into real scenes
reality-virtuality continuum (Milgram & Kishino, 1994)

consult also www.slideshare.net/busaco/from-virtual-to-augmented-reality
Mobile phone AR & VR

HMD = VR mount + smartphone

**mobile phone AR**
smartphone + live camera view + sensor input
(e.g., GPS, compass)

**mobile phone VR**
smartphone + sensor input + additional VR viewer
case study

Mobile phone AR & VR

low-cost immersive viewers

VR2GO (MxR Lab, 2013)
projects.ict.usc.edu/mxr/diy/vr2go/

Google Cardboard (2014)
g.co/cardboard

M. Billinghurst, Cardboard VR: Building Low Cost VR Experiences (2016)
www.slideshare.net/marknb00/cardboard-vr-building-low-cost-vr-experiences
Mobile phone AR & VR

popular software toolkits:

ARCore (Google) – developers.google.com/ar/

+ Google VR – developers.google.com/vr/

ARKit (Apple) – developer.apple.com/arkit/

M.Billinghurst, Developing AR and VR Experiences with Unity (2017)
www.slideshare.net/marknb00/developing-ar-and-vr-experiences-with-unity
case study

AR & VR in the modern Web context

3D content via WebGL

developer.mozilla.org/docs/Web/WebGL
github.com/sjfricke/awesome-webgl

WebXR (draft W3C specification, 21 May 2019) support for accessing VR + AR devices, including sensors and head-mounted displays, on the Web

immersiveweb.github.io/webxr/

for other details, consult webvr.info/developers/
<table>
<thead>
<tr>
<th>Device</th>
<th>Chrome</th>
<th>Firefox</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vive</td>
<td>X</td>
<td>Supported</td>
</tr>
<tr>
<td>oculus</td>
<td>X</td>
<td>Supported</td>
</tr>
<tr>
<td>Windows Mixed Reality</td>
<td>X</td>
<td>N/A</td>
</tr>
<tr>
<td>SAMSUNG Gear VR</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Daydream</td>
<td>N/A</td>
<td>Supported</td>
</tr>
<tr>
<td>Cardboard</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Current support provided by Web browsers: webvr.rocks
### Chrome for Android

WebVR in Chrome for Android mobile

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samsung Gear VR</td>
<td>✗</td>
</tr>
<tr>
<td>Daydream</td>
<td>✓ Supported</td>
</tr>
<tr>
<td>Cardboard</td>
<td>✓ Supported</td>
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</tbody>
</table>

### Servo

Mozilla’s next-generation parallel, embedded browser engine

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</tr>
</tbody>
</table>
ubiquitous computing

Scales of devices

new proposals (Stefan Poslad, 2009)

dust – miniaturized devices without visual output

smartdust: a system of many tiny micro-electromechanical systems (MEMS) that can detect light, temperature, vibration, magnetism, chemicals,...
ubiquitous computing

Scales of devices

new proposals (Stefan Poslad, 2009)

skin – fabrics based upon light emitting, conductive, polymers, organic computer devices

smart clothes ➔ wearable computing
The Amazing FLUXX

FILLING HOSPITALS WITH HEROES

CRITICAL MAKING - SPRING 2015
CS 298, NWMedia 203

User Research
We interviewed two pediatric nurses to try and understand their daily interactions with patients.

"Children are scared that they are in a strange place, with strange people"

"A lot of dealing with children in pain is distraction techniques, if possible"

Which led us to ask...
How can we create a more positive healing experience for pediatric patients?

Xio, Oscar, Jonathan, Lia, Sangeetha

And then we got to work
The hardware team worked extensively to ensure the smallest possible size for all components

PEW! PEW!

www.hackster.io/team-fluxx/fluxx-005ac5
ubiquitous computing

Scales of devices

new proposals (Stefan Poslad, 2009)

clay – ensembles of MEMS that can be formed into arbitrary 3D shapes, resembling physical objects

remember tangible interfaces?
www.slideshare.net/Boltzmann/wearable-sensors-and-ux-development
ubiquitous computing: future

Brain-Computer Interface

direct communication between the brain and an external device

assisting, augmenting, or repairing human cognitive or sensory-motor functions
noninvasive brain–computer interface systems can restore functions lost to disability, allowing for spontaneous, direct brain control of external devices

doi.org/10.1371/journal.pbio.2003787
“Conclusion”

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

“Conclusion”

sensorial experience
natural user interfaces
multimodal interaction
ubiquitous computing

ukfiremag.mdmpublishing.com/how-augmented-reality-can-assist-fire-and-rescue-safety/
Good luck!