



Basics of Human-Computer Interaction

Human-Computer Interaction Lecture

Slides adapted from hci-lecture.org (A. Schmidt, N. Henze, K. Wolf, V. Schwind), Image from: Albrecht Schmidt



The following content is licensed under a Creative Commons Attribution 4.0 International license (CC BY-SA 4.0)

Human-Computer Interaction

- HCI determines **how humans use computer systems**
- For examples, it impacts...
 - › what we can do with products and services
 - › how easy or hard it is to work with a software or device
 - › how quickly you can learn to use a system
 - › how a system can support and augment human abilities
 - › how safe a product is
- **HCI is the central discipline** how we feel and what we experience while interacting with digital technologies

Which disciplines are related to HCI?

Discussion

Related Disciplines

Computer Science

AI

Computer Vision

Digital Imaging

Design

Language

Engineering

Ergonomics

Machine Learning

Social Sciences

HCI

GUIs

Art

Health

Usability

Games

Typography

Printing/Plotting

Cognition/ Perception

Displays

Psychology

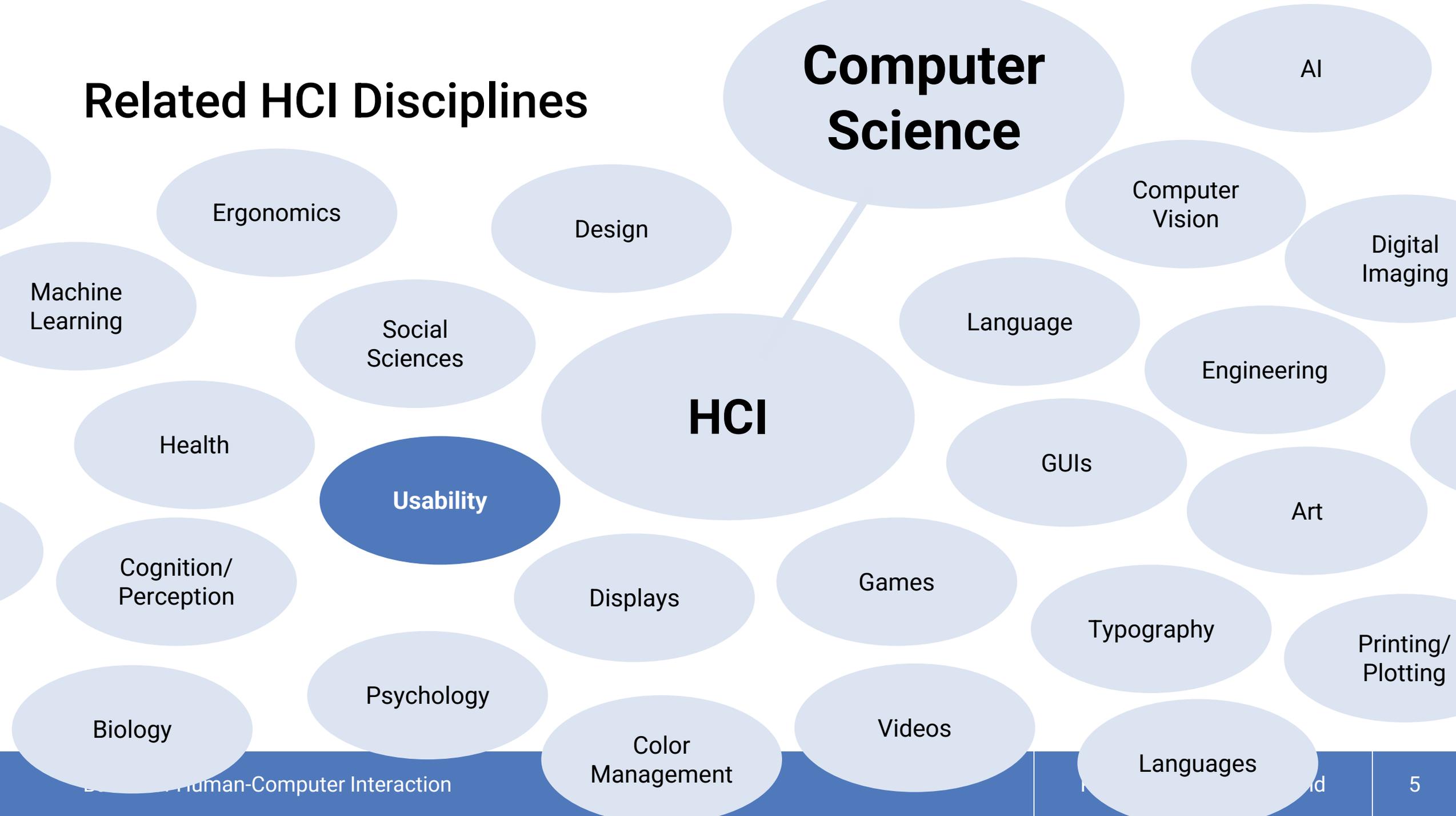
Videos

Languages

Biology

Color Management

Related HCI Disciplines



Computer Science

HCI

Usability

Ergonomics

Design

Social Sciences

Health

Cognition/
Perception

Psychology

Biology

Color
Management

Games

Videos

GUIs

Language

Computer
Vision

Engineering

Art

Typography

Printing/
Plotting

AI

Machine
Learning

Digital
Imaging

Why is Usability important?

- **Improving usability** can...
 - > **increase productivity** of users
 - > **reduce costs** (support, efficiency)
 - > **increase sales/revenue** (web shop)
 - > **enhance customer loyalty**
 - > **win new customers**
- Usability is often considered as **sign of quality and value**
- Usability gives a **competitive advantage**



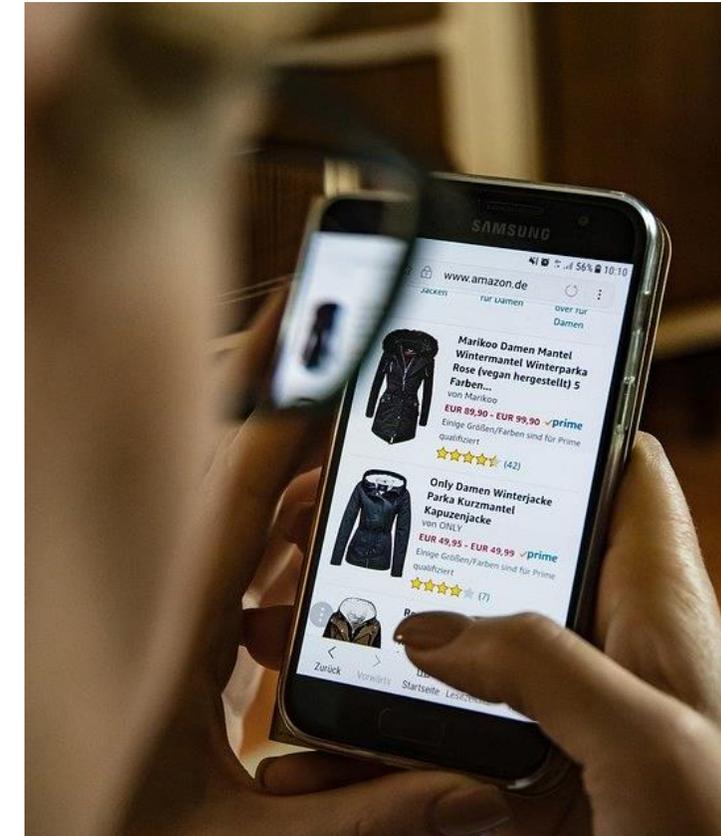
<https://pixabay.com/de/photos/grafik-diagramm-investitionen-4737109/>

When usability is so important why no one cares?

Discussion

The Value of Products

- Typical **product discrimination** is done by
 - › Price
 - › Functionality/Features
- Why should a customer pick you, if systems of competitors offer **similar functions** (e.g., messaging services) with **similar prices** (e.g., payed by advertising)?
 - › Is your system **easier** to use?
 - › Can you do tasks **faster**?
 - › Does your system provide **more fun** when you are doing something?



<https://pixabay.com/de/photos/online-shopping-kleidung-handy-2900303/>

Why Focusing on User and Interaction?

- It becomes **harder to discriminate technology**
 - › Availability of bandwidth, storage and processing
 - › New input and output technologies
 - › Computing becomes part of many traditional devices
 - › Willingness for training or learning applications decreases
 - › Life-style technologies are more and more digital
 - › Broad and diverse user groups
- **Majority of users is not interested in technology**
 - › New understanding of computing
 - Book by Ben Shneiderman: Leonardo's Laptop (2002)
 - › The old question: What can computers do?
 - › The new question: What can humans do with computers?



<https://commons.wikimedia.org/wiki/File:Photographer1850s.png>

Economic Dimensions of Usability?

- User Interface is often **the central discriminating factor**
- Often the same **product/service is sold at very similar prices**
- **Competition** is very close (just another app, browser tab, ...)
- **Comparison** is easily possible, Examples: Online-Shop
 - › Users who cannot find the product in the shop cannot buy it
 - › Users who can fill in the payment form are not going to buy
 - › Users who worry if the item fits them are less likely to buy
 - › Typically a direct correlation between usability and sales
- “Bad Usability is Like a Leaky Pipe”



<https://90percentofeverything.com/2006/11/13/bad-usability-is-like-a-leaky-pipe/>



Why do physical stores go broke?

Discussion

Zalando verwendet Cookies, um Ihnen den bestmöglichen Service zu gewährleisten. Wenn Sie auf der Seite weitersurfen stimmen Sie der [Cookie-Nutzung](#) zu. [Ich stimme zu.](#)

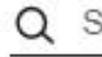
Wir liefern wie gewohnt. Nähere Informationen zur Lieferzeit findest du im Warenkorb.

DAMEN | HERREN | KINDER



Deutsch Anmelden

Get the Look NEU Bekleidung Schuhe Sport Accessoires Beauty Premium Marken **Sale %**



Europas größte Auswahl an Fashion & Trends

Entdecke über 2000 Marken und lass dich modisch inspirieren. Bestelle



Kostenlose Standardlieferung für alle
Einkäufe ab 25€! Lieferzeit: 4-6
Werktage*

Verlängertes Rückgaberecht: 100 Tage*

E-Geschenkkarte schenken



H&M setzt Cookies ein, um



Suchbegriff / Artikelnr. eingeben 🔍

- Service
- Mein Konto
- Merkzettel
- Warenkorb

Inspiration . Damen . Herren . Kinder . Wäsche/Bademode . Sport . Schuhe . Große Größen
 Multimedia . Haushalt . Küche . Heimtextilien . Möbel . Baumarkt . Spielzeug . Marken . %Sale%

Startseite | Damen | Bekleidung | **Blusen (9.340)** Seite 1 von 130 >

Blusen

15€ für Neukunden & Gratis-Liefer-Flat > Code 85845

- Carmenblusen (156)
- Chiffonblusen (262)
- Crinkleblusen (16)
- Druckblusen (1826)
- Flanellhemden (14)

Sortieren nach Topseller ▼



next

Produkt oder Marke suchen



Mein Konto | Quickshop | Hilfe ZUR K

SALE NEU MÄDCHEN JUNGEN BABY NACHTWÄSCHE DAMEN HERREN SCHUHE MARKEN HOME

WIR SIND WIE GEWOHNT FÜR SIE DA:
Bestellen Sie jetzt und profitieren Sie von kostenfreier Zustellung nach Hause*
*Es gelten die AGB



Concerns in Human-Computer Interaction

- **Science, engineering, and design**
- **Psychology** and **biases**
- The **joint performance of tasks** by humans and machines
- The **structure of communication** between humans and machines
- **Human capabilities** to use machines (including the learnability of interfaces)
- Engineering concerns that arise in **designing and building interfaces**
- The process of **specification, design, and implementation of interfaces**
- **Design trade-offs**
- **Algorithms** and **programming** of the user interface itself

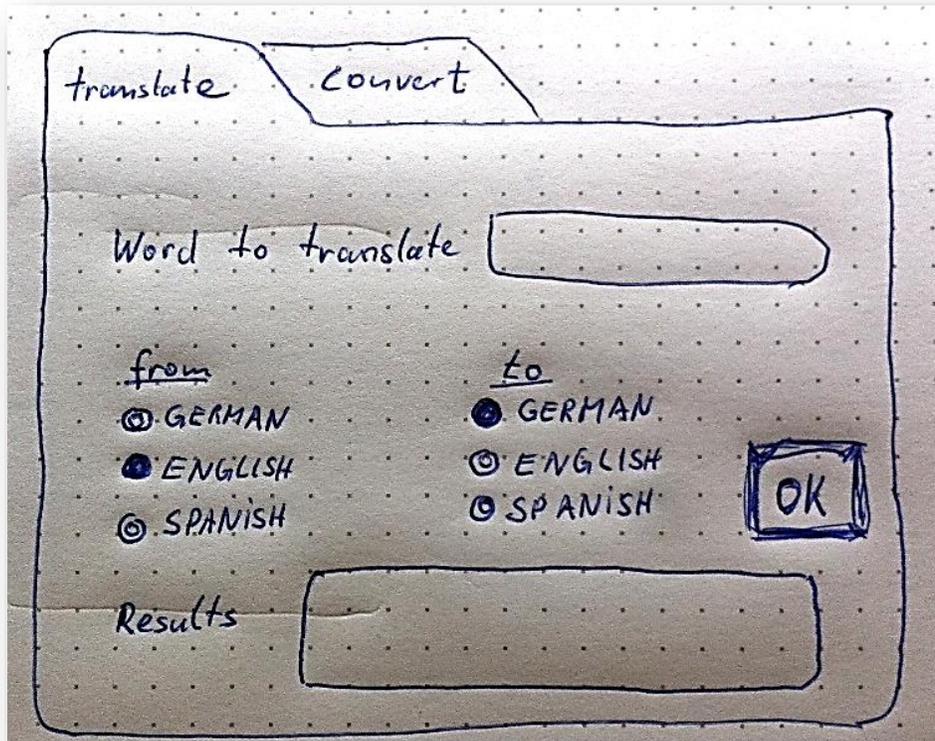
Discussion: Sketching an Interface

```
String translate(int fromLanguage, int toLanguage, String str)
// translate is a function that takes a word (str)
// the word is from a specific language (fromLanguage) and it
// translates it into a word into another language (toLanguage)
// Example: wordInSpanish = convert(1, 3, "Haus")
// fromLanguage is the language the word is from, toLanguage
// ist die target language (1=German, 2=English, 3=Spanish)

float convert(int fromCurrency, int toCurrency, float amount)
// convert is a function that takes a number (amount) of a specific
// currency (fromCurrency) and it converts it into a number
// (toCurrency) representing the amount in the target currency
// Example: myDollar = convert(6, 7, 19.23)
// fromCurrency ist initial currency and toCurrency is the target
// currency (6=Euro, 7=US Dollar, 8=Britisches Pfund)
```

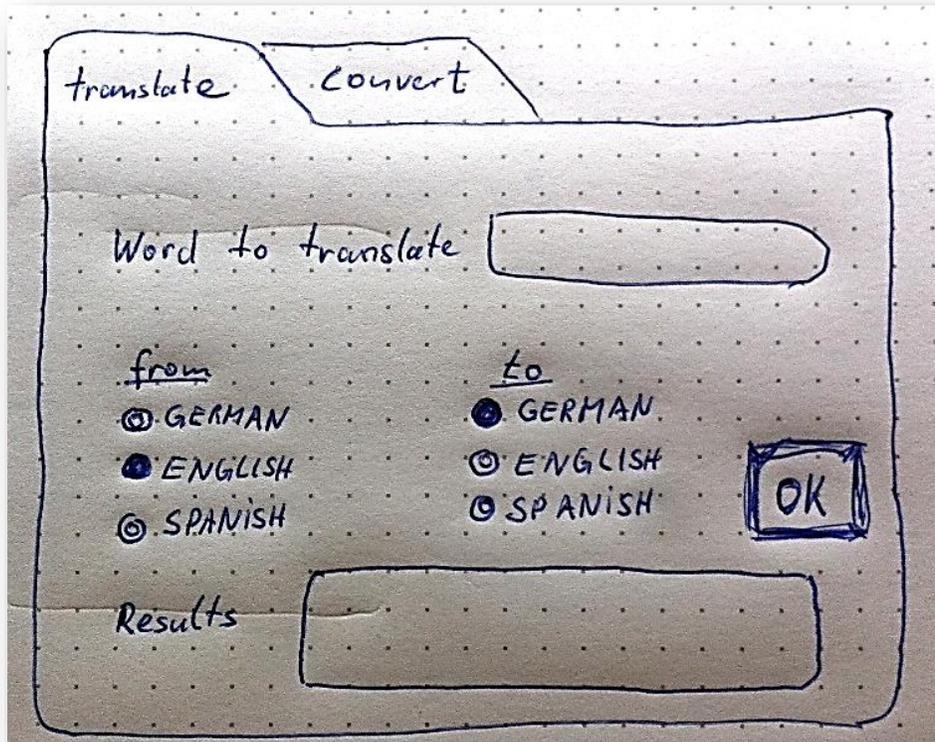
Sketching an interface (1)

```
String translate(int fromLanguage, int toLanguage, String str)
```

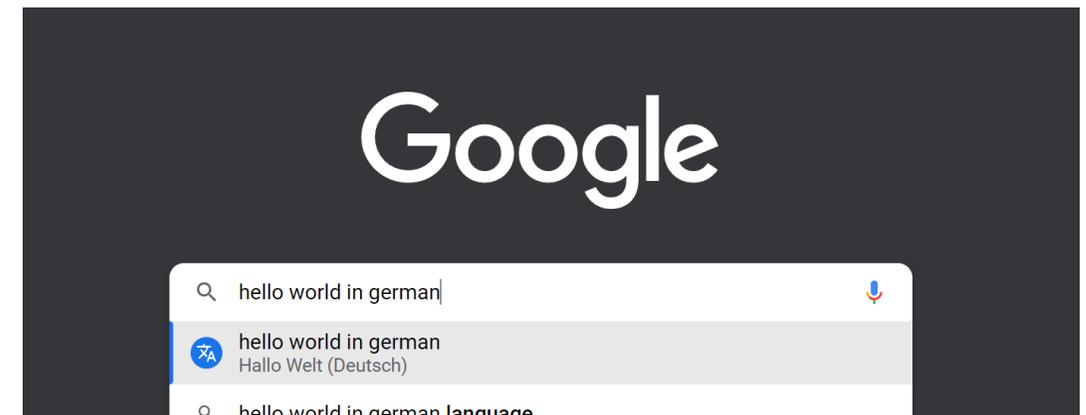
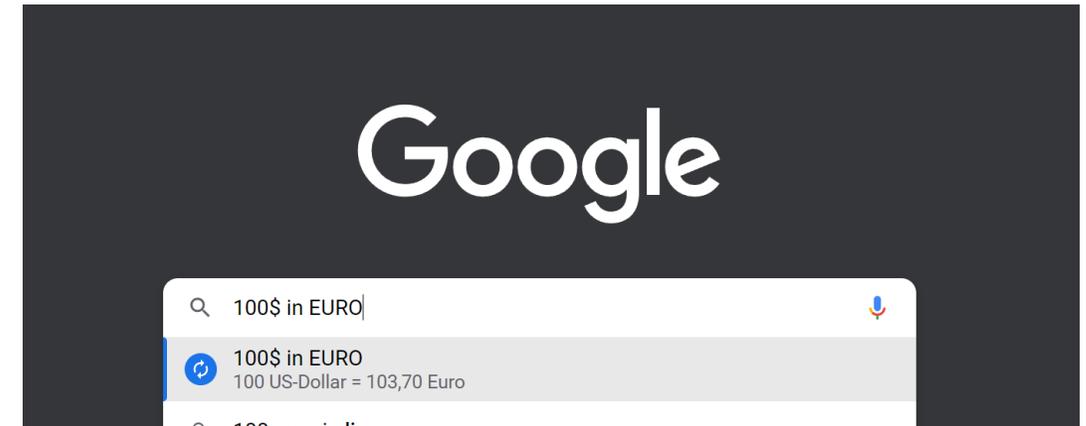


Sketching an interface (2)

```
String translate(int fromLanguage, int toLanguage, String str)
float convert(int fromCurrency, int toCurrency, float amount)
```



One Interface for Everything



It is NOT only about the user interface!

The screenshot shows the Amazon.de website's help section for returning an item. The browser address bar displays the URL: `www.amazon.de/fachbücher-fachbuch/b/ref=sd_allcat_tb?ie=UTF8&node=288100`. The page title is "Hilfe > Rückgabe > Einen Artikel zurückgeben". The main content area is titled "Einen Artikel zurückgeben" and contains the following text:

Diese Hinweise gelten nur für Artikel, die direkt von Amazon.de verkauft wurden, sowie für Artikel von Verkaufspartnern, deren Versand durch Amazon übernommen wurde ([Versand durch Amazon.de](#)). Informationen zur Rückgabe von Artikeln, die Sie über die Plattform Amazon.de Marketplace erworben haben und die direkt vom Verkäufer versandt wurden, finden Sie auf unseren [Hilfeseiten](#). **Bitte schicken Sie von Verkäufern versandte Marketplace-Artikel nicht an Amazon.de zurück.**

Kunden im Ausland finden für sie relevante Informationen auf unserer Hilfeseite [Rückgabe aus Ländern außerhalb Deutschlands](#).

Welche Fristen sind bei der Rücksendung von Artikeln zu beachten?
Wie gebe ich einen Artikel zurück, den ich selbst bestellt habe?
Wie gebe ich einen Artikel zurück, den ich nicht bestellt habe?
Kann ich den erhaltenen Artikel umtauschen?
Wie reklamiere ich einen defekten, beschädigten oder falschen Artikel?

Welche Fristen sind bei der Rücksendung von Artikeln zu beachten?

Widerrufsrecht: Sie können Ihre Bestellung **innerhalb von zwei Wochen** ohne Angabe von Gründen widerrufen (die vollständige Widerrufsbelehrung und weitere Informationen zum Widerrufsrecht finden Sie in unseren [AGBs](#)). Der Widerruf kann auch online durch Nutzung unseres [Online-Rücksendezentrums](#) erfolgen.

Freiwillige Rücknahmegarantie: Unabhängig von Ihrem Widerrufsrecht können Sie sämtliche Produkte aus den Amazon.de-Shops **innerhalb von 30 Tagen** ab Erhalt der Ware an Amazon.de zurücksenden, sofern die Ware vollständig ist und sich in ordentlichem Zustand befindet. Bitte nutzen Sie dazu unser [Online-Rücksendezentrum](#).

The page also features a search bar with "Hilfe" entered, a sidebar with navigation links, and a "Hilfe zur Selbsthilfe" section with various self-help options.

The Problem with Problems

■ Problems

- › no need to solve them because of reasons...
- › often not seen as problem before there is a solution
- › if problems are identified, are they typically easy to understand?

■ Solutions

- › once a solution is there, people will generally not remember that there was a problem
- › good and in particular great solutions often appear obvious

■ However, the step from problem to solution is not trivial

- › **often forgotten**, once there is a solution

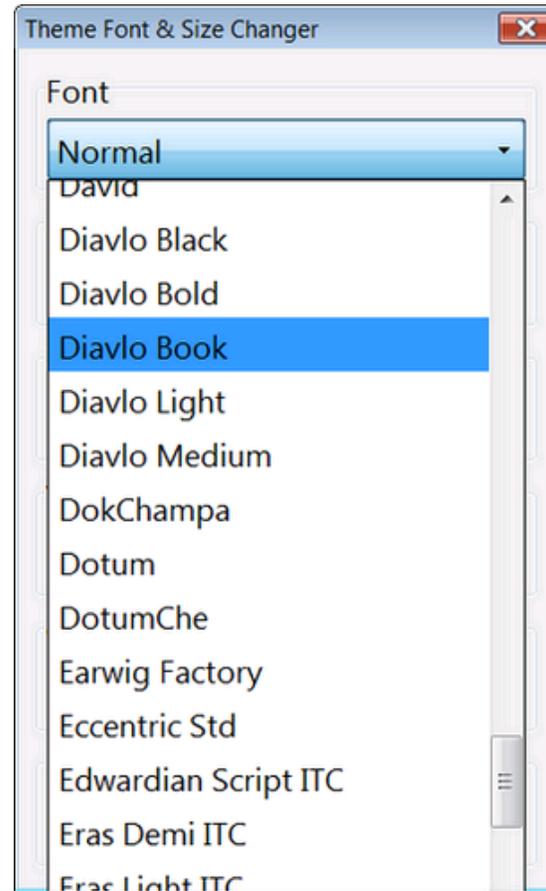
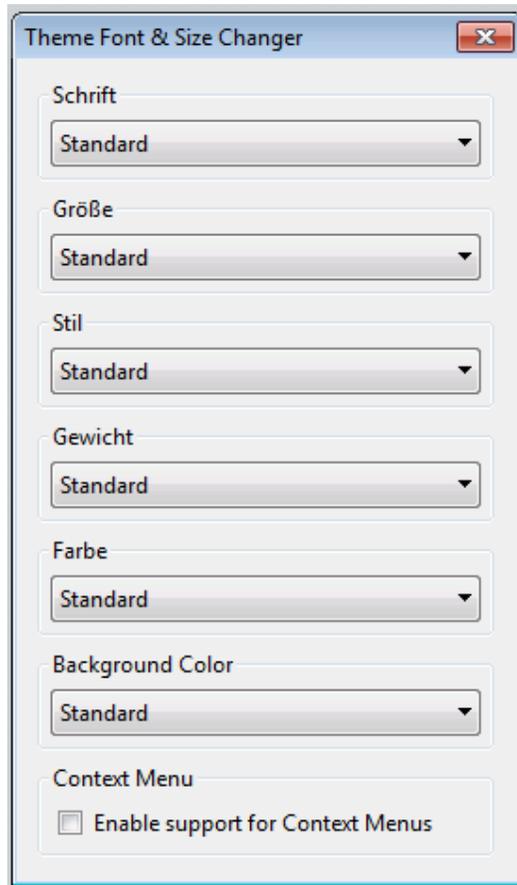


<https://www.metmuseum.org/art/collection/search/398598>

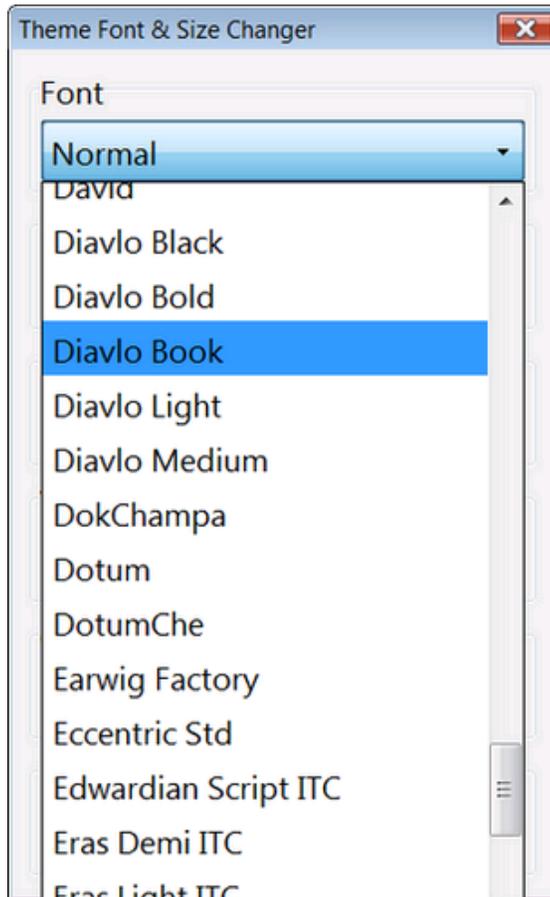


Selection/Menu for Fonts (1)

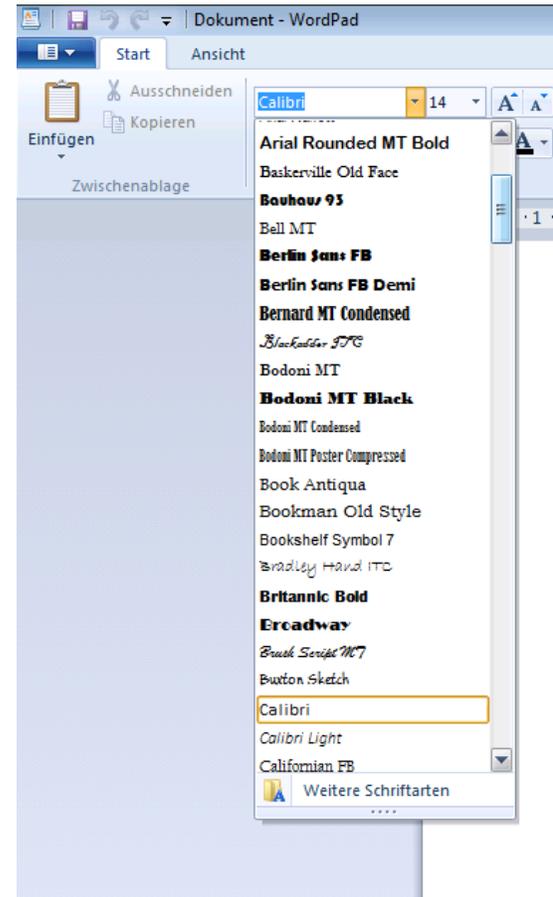
Is there a Problem? How to improve it?



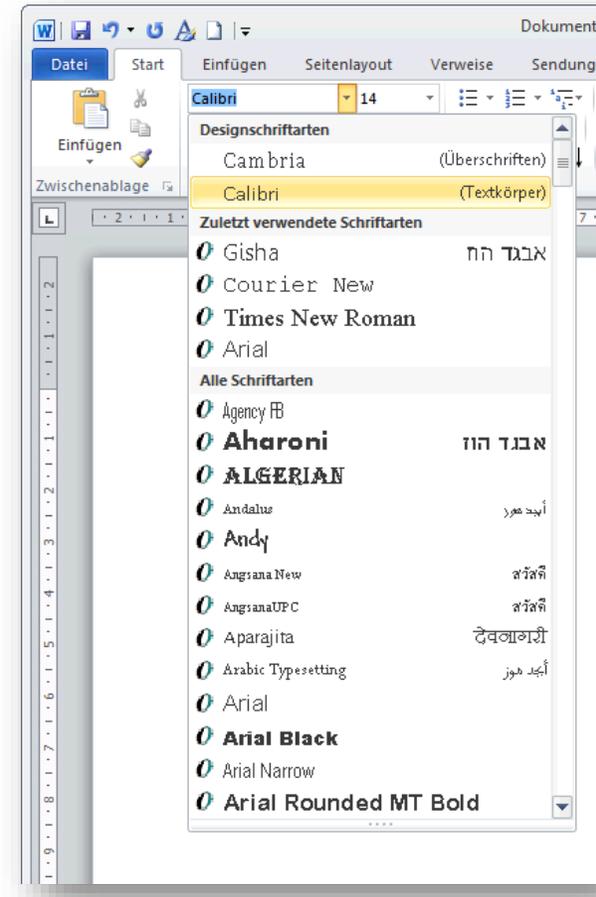
Selection/Menu for Fonts (2)



<https://addons.mozilla.org/en-US/firefox/addon/theme-font-size-changer/>



WordPad/Win7



Microsoft Office Professional Plus 2010

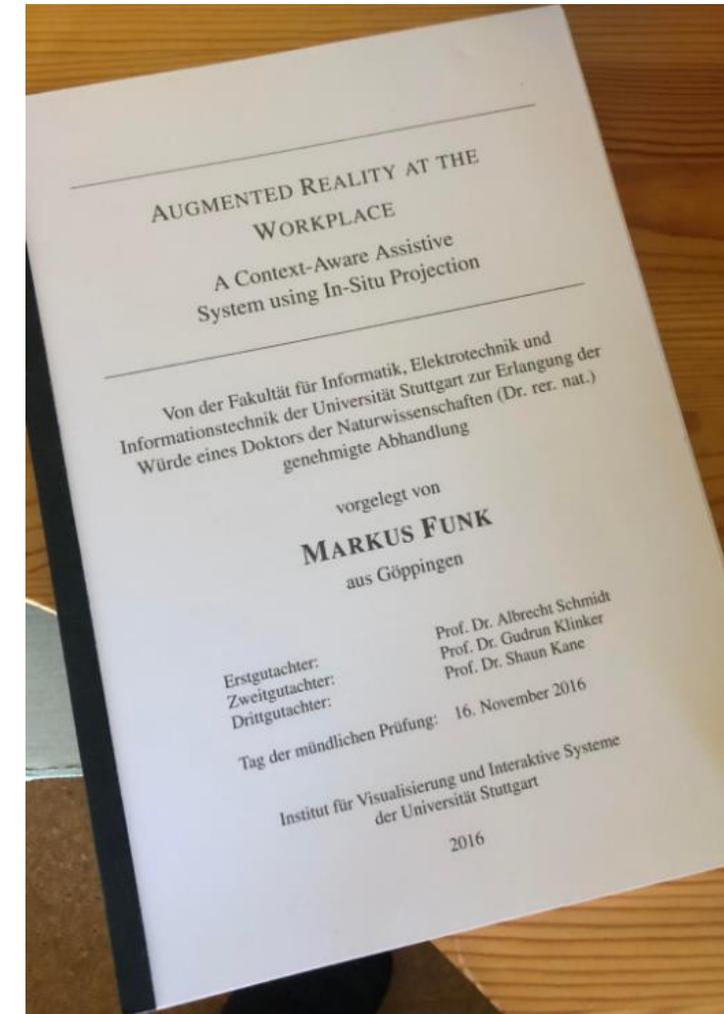
Writing a Thesis

■ Assume the following:

- › Your thesis will have 40.000 words
- › The average typing speed for physical keyboards is ca. 50 words per minute (WPM)
 - › 13.3 hours (you are done in 2 days!)
- › Your typing speed for phone keyboard is ca. 35 words per minute
 - › 19.0 hours (you are also done in 2 days!)

■ Can you write a thesis in 2 days?

- › Why does this calculation make no sense?
- › What are we missing here?



Summary

- **Interfaces and interaction design**
 - › define how we can use devices, services, and applications
 - › impact the performance of the user
- It is important to **understand the way how people use a system** as a tool to achieve their goals
- **Understanding aspects of human-computer interaction is relevant** as it becomes harder to differentiate products based on features and can have huge social impact
- Good **usability is economically important**
- Innovations in HCI are **highly visible**



A Brief History of HCI

Human-Computer Interaction Lecture

Image from: Computermuseum, Fakultät Informatik, Universität Stuttgart



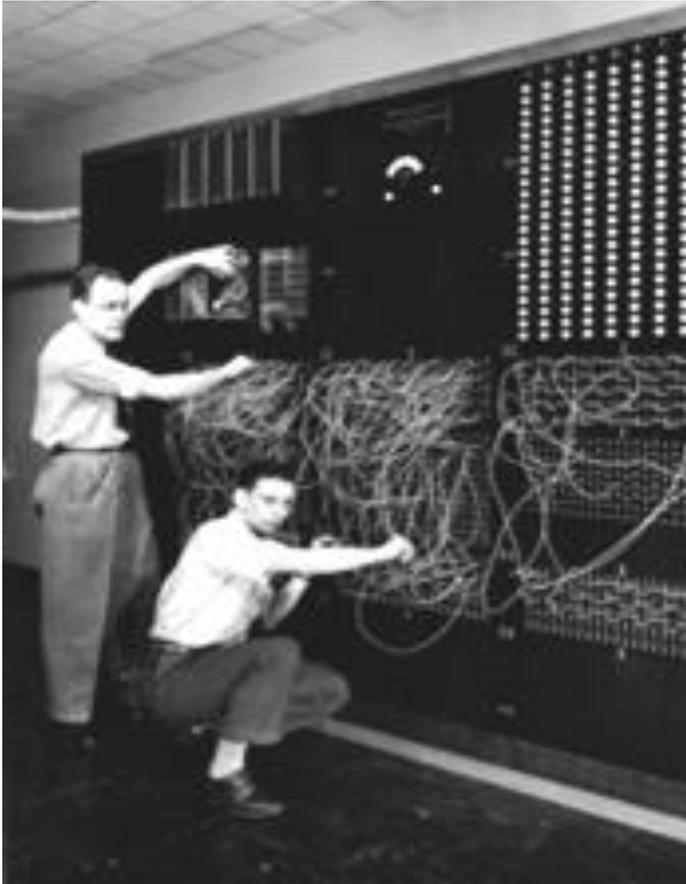
The following content is licensed under a Creative Commons Attribution 4.0 International license (CC BY-SA 4.0)



Timeline of Important Technologies

- **1945**: Vannevar Bush: “As We May Think”, MEMEX
- **1950**: Whirlwind with cathode ray tube (CRT)
- **1955**: SAGE Radar with CRT and light pen
- **1962**: “Spacewar”: video game on a PDP-1 computer with joystick
- **1963**: I. Sutherland’s “Sketchpad” (interactive 2D CAD system)
- **1968**: D. Engelbart: computer supported cooperative work (CSCW)
- **1969**: I. Sutherland: virtual reality (VR), head-mounted display (HMD)
- **1973**: Xerox Alto – implementation of a graphical user interface
- **1981**: Xerox Star – Fully functional graphical user interface
- **1982**: Apple Lisa
- **1984**: Apple Mac – first commercially successful GUI
- **1984**: X Window system

Early Computer Operators and Engineers



Images from: <http://www.computerhistory.org>

Timeline in HCI – The User’s Perspective

1950: Experimental computers, specific tasks interface at the hardware level for engineers (switch panels)

1960, 1970: Batch / offline mode; punch cards / printer interface at the programming level (COBOL, FORTRAN)

1970, 1980: Timesharing / text terminals (IBM 3270, DEC VT100) interface at the terminal level (command languages)

1980, 1990: Raster graphics / GUI on PCs / workstations interface at the interaction dialogue level (GUIs, multimedia)

2000: Multimedia: graphics, video, and audio; internet, interface at the work setting (networked systems, groupware)

2010: Mobile, Wearable, Embedded, Ubiquitous interface is pervasive, everywhere, and more and more Natural

Vannevar Bush

- **As we may think** (1945): an article in Atlantic Monthly
 - › Sees the problem of storing, accessing, distributing, and annotating information
 - › Understands the wealth of large amounts of information and easy access to it
 - › Identifies organization of information as key issue

“Consider a future device ... in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory.” - by Vannevar Bush



Video explaining the concept:

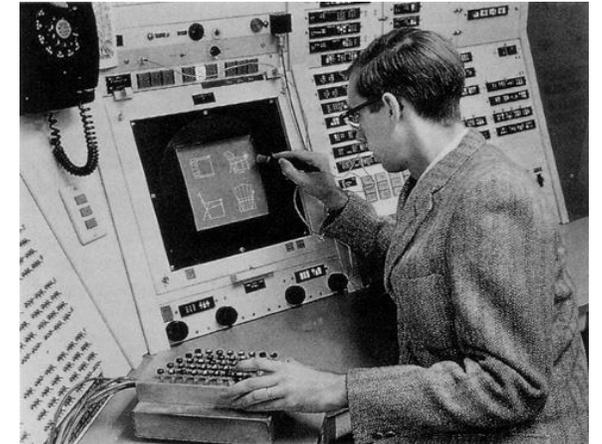
<http://www.youtube.com/watch?v=c539cK58ees>

Recommended further reading:

<http://www.theatlantic.com/magazine/archive/1945/07/as-we-may-think/3881/>

Ivan Sutherland

- **SketchPad** (1963)
 - › Drawing package
 - › User interface included:
 - › icons,
 - › copying,
 - › light-pen input
 - › Development based on “OO”-principles
 - › Many ideas are still in use
- **3D Head-Mounted Display** (1965-1970)
 - › 3D “visualization” (very basic)
 - › Large apparatus

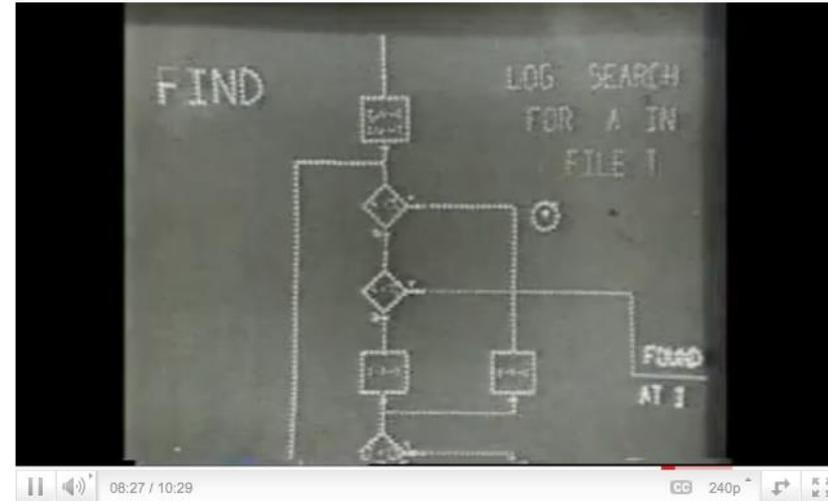


Ivan Sutherland: Sketchpad



Part 1 of 2

http://www.youtube.com/watch?v=USyoT_Ha_bA



Part 2 of 2

<http://www.youtube.com/watch?v=BKM3CmRqK2o>

Sketchpad, A Man-Machine Graphical Communication System

Ivan Sutherland's Ph.D. Thesis from Massachusetts Institute of Technology 1963.

Republished by University of Cambridge in 2003 as Technical Report Number 574

<http://www.cl.cam.ac.uk/TechReports/UCAM-CL-TR-574.pdf>

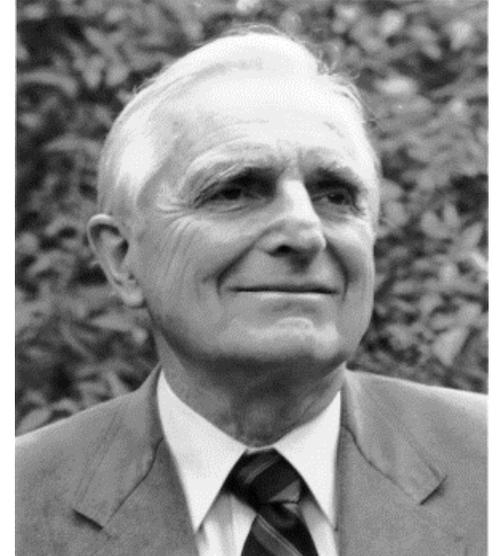
Douglas Engelbart: The Mother of All Demos (1968)



The Mother of All Demos, presented by Douglas Engelbart (1968)

Douglas Engelbart: Augmenting Human Intellect

- A Conceptual **Framework for Augmenting Human Intellect** (SRI Report, 1962)
- Provides an **understanding of the need for collaborative** (several potentially distributed people together) and **immediate problem solving**
- A key issue is to **improve peoples' abilities** to make use of information



Rainer Mallebrein: RKS

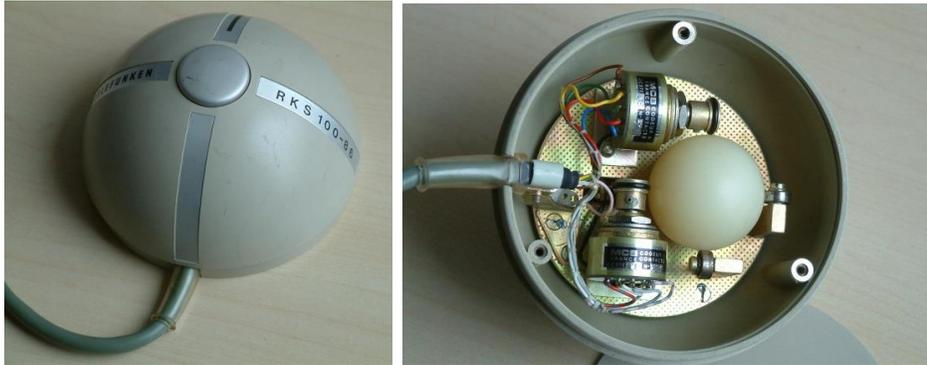
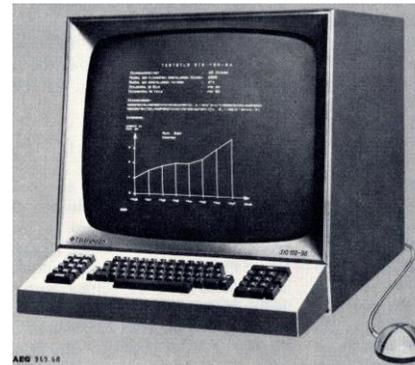


Image: Computermuseum,
Fakultät Informatik,
Universität Stuttgart



Der SIG-100 mit Rollkugel
Image: Computerschauausammlung der
FH Kiel



Die Computer Maus - eine deutsche Erfindung - Interview
mit Rainer Mallebrein

https://www.youtube.com/watch?v=Pja-ytuk_s

Hiroshi Ishii: Tangible Bits / Radical Atoms



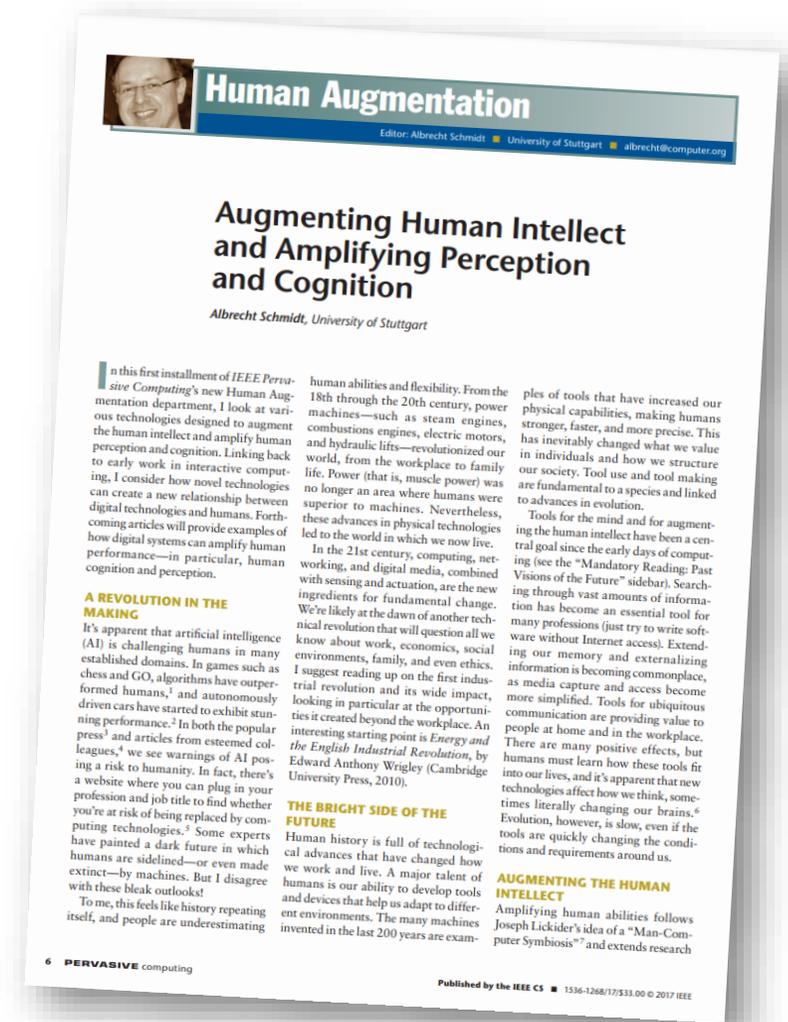
Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms. (Hiroshi Ishii and Brygg Ullmer – MIT Media Laboratory – Tangible Media Group)



Radical Atoms: Beyond the "Pixel Empire" | Hiroshi Ishii | TEDxTokyo

<https://www.youtube.com/watch?v=9mFw5uQsjpA>

Albrecht Schmidt: Amplifying Perception



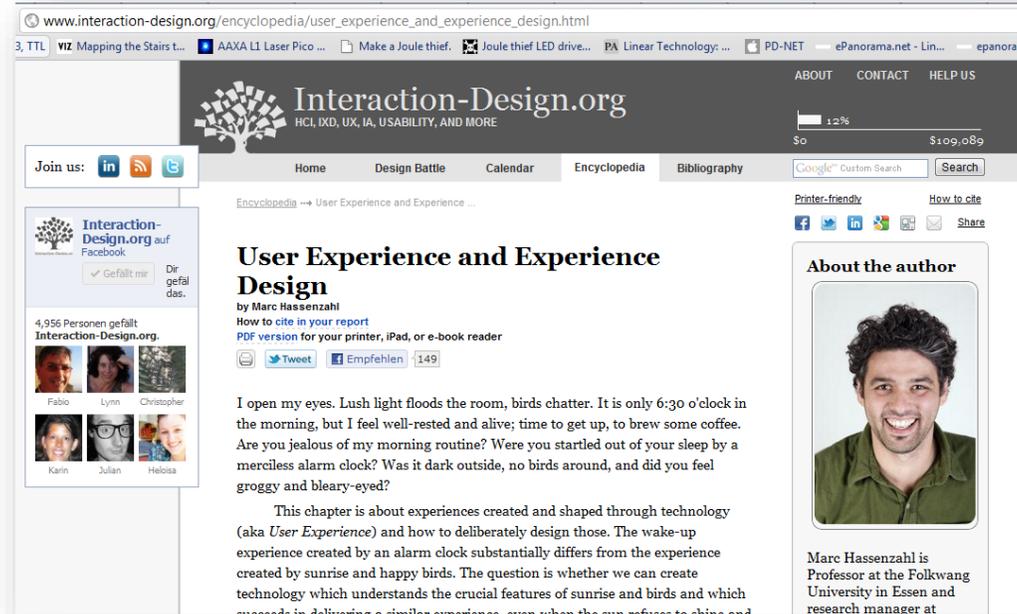
A. Schmidt, "Augmenting Human Intellect and Amplifying Perception and Cognition," in IEEE Pervasive Computing, vol. 16, no. 1, pp. 6-10, Jan.-Mar. 2017, doi: 10.1109/MPRV.2017.8.

Marc Hassenzahl: User Experience in Detail



Video 3.1: Marc's introduction to User Experience and Experience Design.

Courtesy of Rikke Friis Dam and Mads Soegaard. Copyright: CC-Att-ND (Creative Commons Attribution-NoDerivs 3.0 Unported). View full screen version on youtube. View transcription/captions.



Hassenzahl, Marc (2013): User Experience and Experience Design. In: Soegaard, Mads and Dam, Rikke Friis (eds.). "The Encyclopedia of Human-Computer Interaction, 2nd Ed.". Aarhus, Denmark: The Interaction Design Foundation.

http://www.interaction-design.org/encyclopedia/user_experience_and_experience_design.html

Effie Lai-Chong Law, Virpi Roto, Marc Hassenzahl, Arnold P.O.S. Vermeeren, and Joke Kort. 2009. Understanding, scoping and defining user experience: a survey approach. In Proceedings of the 27th international conference on Human factors in computing systems(CHI '09). ACM, New York, NY, USA, 719-728. DOI=10.1145/1518701.1518813

<http://doi.acm.org/10.1145/1518701.1518813>

Approaches to Human-Computer Interaction

- **Programming level**
- **Command language level**
- **Dialogue level** (forms, questions & answers)
- **Direct manipulation of digital elements**
- **Tangible interaction**
- **Cognition and perception**
- **Human-Robot Interaction**
- **Cooperation & Collaboration**

More People in HCI

- J.C.R. Licklider
 - › man-computer symbiosis (1960)
 - › Interactive computing
- Alan Kay
 - › Vision of a notebook computer Dynabook (1969)
 - › Mockup to convey the idea
 - › Computing for everyone
- Jakob Nielsen
 - › Usability principles
- Dan Norman
 - › *“People are so adaptable that they are capable of shouldering the entire burden of accommodation to an artifact, but skillful designers make large parts of this burden vanish by adapting the artifact to the users.”*

Lessons Learned from History

- **Technology drives new user interface concepts and interaction metaphors**
- New user interfaces create **new applications**
- Interaction designs and user interface concepts evolve
- **You can not hide the user interface** - good ideas spread out
- **User will never ignore the user interfaces**
- The first to come out with a new user interface is not necessarily the most successful



Terms and Definitions

Human-Computer Interaction Lecture

Image from: pxhere.com



The following content is licensed under a Creative Commons Attribution 4.0 International license (CC BY-SA 4.0)

Human-Computer Interaction

- Definition by Wikipedia [1]:
 - › “Human–computer interaction (HCI) **is research in the design and the use of computer technology, which focuses on the interfaces between people (users) and computers. HCI researchers observe the ways humans interact with computers and design technologies that allow humans to interact with computers in novel ways. A device that allows interaction between human being and a computer is known as a "Human-computer Interface (HCI)".**
 - › As a field of research, human–computer interaction is **situated at the intersection of computer science, behavioral sciences, design, media studies,** and several other fields of study. The term was popularized by Stuart K. Card, Allen Newell, and Thomas P. Moran in their 1983 book, *The Psychology of Human–Computer Interaction.*”
- Definition in the ACM SIGCHI Curricula for HCI, 1992 [2]:
 - › “Human-computer interaction is a discipline concerned with the **design, evaluation and implementation of interactive computing systems for human use** and with the study of major phenomena surrounding them.”

[1] https://en.wikipedia.org/wiki/Human%E2%80%93computer_interaction

[2] Thomas T. Hewett, Ronald Baecker, Stuart Card, Tom Carey, Jean Gasen, Marilyn Mantei, Gary Perlman, Gary Strong, and William Verplank. 1992. ACM SIGCHI Curricula for Human-Computer Interaction. Technical Report. Association for Computing Machinery, New York, NY, USA.

Interactive Systems

- An **interactive system** is a computational system that allows users to interact in real-time¹. Interactions provide instant feedback visible to the user.
- The term **interactive computing** is used in a similar way, with a focus that is less on the systems aspect. Examples:
 - › Graphical user interfaces, such as Windows 10 or MacOS
 - › Mobile devices, such as an Android phone
 - › Gaming consoles, such as Xbox with Kinect or Nintendo Switch
 - › Ticket vending machines, such as the DB-ticket machine
 - › Command line interfaces, such as an SSH console

Discussion: What is an Interactive System?

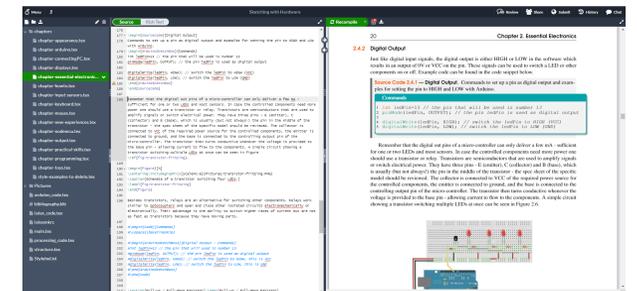
- Which of the following devices and applications can be considered an interactive system?*

- › Why can they be considered an interactive systems?
- › Why may they be not considered an interactive system?

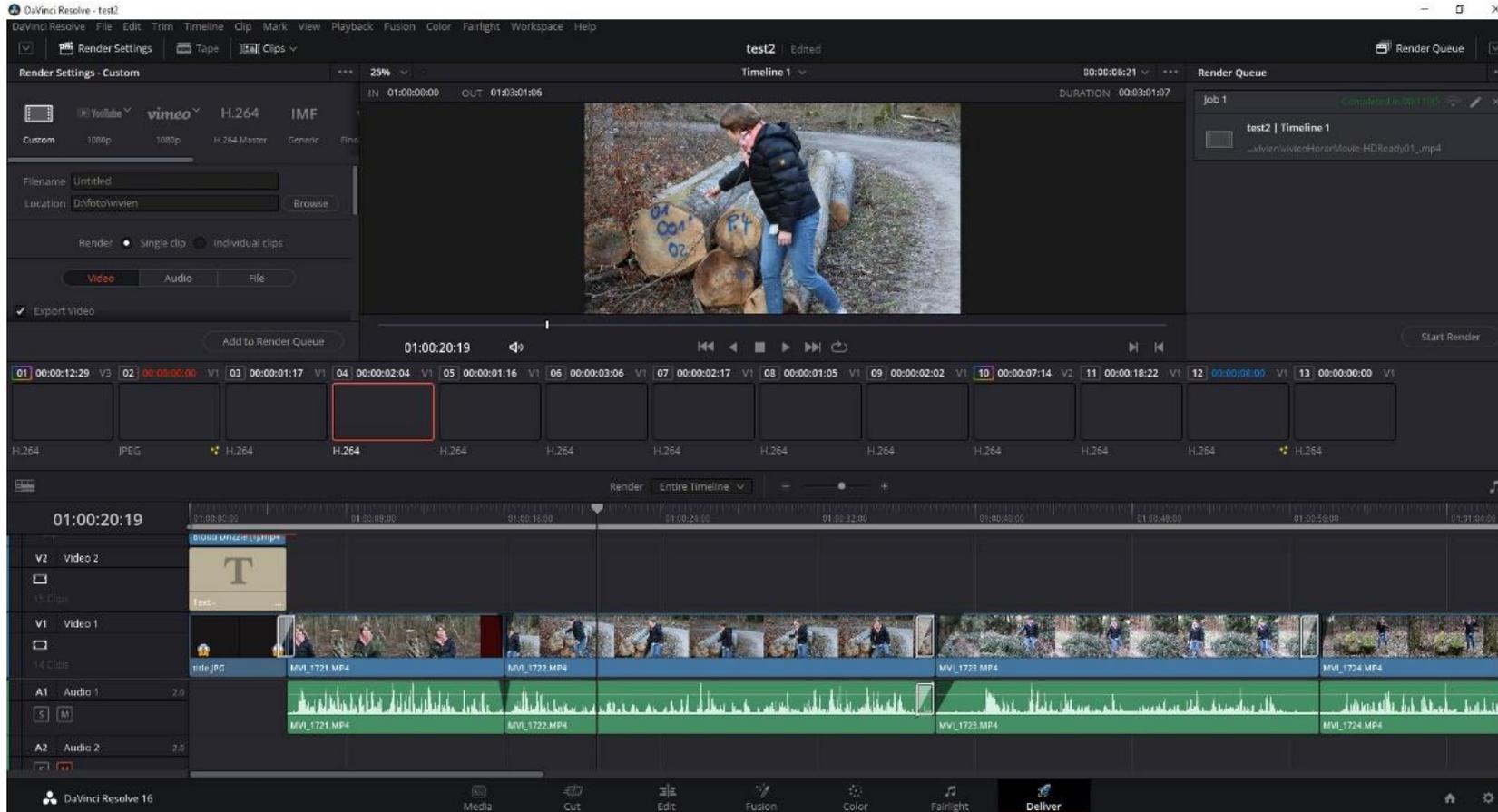
- Discuss one of the following

1. Professional video editing tool
2. Electronic signage at the railway station
3. Latex text processing system

**There may be not 'yes' or 'no' answer. Consider different aspects and think how the design impacts whether or not this is perceived as an interactive system.*



Discussion: What is an Interactive System? (1)



Discussion: What is an Interactive System? (2)



Discussion: What is an Interactive System? (3)

The screenshot shows the 'Sketching with Hardware' IDE. The left pane displays a file explorer with a tree view of chapters, including 'chapter-essential-electronic...'. The main editor shows LaTeX source code for a document section on digital output. The code includes comments and LaTeX commands for including a figure and a code block. The right pane shows the rendered PDF of 'Chapter 2. Essential Electronics', specifically section 2.4.2 'Digital Output'. The PDF text explains that digital output is either HIGH or LOW and provides an example code snippet. Below the text is a photograph of an Arduino Uno board connected to a breadboard circuit with several LEDs and resistors.

```
176
177 - \begin{sourcecode}[Digital Output]
178 Commands to set up a pin as digital output and examples for setting the pin to HIGH and LOW
with Arduino.
179 - \begin{ArduinosketchBox}[Commands]
180 int ledPin=13 // the pin that will be used is number 13
181 pinMode(ledPin, OUTPUT); // the pin ledPin is used as digital output
182
183 digitalWrite(ledPin, HIGH); // switch the ledPin to HIGH (VCC)
184 digitalWrite(ledPin, LOW); // switch the ledPin to LOW (GND)
185 \end{ArduinosketchBox}
186 \end{sourcecode}
187
188 Remember that the digital out pins of a micro-controller can only deliver a few mA -
sufficient for one or two LEDs and most sensors. In case the controlled components need more
power one should use a transistor or relay. Transistors are semiconductors that are used to
amplify signals or switch electrical power. They have three pins - E (emitter), C
(Collector) and B (base), which is usually (but not always!) the pin in the middle of the
transistor - the spec sheet of the specific model should be reviewed. The collector is
connected to VCC of the required power source for the controlled components, the emitter is
connected to ground, and the base is connected to the controlling output pin of the
micro-controller. The transistor then turns conductive whenever the voltage is provided to
the base pin - allowing current to flow to the components. A simple circuit showing a
transistor switching multiple LEDs at once can be seen in Figure
\ref{fig:transistor-fritzing}.
189
190 - \begin{figure}[h]
191 \centering\includegraphics[scale=0.6]{Pictures/transistor-fritzing.PNG}
192 \caption{Schemata of a transistor switching four LEDs.}
193 \label{fig:transistor-fritzing}
194 \end{figure}
195
196 Besides transistors, relays are an alternative for switching other components. Relays work
similar to optocouplers and open and close other isolated circuits electromechanically or
electronically. Their advantage is the ability to switch higher rates of current but are not
as fast as transistors because they have moving parts.
197
198 \begin{code}[Commands]
199 \vspace{\baselineskip}
200
201 \begin{ArduinosketchBox}[Digital Output - Commands]
202 \int ledPin=13 // the pin that will used is number 13
203 pinMode(ledPin, OUTPUT); // the pin ledPin is used as digital output
204 digitalWrite(ledPin, HIGH); // switch the ledPin to HIGH, this is VCC
205 digitalWrite(ledPin, LOW); // switch the ledPin to LOW, this is GND
206 \end{ArduinosketchBox}
207 \end{code}
208
209
210 - \section[Pull-up / Pull-down Resistor]{index[Pull-up / Pull-down Resistor]}
```

Chapter 2. Essential Electronics

2.4.2 Digital Output

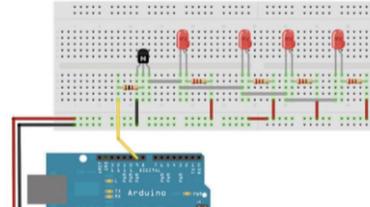
Just like digital input signals, the digital output is either HIGH or LOW in the software which results in an output of 0V or VCC on the pin. These signals can be used to switch a LED or other components on or off. Example code can be found in the code snippet below.

Source Code 2.4.1 — Digital Output. Commands to set up a pin as digital output and examples for setting the pin to HIGH and LOW with Arduino.

Commands

```
1 int ledPin=13 // the pin that will be used is number 13
2 pinMode(ledPin, OUTPUT); // the pin ledPin is used as digital output
3
4 digitalWrite(ledPin, HIGH); // switch the ledPin to HIGH (VCC)
5 digitalWrite(ledPin, LOW); // switch the ledPin to LOW (GND)
```

Remember that the digital out pins of a micro-controller can only deliver a few mA - sufficient for one or two LEDs and most sensors. In case the controlled components need more power one should use a transistor or relay. Transistors are semiconductors that are used to amplify signals or switch electrical power. They have three pins - E (emitter), C (collector) and B (base), which is usually (but not always!) the pin in the middle of the transistor - the spec sheet of the specific model should be reviewed. The collector is connected to VCC of the required power source for the controlled components, the emitter is connected to ground, and the base is connected to the controlling output pin of the micro-controller. The transistor then turns conductive whenever the voltage is provided to the base pin - allowing current to flow to the components. A simple circuit showing a transistor switching multiple LEDs at once can be seen in Figure 2.6.



The User Interface

- The part of a system where a user can **interact** with a **system, device or application**. The user interfaces can support **input, output or both**.
 - › User interfaces are not restricted to digital technologies or interactive systems
- **Similar terms:**
 - › Human-computer interface (HCI)
 - › Man-machine interface (MMI) or Human-Machine-Interface (HMI)
- **Examples:**
 - › Graphical user interface (GUI) on a web page
 - › Voice user interface in a smart speaker (e.g. Alexa)
 - › Buttons, switches, wheels and levers in a cockpit



User, Interactive System, and User Interface [1]

- **User**: the person who interacts with a system, product or service.
- **Context of Use**: the combination of users, goals and tasks, resources, and environment.
- **Interactive System**: the combination of hardware and/or software and/or services and/or people that users interact with in order to achieve specific goals.
- **User Interface**: all components of an interactive system (software or hardware) that provide information and controls for the user to accomplish specific tasks with the interactive system.

[1] ISO 9241-210:2019 Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems <https://www.iso.org/standard/77520.html>

Usability, User Experience and Human-Centred Design

- **Usability:** extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.
- **User Experience:** user's perceptions and responses that result from the use and/or anticipated use of a system, product or service.
- **Human-Centred Design:** approach to systems design and development that aims to make interactive systems more usable by focusing on the use of the system and applying human factors/ergonomics and usability knowledge and techniques.

<https://www.iso.org/obp/ui/#iso:std:iso:9241:-210:ed-2:v1:en>

Utility, Usability, Likeability, Affordance

- **Utility:** a product can be used to reach a certain goal or to perform a certain task. This is essential!
- **Usability:** relates to the question of quality and efficiency. E.g. how well does a product support the user to reach a certain goal or to perform a certain task.
 - › “Usability is a quality attribute that assesses how easy user interfaces are to use. The word ‘usability’ also refers to methods for improving ease-of-use during the design process.” – Usability 101 by Jakob Nielsen
- **Likeability:** this may be related to utility and usability but not necessarily. People may like a product for any other reason...
- **Affordance:** what the system offers to an individual or the “functional tinting” of a perceiver with respect to its stimuli.

Jakob Nielsen's Alertbox, August 25, 2003: Usability 101: Introduction to Usability <https://www.nngroup.com/articles/usability-101-introduction-to-usability/>

Term: Affordance

“A fruit says ‘Eat me’; water says ‘Drink me’; thunder says ‘Fear me’...”

THE ORIGIN OF THE CONCEPT OF AFFORDANCES

The Gestalt psychologists recognized that the meaning or value of a thing seems to be perceived just as immediately as its color. The value is clear on the face of it, as we say, and thus it has a *physiognomic* quality in the way that the emotions of a man appear *on his face*. To quote from the *Principles of Gestalt Psychology* (Koffka, 1935): “Each things says what it is . . . a fruit says ‘Eat me’; water says ‘Drink me’; thunder says ‘Fear me’; and woman says ‘Love me’ [p. 7].” These values are a vivid and essential feature of the experience itself. Koffka did not believe that a meaning of this sort could be explained as a pale context of memory images or an unconscious set of response tendencies. The postbox “invites” the mailing of a letter, the handle “wants to be grasped,” and things “tell us what to do with them [p. 353].” Hence they had what Koffka called “demand character.”

77.

J. J. Gibson (1975). 'Affordances and behavior'. In E. S. Reed & R. Jones (eds.), *Reasons for Realism: Selected Essays of James J. Gibson*, pp. 410-411. Lawrence Erlbaum, Hillsdale, NJ, 1 edn.

3

The Theory of Affordances¹

James J. Gibson

Cornell University

A description of what the environment *affords* the animal can be given in terms of a list beginning with simple and ending with complex things. Such a list includes features of the terrain, shelters, water, fire, objects, tools, other animals, and human displays. In addition, the information that is available in ambient light for the perception of substances, their surfaces, and the layout of these surfaces must also be described. An attempt should also be made to connect the two, to show that the variables of substances and layout combine to make affordances for animals and to demonstrate that the optical information for perceiving the variables combines to yield information for perceiving the affordances. What is being attempted is an explanation of how the “values” or “meanings” of things in the environment could be directly perceived.

What is meant by *an affordance*? A definition is in order, especially since the word is not to be found in any dictionary. Subject to revision, I suggest that *the affordance of anything is a specific combination of the properties of its substance and its surfaces taken with reference to an animal*. The reference may be to an animal in general as distinguished from a plant or to a particular species of animal as distinguished from other species. Note that the properties of substance and surface are physical properties but that they are not described in classical physics, only in ecological physics. The combination of properties is uniquely related to the animal or species being considered. It is assumed that if the properties of substance and surface are given in light the combination is given, and hence that if the properties are perceivable the special set of properties will be perceivable. In fact we can entertain the hypothesis that the affordance may be more easily perceived by an animal than the properties in isolation, for the

¹This is a preliminary version of a chapter from a forthcoming book entitled *An Ecological Approach to Visual Perception* to be published by Houghton-Mifflin Co.

67

Affordance

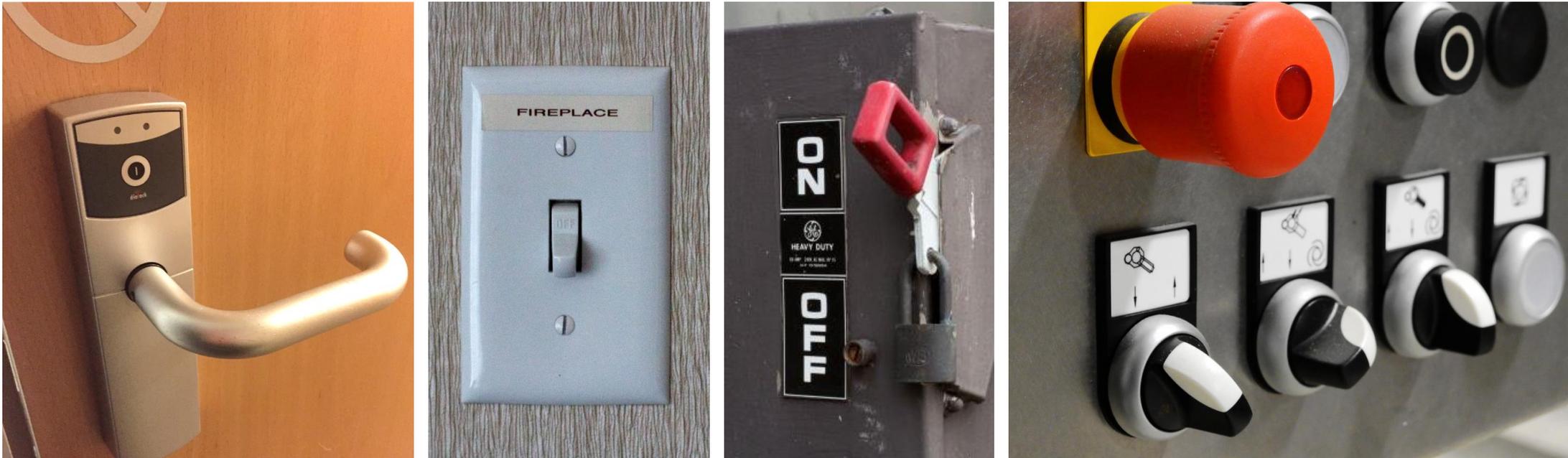
- Donald Norman brought the term into HCI and added the concept of signifiers [1]
 - › **Affordances** determine *what actions* are possible
 - › **Signifiers** communicate *where the action* should take place
- William Gaver divided affordances into three categories [2]:
 - › A **false affordance** is an apparent affordance that does not have any real function, meaning that the actor perceives nonexistent possibilities for action (“placebo button”)
 - › A **hidden affordance** is when there are possibilities for action, but these are not perceived by the actor (“open a wine bottle using a shoe”)
 - › A **perceptible affordance** is when there is information available such that the actor perceives and can then act upon the existing affordance.

[1] Norman, Donald (2013). The Design of Everyday Things: Revised and Expanded Edition (2nd ed.). Basic Books.

[2] Gaver, William W. (1991). "Technology affordances". Proceedings of the SIGCHI conference on Human factors in computing systems Reaching through technology - CHI '91. pp. 79–84. doi:10.1145/108844.108856. ISBN 978-0-89791-383-6. S2CID 13171625.

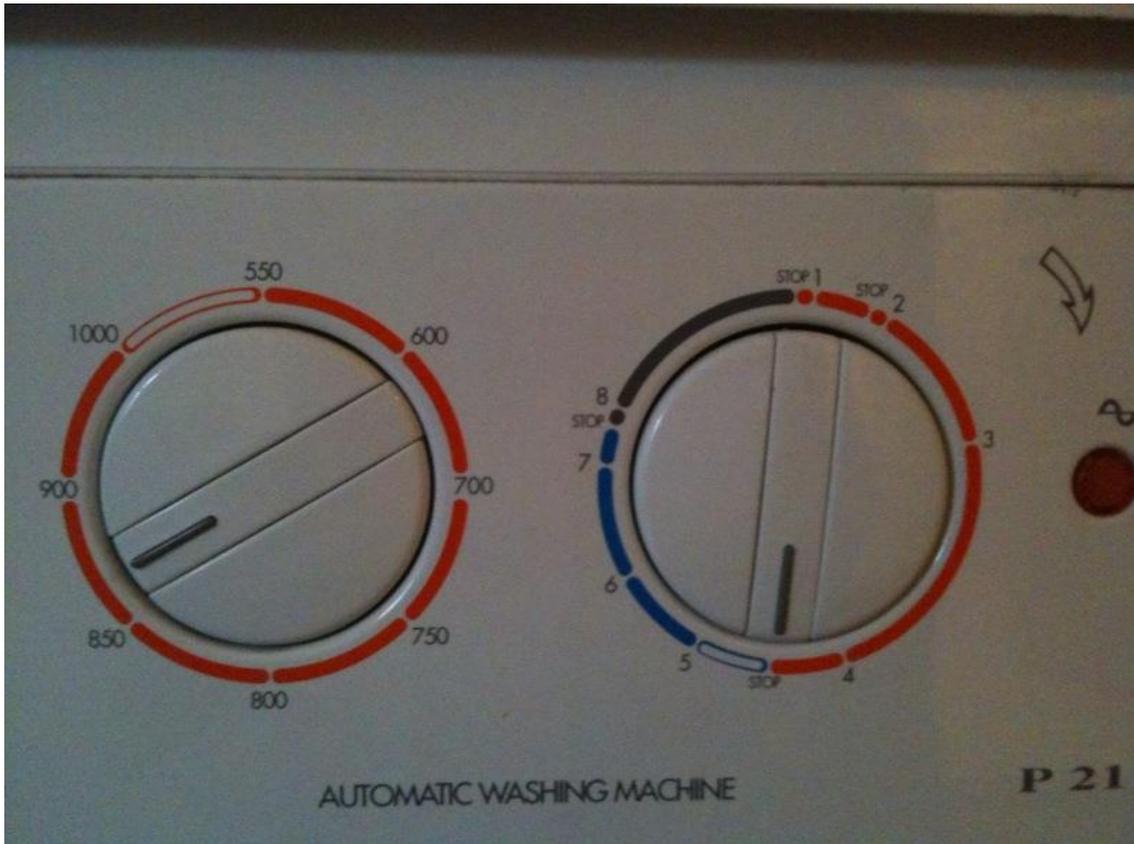
How to tell the user how to use it? (1)

- How to make things that are obvious to use?
- Is there something like an intuitive user interface?



Images: Albrecht Schmidt, <https://pxhere.com/de/photo/204205>, <https://pxhere.com/de/photo/217090>, <https://pxhere.com/de/photo/1213730>

How to tell the user how to use it? (2)



Images: john allspaw <https://www.flickr.com/photos/allspaw/4589119190/> , https://commons.wikimedia.org/wiki/File:Bad_design_-_Apple_Magic_Mouse_2,_unusable_when_charging_2.jpg

How to tell the user how to use it? (3)



Sehr geehrte Damen und Herren,

aus aktuellem Anlass übersenden wir Ihnen mit diesem Schreiben wichtige Handhabungshinweise für die motorisch betätigten Fenster an o.g. Bauvorhaben:

- Die Fenster sind nur über die zur Betätigung installierten Taster zu bedienen.
- Der Öffnungs- und Schließvorgang muss **immer** bis zum Erreichen der Endlage der Antriebe ausgeführt werden. Die Endlage erkennen Sie zweifelsfrei, wenn die Laufgeräusche nicht mehr zu vernehmen sind.
- Unterbrechungen des Tastendrucks während des Öffnungs- und Schließvorgangs sind unbedingt zu vermeiden.
- Mehrmaliges, kurz aufeinanderfolgendes Betätigen der Taster ist zu vermeiden. Die interne Logik der Antriebe wird dadurch gestört.

Bitte beachten Sie die Hinweise und leiten Sie diese an die Nutzer weiter. Nichtbeachtung führt zu Störungen bis hin zum Ausfall der Antriebe, auch mechanische Beschädigungen sind nicht ausgeschlossen.

Für weitere Rückfragen stehen wir Ihnen gerne zur Verfügung.

Mit freundlichen Grüßen

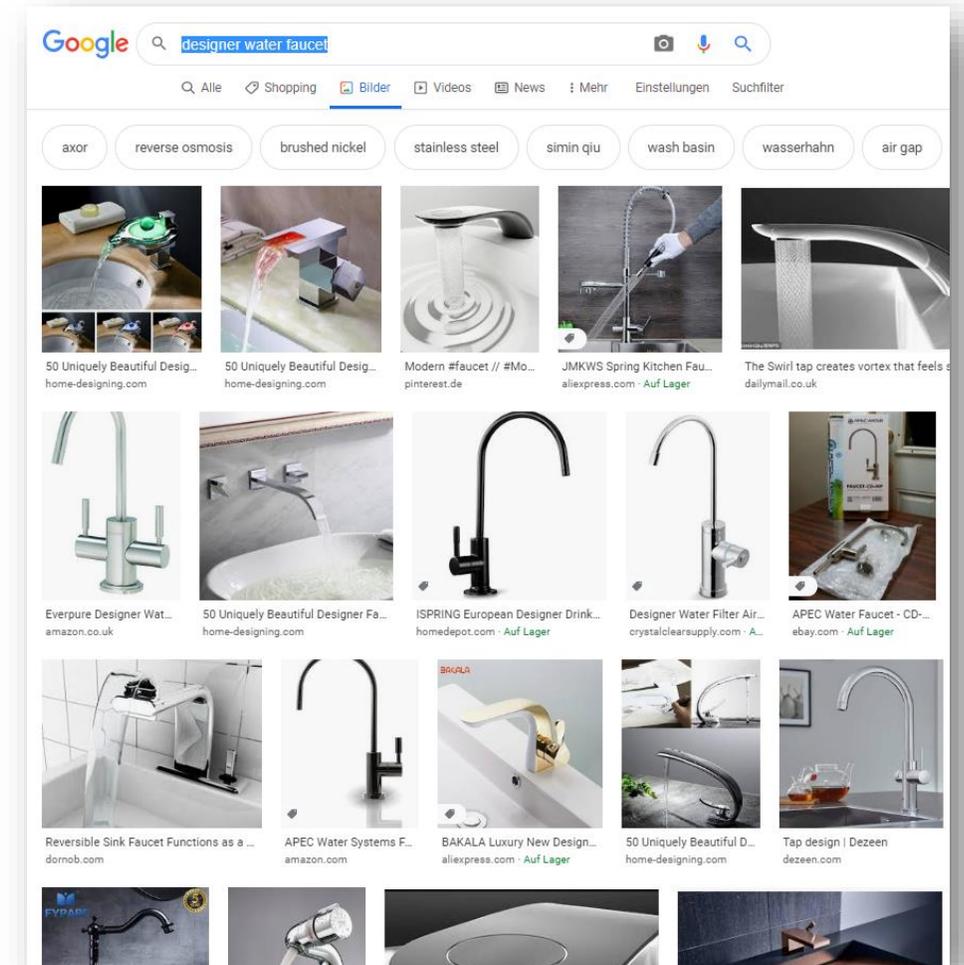
Starz Metallbau

i.A.



Affordance and Perceived Affordance

- **Task: Perform a google image search for**
 - > designer water faucet
 - > find examples of products where it is NOT clear how to use them.
- **Why do people design things that are not obvious to use?**



Design Task: Usable Security

■ Scenario:

- › You have one lock to a room which holds expensive equipment
- › Room is shared by 20+ people from one department, who need to access it infrequently (typically every few weeks)
- › People from other departments should not get into the room
- › Currently solution: there is one key that can be borrowed from the caretaker and 5 out of the 20+ people have personal key to this room

■ Design a better solution:

- › **Replace the old lock by something else**
- › What is your design?
- › What are positive and negative aspects of your proposal?



Photo by D4m1en, CC BY-SA 3.0
<https://commons.wikimedia.org/w/index.php?curid=34336655>

Usability has five quality components

- **Learnability:** How easy is it for users to accomplish basic tasks the first time they encounter the design?
- **Efficiency:** Once users have learned the design, how quickly can they perform tasks?
- **Memorability:** When users return to the design after a period of not using it, how easily can they reestablish proficiency?
- **Errors:** How many errors do users make, how severe are these errors, and how easily can they recover from the errors?
- **Satisfaction:** How pleasant is it to use the design?

Jakob Nielsen's Alertbox, August 25, 2003: Usability 101: Introduction to Usability <https://www.nngroup.com/articles/usability-101-introduction-to-usability/>

Interaction Design vs User Experience Design

- **Interaction Design (IxD):** the design of interactive products and services in which a designer's focus goes beyond the item in development to **include the way users will interact with it.**"
- **User Experience Design (UXD):** the more holistic approach **in designing the experience a person will encounter** when interacting with a devices, system or application. It considers the user interface design in the broader context of use.
- **User Interface Design (UID):** refers to the conception and design of the user interface, including the choice of modalities, selection of interface elements, and their placement in the interface.

<https://www.interaction-design.org/literature/topics/interaction-design>

4 Dimensions of Interaction Design

- **1-D:** includes **words** and poetry. [...]
- **2-D:** languages that **interaction design** can borrow from include painting, typography, diagrams, and icons. [...]
- **3-D:** languages are those of **physical**, sculptural form. [...] If something has a handle, for example, we know we are meant to grab it [...]
- **4-D:** is **time**. The 4-D languages include sound, film, and animation.

Foreword "What is Interaction Design?". Interview with Gillian Crampton Smith. Moggridge, Bill, and Bill Atkinson. *Designing interactions*. Vol. 17. Cambridge, MA: MIT press, 2007. page xvii

5 Dimensions of Interaction Design

- Originally by Gillian Crampton Smith (4 dimensions); Kevin Silver added a fifth.
- **1-D: words** should be meaningful and simple to understand.
- **2-D: visual representations** supplement the words used to communicate information to users.
- **3-D: physical objects** or space looks at what physical objects do users interact with the product (laptop, mouse, touchscreen, phones, etc.)? These all affect the interaction between the user and the product.
- **4-D: time** refers to media that changes with time (e.g. animation, videos, sounds).
- **5-D: behaviour** includes the mechanism of a product. How do users perform actions?

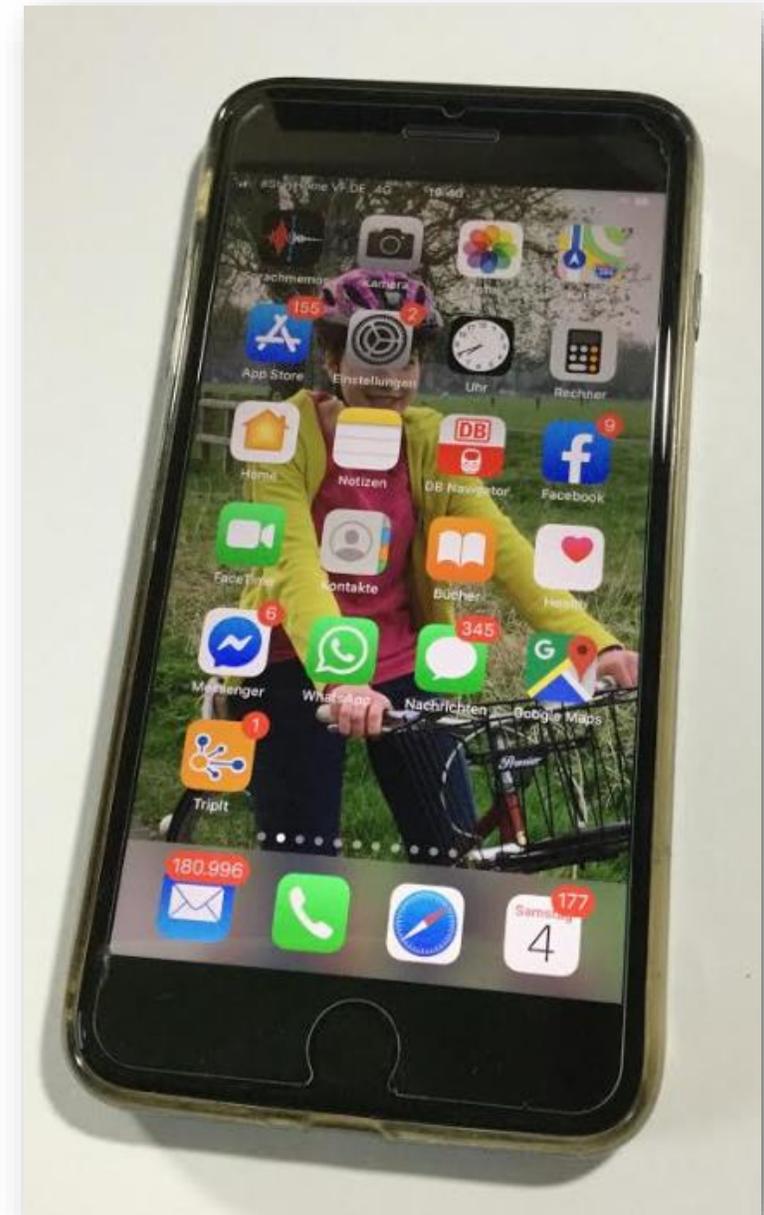
<https://www.interaction-design.org/literature/article/what-is-interaction-design>

Fashion

How long does an interface look “new”? What is “timeless”?



Photo by Bcos47 (public domain)
http://en.wikipedia.org/wiki/File:IBM_Simon_Personal_Communicator.png



Aspects of Design

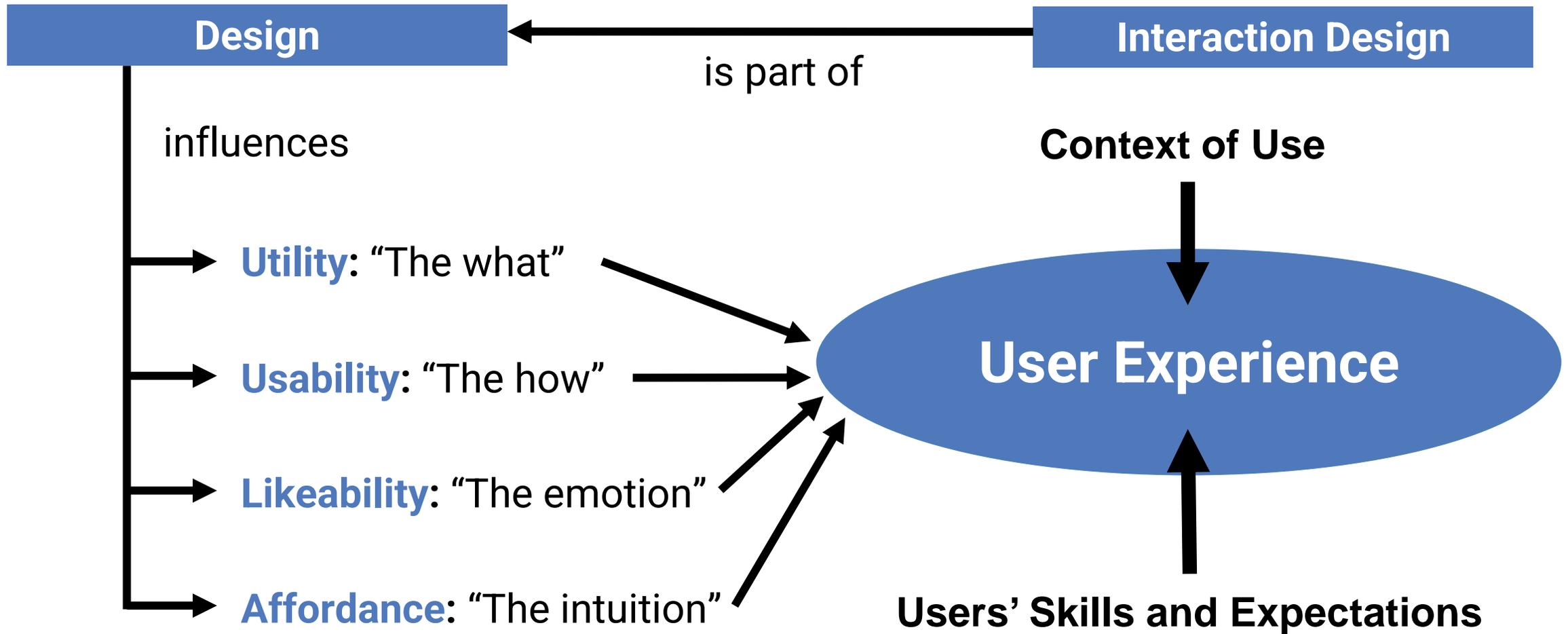
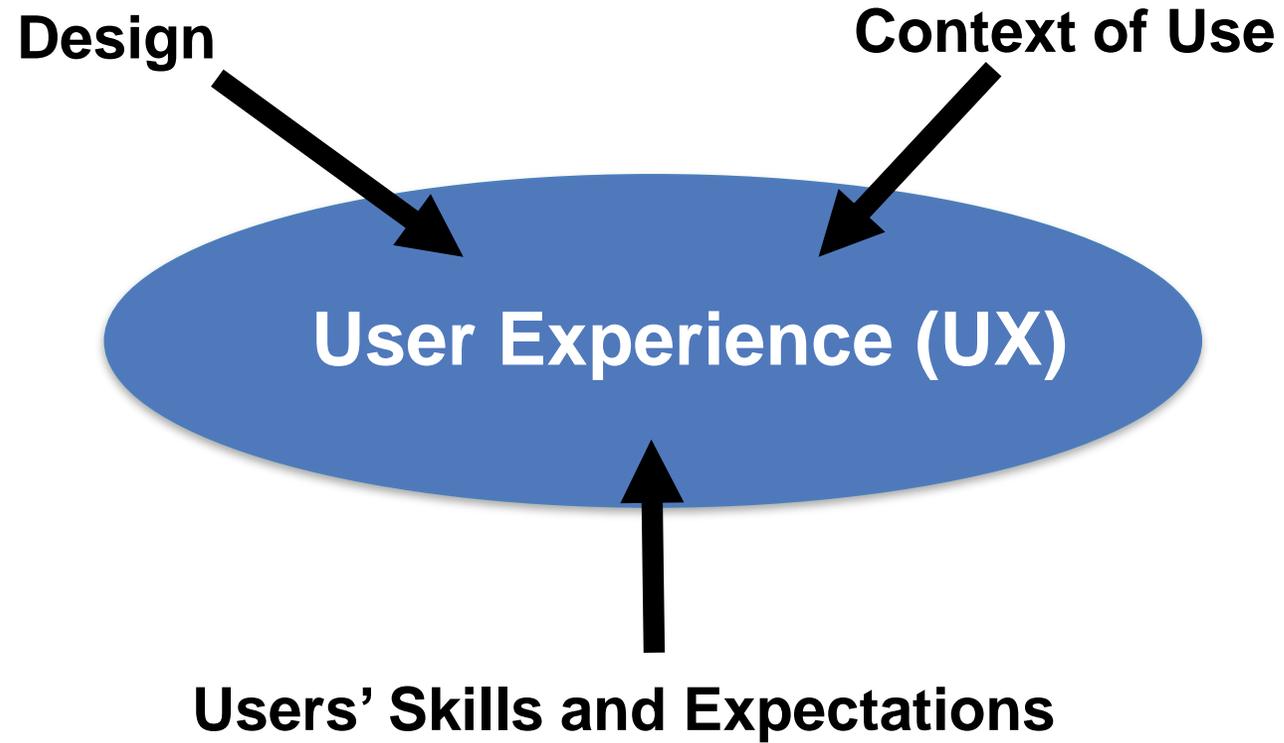




Image from Gantner: <https://www.gantner.com/electronic-door-locks/>

User Experience



Experiences never “Stand Alone”



Foxconn Workers on Strike Over iPhone 5 Demands, Labor Group Says

By Lauren Indvik | Mashable – Fri, Oct 5, 2012

Email Recommend 7 Tweet 9 Share 4 +1 0 Print

RELATED CONTENT



apple foxconn

Some 3,000 to 4,000 [production workers](#) at Foxconn's Zhengzhou factory went on strike Friday afternoon, according to an alert sent out Friday by [China Labor Watch](#), a not-for-profit, U.S.-based watchdog for [Chinese workers'](#) rights.

[More from [Mashable](#): [Apple Experts: Stop Comparing Tim Cook to Steve Jobs](#)]

Production was halted as workers -- primarily [quality control inspectors](#) -- protested against a series of escalating demands.

According to the group, Apple and Foxconn "raised strict quality demands on workers, including indentations standards of 0.02mm and demands related to scratches on frames and back covers" on iPhone 5 devices. When workers failed to meet the new standards, friction between quality control inspectors and workers came to a head, in some cases escalating to physical violence. Several workers were hospitalized, CLW said.

Altered Perception of Reality (2011)



Image from: <http://www.cs.nott.ac.uk/~jqm/?p=501>
Marshall, Joe, et al. "The gas mask: a probe for exploring fearsome interactions."
CHI'11 Extended Abstracts on Human Factors in Computing Systems. ACM, 2011.

Figure 1. Gas Mask and Respiration Monitor



Image credit: Razer, CES 2021

Terms Summary

- **HCI** is widely **relevant to the development of interactive technologies**
- The **interaction** and **interface design** determines how people can and will use an **object, device, or application**
- The goal is to make an interface and interaction design that intuitively communicates **how it is being used**
- As constraints are removed when moving from mechanical to digital the interaction design plays a bigger role
- **Affordance describes how objects communicate how you can use them**
- Designing objects requires an overarching **understanding of how perceived affordances** must be created



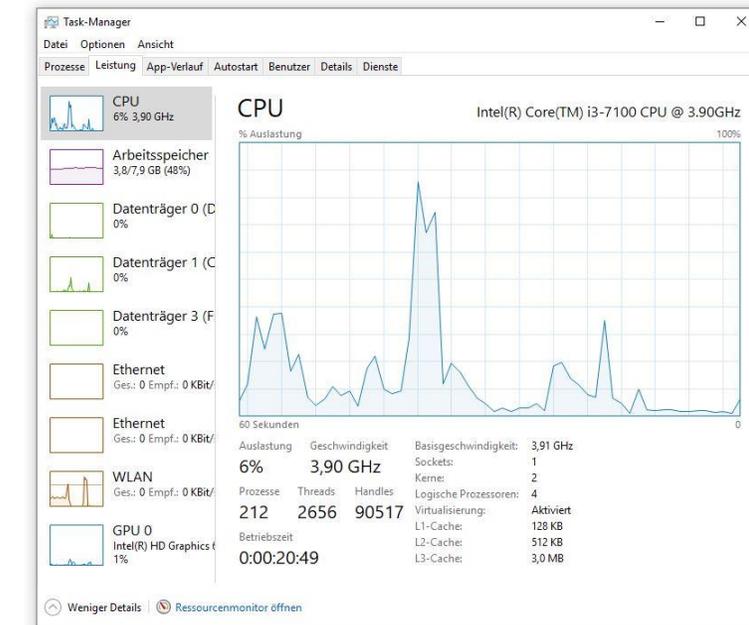
Ubiquitous Human-Computer Interaction

Human-Computer Interaction Lecture

Image from: Albrecht Schmidt

Limitations

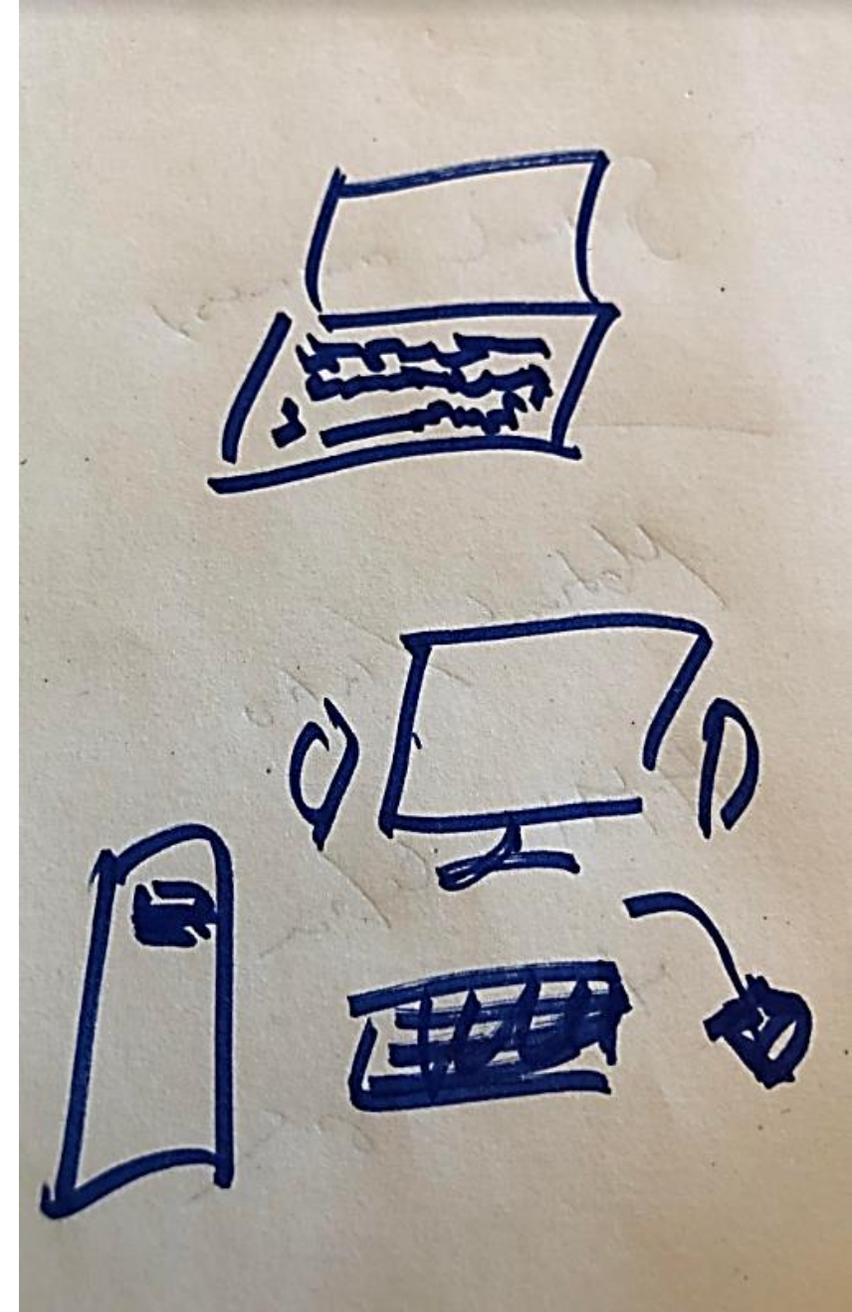
- What limits what applications you can build and use?
 - › Processing power?
 - › Network connectivity?
 - › Screen size?
 - › Keyboard input speed?
 - › Your creativity to think of something useful?



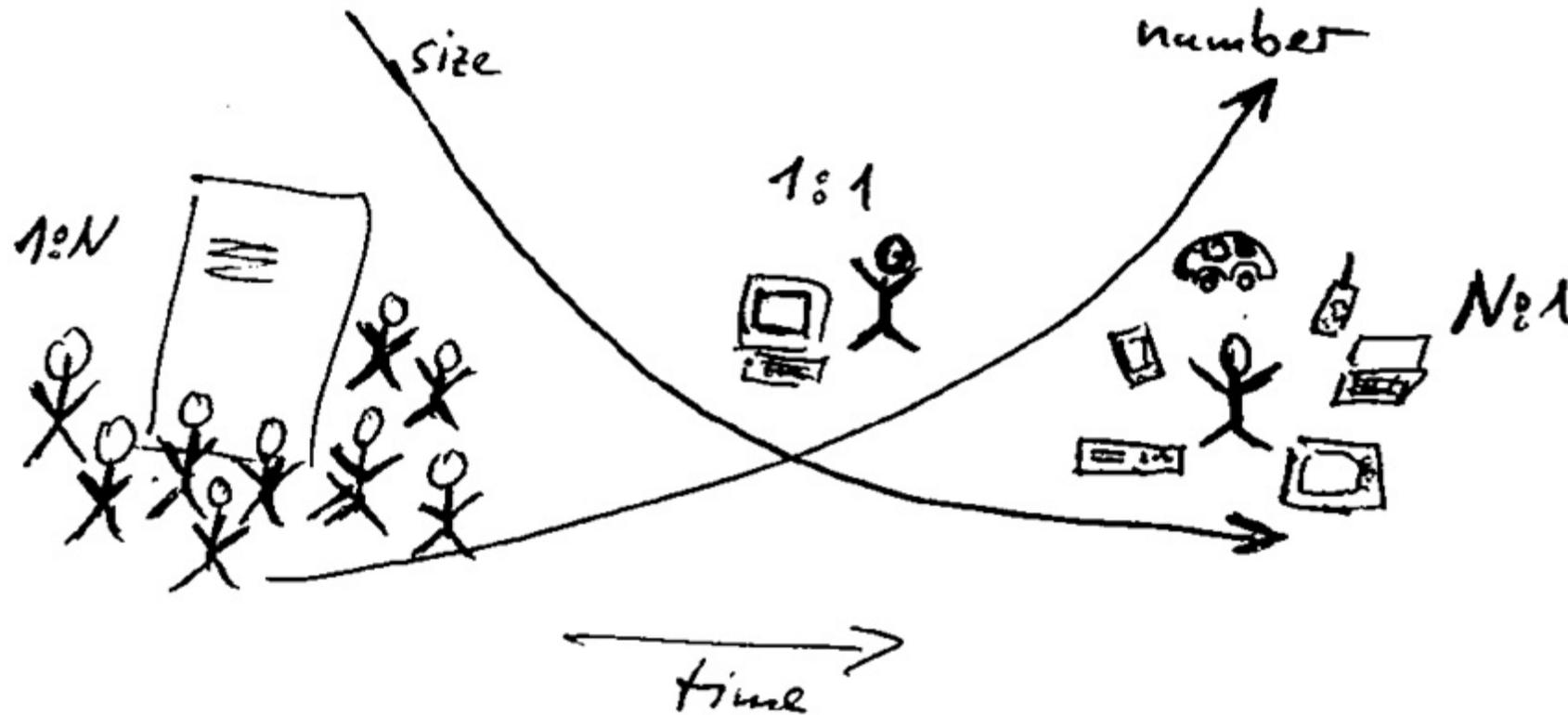
The cRaCkEr / CC BY-SA (<https://creativecommons.org/licenses/by-sa/3.0>)
https://commons.wikimedia.org/wiki/File:Cray_XE6.jpg

Mini-Exercise: Draw a Computer

- How did your first computer look like?
- How does your current computer look like?
- Pick a computer and draw a sketch!



Ubiquitous Computing



Mark Weiser. 1999. The computer for the 21st century. SIGMOBILE Mob. Comput. Commun. Rev. 3, 3 (July 1999), 3-11. DOI:<https://doi.org/10.1145/329124.329126>

With how many computers have you interacted today?



Images from Albrecht Schmidt, GeorgDerReisende, CC BY-SA 4.0 via Wikimedia Commons

Many things become computational artifacts

- How many of things you use will be “computers” in 2050?
- **Mini Exercise:**
 - › Think of 10 things you have or use today that have become a computational device in the last 20 year?
 - › Think of 10 things you have or use today that may become a computational device in the next 30 year?
(Start with things that already now use power...)



What do you interact with?

You Can Touch This: Eleven Years and 258218 Images of Objects



Figure 1: All objects touched by Alberto Frigo in January 2004, 2009 and 2014. Every line shows the images of the touched objects for one day. Please use the magnifying functionality of your PDF reader to take a closer look at the photos.

Nina Runge
Digital Media Lab
University of Bremen, TZI
Bremen, Germany
nr@tzi.de

Johannes Schöning
Expertise Centre for
Digital Media
Hasselt University - tUL
iMinds, Diepenbeek, Belgium
johannes.schoening@uhasselt.be

Rainer Malaka
Digital Media Lab
University of Bremen, TZI
Bremen, Germany
malaka@tzi.de

Alberto Frigo
Södertörn University,
Media and Communication
Stockholm, Sweden
alberto.frigo@gmail.com

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from Permissions@acm.org.
CHI 16 Extended Abstracts, May 07–12, 2016, San Jose, CA, USA.
Copyright is held by the owner/author(s). Publication rights licensed to ACM.
ACM 978-1-4503-4082-3/16/05 ...\$15.00
DOI: <http://dx.doi.org/10.1145/2851581.2892575>

Abstract
Touch has become a variety of interactive devices operated using touch artifacts, people touch in their daily lives. We maintain all touched objects were contributed by Frigo in the "Quantified Self" project. We analyzed the 258,218 images of their distribution, and

Author Keyword:
Touch Interaction; Tangible Self

ACM Classification:
H.5.2. [User Interfaces]

Introduction & Context:
Touch interaction is a computer interaction modality [3, 20]. In the digital world, like



Runge, N., Schöning, J., Malaka, R., & Frigo, A. (2016, May). You can touch this: Eleven years and 258218 images of objects. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (pp. 541-552).



Mechanical Constraints vs. Digital Design Opportunities



Images from Albrecht Schmidt

Ubiquitous Computing (2)

- **Ubiquitous Computing** is new paradigm with seamless integration of hundreds and thousands of self-communicating small scale computers and intelligent devices into the user environment and daily life activities [1]
- This paradigm is also described as **pervasive computing** or **ambient intelligence**
- **Internet of things** (IoT) describes physical objects with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks.
- As constraints are removed when moving from mechanical to digital the interaction design and human factors play a bigger role.

[1] Bashir, R. N., Qadri, S., Saleem, R. M., Naeem, M., & Ghafoor, Y. (2014). Human computer interaction (hci) in ubiquitous computing. International Journal of Innovation and Applied Studies, 9(2), 534.

Ubiquitous Computing (1)

- Ubiquitous computing emphasizes the creation of a human-computer interface that can **interpret and support the users' intentions based on all devices in their surroundings**
- As we interact with these **anonymous devices**, they will adopt our information personalities and understand the context [1]
- **Privacy** is likely the most often-cited criticism of ubiquitous computing and may be the greatest barrier to its long-term success [2]
- Instead of escaping the physical world and enter a cyberspace, ubiquitous computing rather brings computers and communications to us [3]

[1] Weiser, Mark (1991). "The Computer for the 21st Century". Archived from the original on 22 October 2014.

[2] Hong, Jason I.; Landay, James A. (June 2004). "An architecture for privacy-sensitive ubiquitous computing" (PDF). Proceedings of the 2nd international conference on Mobile systems, applications, and services - MobiSYS '04. pp. 177=189. doi:10.1145/990064.990087. ISBN 1581137931. S2CID 3776760

[3] Winter, Jenifer (December 2008). "Emerging Policy Problems Related to Ubiquitous Computing: Negotiating Stakeholders' Visions of the Future". Knowledge, Technology & Policy. 21 (4): 191–203. doi:10.1007/s12130-008-9058-4. hdl:10125/63534. S2CID 109339320.

Amazon Go



Video: <https://www.youtube.com/watch?v=NrmMk1Myrxc>

References

- B. Shneiderman (2002). Leonardo's Laptop: Human Needs and the New Computing Technologies. <http://mitpress.mit.edu/main/feature/leonardoslaptop/index.html>
- B. Buxton (2010). Sketching user experiences: getting the design right and the right design. Morgan Kaufmann.
- Harry Brignull (2006). Bad usability is like a leaky pipe. <https://90percentofeverything.com/2006/11/13/bad-usability-is-like-a-leaky-pipe/>
- Paula Zuccotti (2015): Every Thing We Touch: A 24-hour Inventory of Our Lives. Penguin UK. <https://www.theguardian.com/society/2015/nov/06/its-the-little-things-everything-i-touched-today>
- Nina Runge, Johannes Schöning, Rainer Malaka, and Alberto Frigo (2016): You Can Touch This: Eleven Years and 258218 Images of Objects. In Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '16). ACM, New York, NY, USA, 541-552. DOI: <https://doi.org/10.1145/2851581.2892575>
- James J. Gibson (1977): The theory of affordances. Hilldale, USA 1.2 https://monoskop.org/images/2/2c/Gibson_James_J_1977_The_Theory_of_Affordances.pdf
- Don Norman (2008): Affordances and Design, jnd.org https://jnd.org/affordances_and_design/
- Norman, D. A. (2013): The design of everyday things: Revised and expanded edition. New York: Doubleday