VRIJE UNIVERSITEIT BRUSSEL

Next Generation User Interfaces

Introduction

Prof. Beat Signer

Department of Computer Science
Vrije Universiteit Brussel

http://www.beatsigner.com

Course Organisation

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  Vrije Universiteit Brussel
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Course Organisation

- **Audrey Sanctorum**
  Vrije Universiteit Brussel
  G.10.735
  asanctor@vub.ac.be

Prerequisites

- Note that this is an advanced Master's level course and the following previous knowledge is required
  - *good programming skills*
- It is not impossible to follow the course without these prerequisites, but in this case you should not complain about the potential additional workload!
- Note that the following courses teach principles that are also relevant for this course on Next Generation User Interfaces
  - User Interfaces (1019885ANR)
  - Information Visualisation (4019538FNR)

Course Goals

- After attending the course on Next Generation User Interfaces, the student has an *understanding of the interaction principles introduced by new devices* such as smartphones, multi-touch tables or gesture-based interfaces as well as the *theoretical background behind these interaction principles*. The student is able to *reflect on the qualities and shortcomings of different interaction styles*, while placing the *user at the core of the interface design process*.
- The student can *apply the theoretical background* and interaction principles discussed in the course and *create interfaces that go beyond the classical WIMP metaphor*.

Course Goals …

- The course should give students the ability to understand the *possibilities and limitations of next generation user interfaces* and to recognise variations of such interfaces. They should further be able to *understand and evaluate new developments and technologies in fields related to the course and have the skills to independently study and master these new technologies*.

Exercises

- The course content is further investigated in a number of exercise sessions
  - the topics covered in the exercise sessions might also be helpful for the assignment
  - assistants: Sandra Trullemans and Audrey Sanctorum
    - Monday 16:00–18:00 (exact slots announced during the semester)
- Lab Sessions
  - work on the assigment and get feedback from the assistants
    - Monday 16:00–18:00 in G.10.731
    - Thursday 10:00–12:00 in G.10.731
- Additional content may be covered in exercise sessions
  - *strongly recommended to attend* all exercise sessions!
  - exam covers content of lectures and exercises

Course Material

- All material will be available on PointCarré
  - lecture slides, exercises, research papers, tutorials, ...
- Make sure that you are subscribed to the *Next Generation User Interfaces* course on PointCarré
  - `http://pointcarre.vub.ac.be/index.php?application=weblcms&go=course_viewer&course=8494`
- Handouts are on PointCarré at least the day before the lecture
- Similar information is also available on the WISE website
  - `http://wise.vub.ac.be/content/next-generation-user-interfaces`

Lecture Schedule

2	Lecture 1: Introduction	K.2 A.1.P
	Information about Assignment and Group Formation	K.2 A.1.P
3	Lecture 2: Interaction Design	K.2 A.1.P
	Exercise 1: Phidgets	E.1.3
4	Lecture 3: Requirements Analysis, Prototyping and Evaluation	K.2 A.1.P
	Initial Project Presentations	TBA
5	Lecture 4: Information Architectures	K.2 A.1.P
	Exercise 2: 3D Printing	G.10.731
6	Lecture 5: Multimodal Interaction	K.2 A.1.P
	Short Progress Presentations	TBA
7	Lecture 6: Pen-based Interaction	K.2 A.1.P
	Exercise 3: Microsoft HoloLens	G.10.731
8	Lecture 7: Interactive Tabletops and Surfaces	K.2 A.1.P
	Exercise 4: Evaluation	E.1.3

Lecture Schedule …

9	Lecture 8: Gesture-based Interaction	K.2 A.1.P
	Interim Project Presentations (Working Prototype)	TBA
10	Lecture 9: Tangible, Embedded and Embodied Interaction	K.2 A.1.P
	Lab Session	G.10.731
11	Lecture 10: Virtual and Augmented Reality	K.2 A.1.P
	Short Progress Presentations	TBA
12	Lecture 11: Implicit and Cross-Device Interaction	K.2 A.1.P
	Exercise 5: Discussion of Papers	G.10.731
13	Lecture 12: Course Review	K.2 A.1.P
	Lab Session	G.10.731
14	Final Project Presentations	G.10.731

Assignment

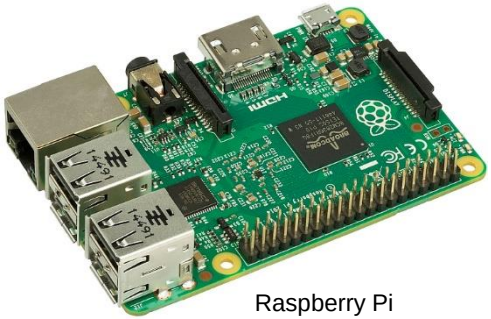
- Next generation user interface
  - realisation of a user interface for the domain of your choice (e.g. information management, analysis or gaming)
    - various presentations and reports
    - evaluated based on creativity, exploration of technologies, documentation, presentations, requirements analysis and evaluation, source code, …
- Assignment handed out later this week
  - group project with *3 students per group*
    - send an email with the 3 group members and your team name to Sandra Trullemans by Friday, September 30 (strullem@vub.ac.be)
    - final presentation (*December 19*), final report and code (*December 23*)
  - assignment counts for 60% for the final grade
    - students have some flexibility in distributing the grades (±2 points)

Available Hardware

Phidgets

Wii Motion Plus

Kinect



Raspberry Pi

Smartphones and Tablets

Pico Projectors

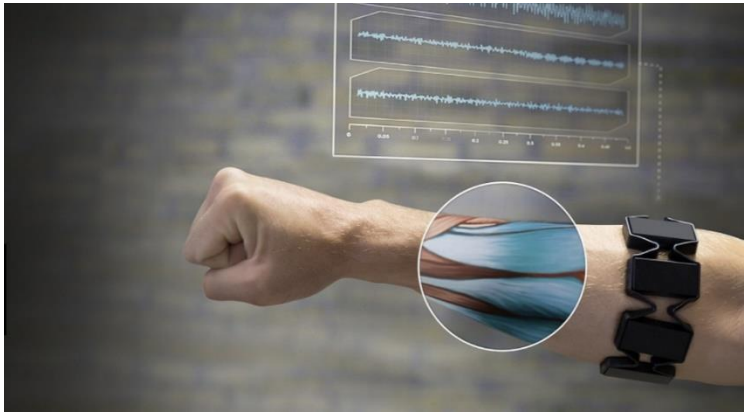
Available Hardware…

Web Cams

Leap Motion Hand Tracking

Digital Pens

Multi-Touch Tabletop



Myo Gesture Control Armband

Available Hardware …

3D Printer

Microsoft HoloLens

Oculus Rift

Exam

- Oral exam in English
  - covers content of lectures and exercises
  - counts 40% for the overall grade
  - 5 mins questions about the assignment
  - 15 mins questions about the course content (no preparation time)
- Overall grade = oral exam (40%) + assignment (60%)

Course Outline

1. Introduction
   - history of human-computer interaction
   - interface types
2. Interaction Design
   - interaction design process
   - understanding and conceptualising interaction
3. Requirements Analysis and Prototyping
   - data gathering and analysis for requirements
   - prototyping
   - types of evaluation
   - usability testing and field studies

Course Outline …

4. Information Architectures
   - personal information management (PIM)
   - cross-media information systems
5. Multimodal Interaction
   - human senses
   - multimodal fusion and fission
6. Pen-based Interaction
   - affordances of pen and paper
   - digital pen and paper solutions
   - pen and touch

Course Outline …

7. Interactive Tabletops and Surfaces
   - frameworks and technologies
   - applications
8. Gesture-based Interaction
   - single and multi-touch gestures
   - offline vs. online gestures
   - mid-air gestures
9. Tangible, Embedded and Embodied Interaction
   - from tangible bits to radical atoms
   - characteristics of tangible interfaces

Course Outline …

10. Virtual and Augmented Reality
    - technologies
    - virtual and augmented reality applications
11. Implicit and Cross-Device Interaction
    - context-aware implicit human-computer interaction (HCII)
    - cross-device and distributed user interfaces
12. Course Review
13. Final Project Presentations

Video: Microsoft Office Labs Vision 2019

Fluid Cross-Media Information Spaces

Prof. Beat Signer
Interactive Paper, Cross-Media Information Architectures

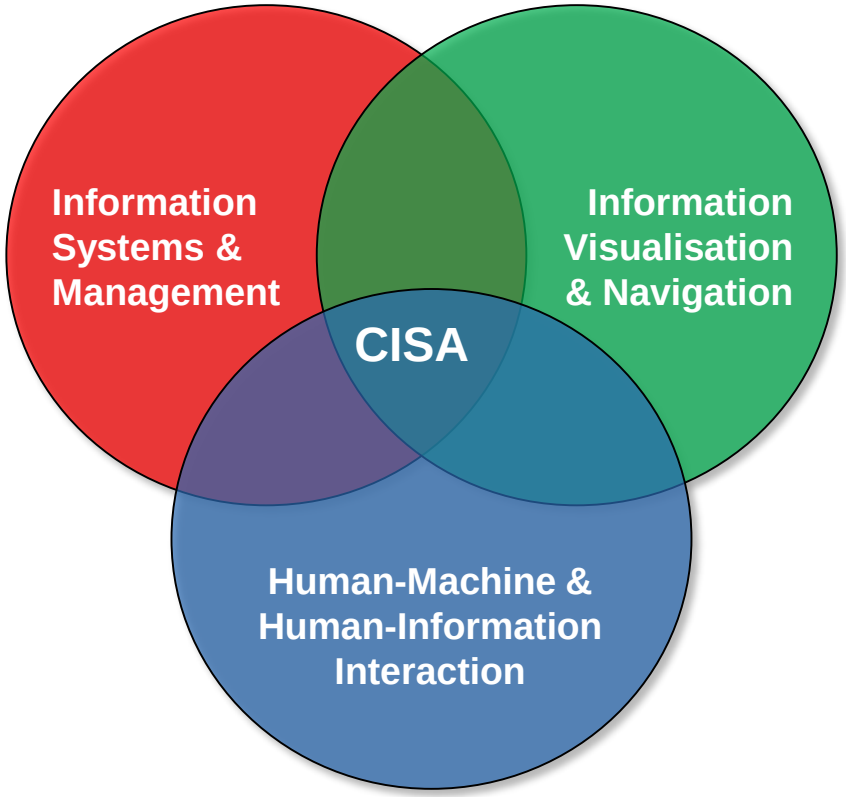
Sandra Trullemans
Personal Cross-Media Information Management

Audrey Sanctorum
User-defined Cross-Device and Cross-Media Interaction

Reinout Roels
MindXpres: Extensible Content-driven Presentation Tool

WISE WEB & INFORMATION SYSTEMS ENGINEERING

CROSS-MEDIA INFORMATION SPACES AND ARCHITECTURES (CISA)



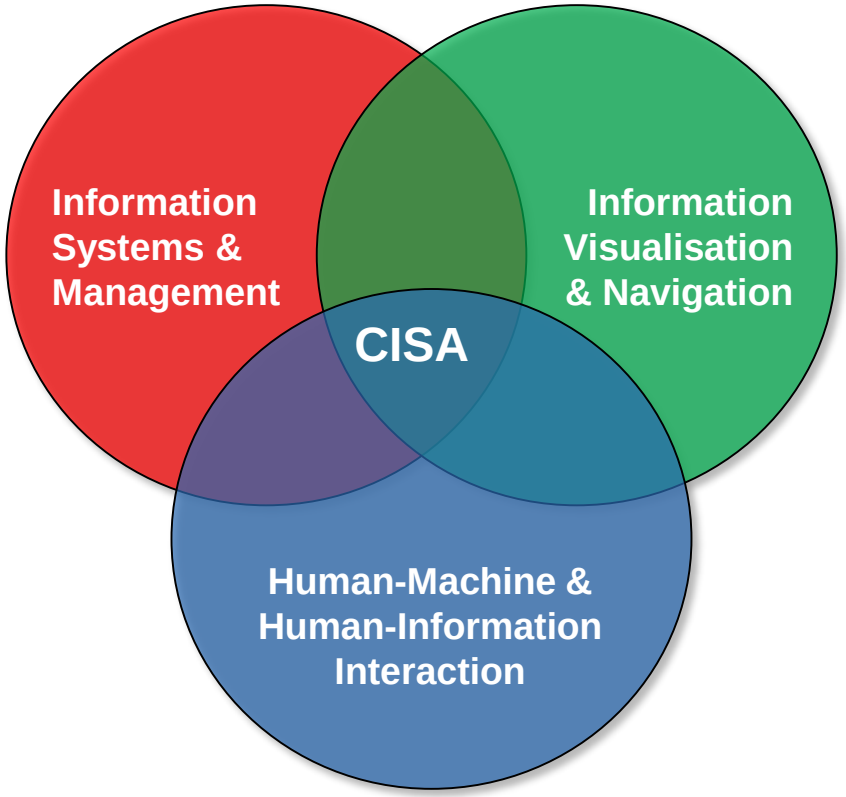
Lars Van Holsbeeke
Smart Environments, Implicit Human-Computer Interaction

Ahmed A.O. Tayeh
Open Cross-Media Authoring, Fluid Document Formats

Cristian Vasquez Paulus
Community Semantics, Structured Data on the Web

WISE WEB & INFORMATION SYSTEMS ENGINEERING

CROSS-MEDIA INFORMATION SPACES AND ARCHITECTURES (CISA)



Beyond Human-Computer Interaction

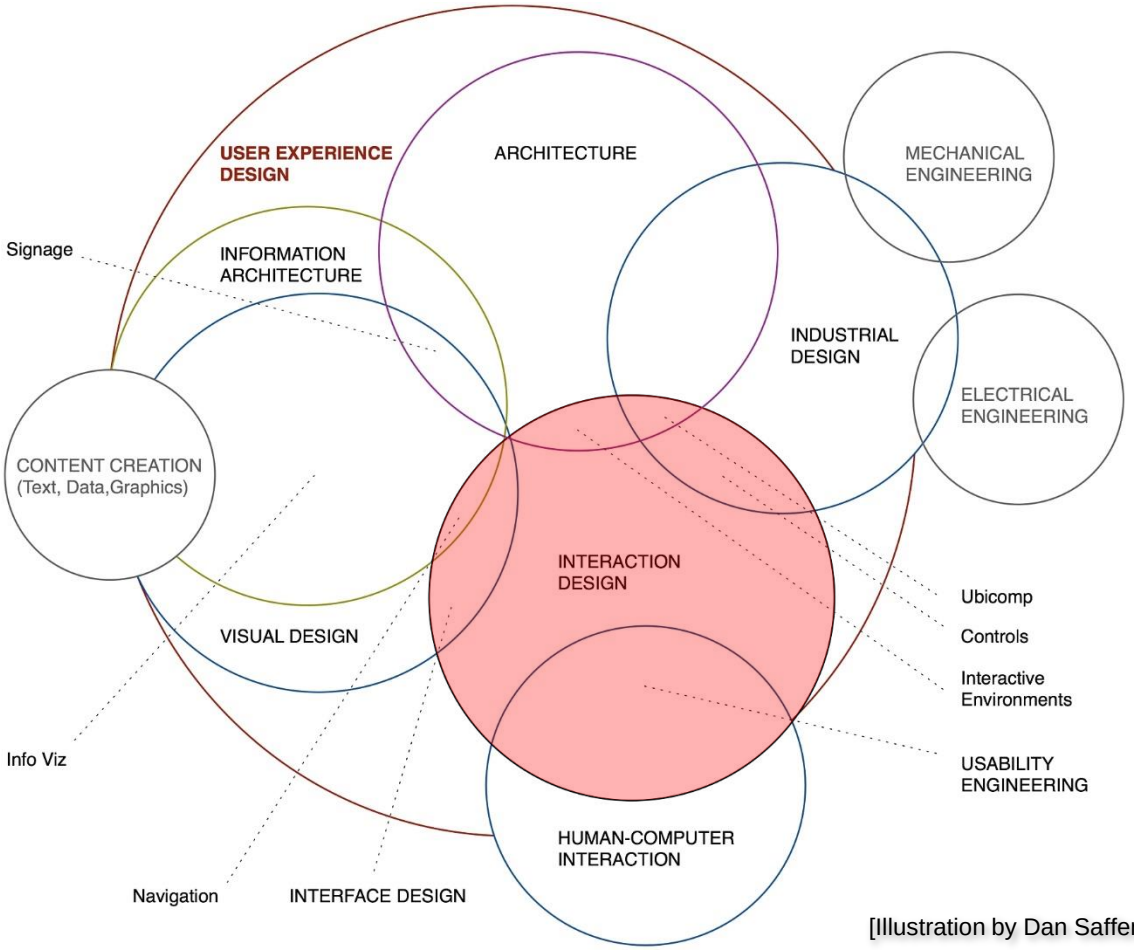
Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them.

ACM SIGCHI Curricula for Human-Computer Interaction

Interaction design addresses the design of interactive products to support the way people communicate and interact in their everyday and working lives.

Yvonne Rogers, Helen Sharp and Jenny Preece, Interaction Design: Beyond Human-Computer Interaction

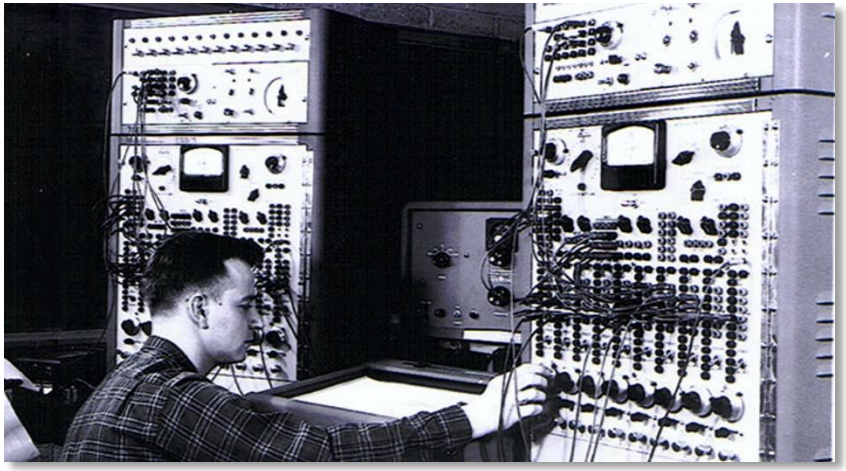
Interaction Design



[Illustration by Dan Saffer]

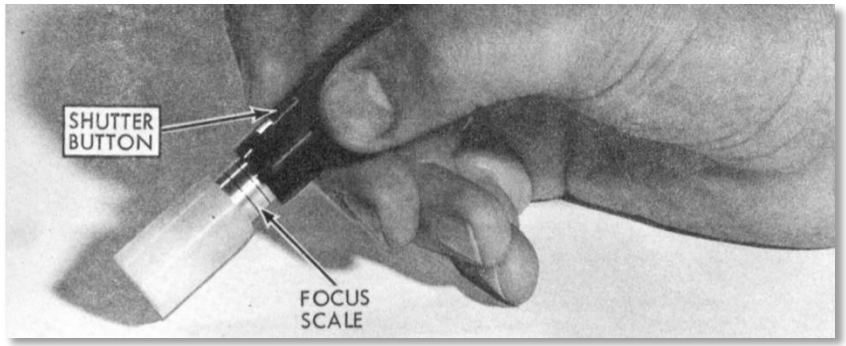
Analogue Computers

- *Focus on technology* and not on human-machine interaction (HMI)
- *Only trained engineers* could use the machines
- Interaction was *limited to* the *programming* of the machines (e.g. punched cards) and the printing of results



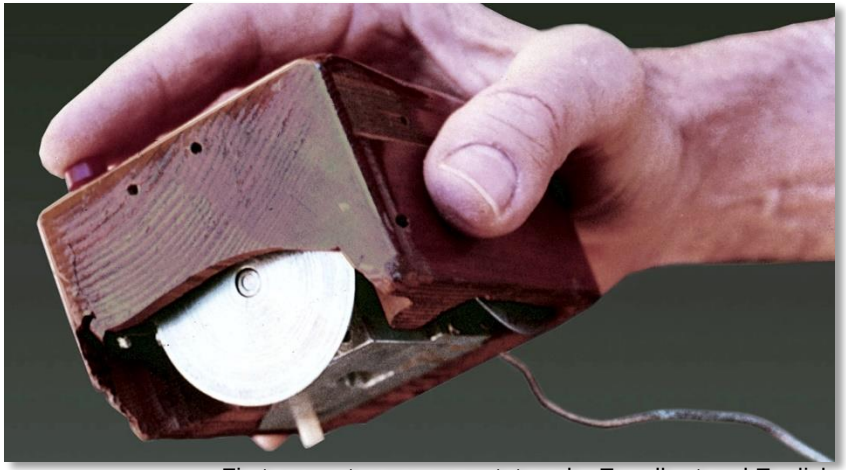
Sketchpad (1963)

- Sketchpad developed as part of Ivan Sutherland's PhD thesis at MIT
  - drawing tool
  - light pen and buttons
  - first graphical user interface
  - *direct manipulation* of graphical objects
  - basis for many new interface ideas

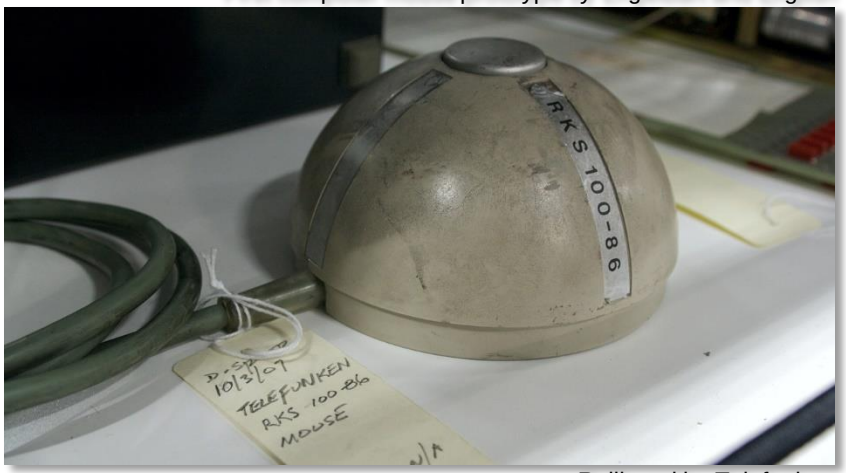


Mouse (1964)

- First mouse invented by Douglas Engelbart with the help of Bill English
  - two wheels and one button
  - oN-Line System (NLS) at Stanford Research Institute
- Similar ‘Rollkugel’ device was developed by Telefunken in Germany
  - “reversed” trackball



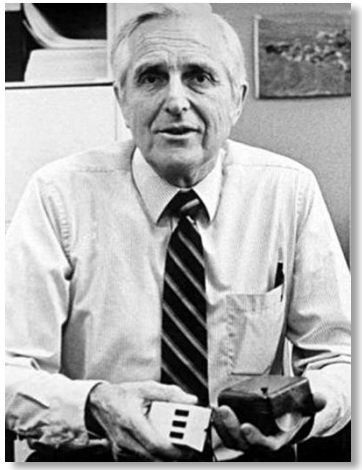
First computer mouse prototype by Engelbart and English



Rollkugel by Telefunken

The Mother of All Demos (1968)

- Douglas Engelbart and his colleagues at the Stanford Research Institute developed the *oNLine System (NLS)* as part of the Augment Project
  - *vision about the future of interactive computing*
- NLS was demonstrated at the Fall Joint Computer Conference in 1968
  - showed first practical use of hypertext
  - computer mouse
  - remote collaboration (connected computers)
  - raster-scan video monitors
  - screen windows
  - ...



Douglas Engelbart

NLS Demo

monday afternoon

december 9

3:45 p.m. / arena

Chairman:
DR. D. C. ENGELBART
Stanford Research Institute
Menlo Park, California

a research center for augmenting human intellect

This session is entirely devoted to a presentation by Dr. Engelbart on a computer-based, interactive, multiconsole display system which is being developed at Stanford Research Institute under the sponsorship of ARPA, NASA and RADC. The system is being used as an experimental laboratory for investigating principles by which interactive computer aids can augment intellectual capability. The techniques which are being described will, themselves, be used to augment the presentation.

Xerox Alto and Xerox Star (1981)

- Personal workstation
  - LAN to share resources
- Desktop metaphor
  - windows, icons, menus, pointer (*WIMP*) interaction
  - "filing cabinets" with *hierarchical folders*
  - seeing and pointing rather than remembering and typing
  - "What You See Is What You Get" (*WYSIWYG*)

Xerox Star 8010 [http://www.digibarn.com/collections/systems/xerox-8010/]

Apple Macintosh (1984)

- Successor of Apple Lisa
  - corrected some mistakes
  - aggressive pricing
- Old ideas (e.g. Xerox Star) but well executed
- Domination in the desktop publishing sector
  - excellent graphics
  - affordable laser printers

Evolution of Interfaces

original Macintosh

27-inch iMac

			comparison
date	January 1984	September 2016	+ 32 years
price	$2,500	$2,299	x 0.92
CPU	68000 Motorola 8 MHz 0.7 MIPS	quad-core Intel core i7 4 GHz 238,310 MIPS	 x 500 x 340,442
memory	128 kB	16 GB	x 125,000
storage	400 kB floppy drive	2 TB fusion drive	x 5,000,000
monitor	9" black and white 512 x 342 68 dpi	27" colour 5120 x 2880 218 dpi	x 3 x 84 x 3.2
devices	mouse keyboard	mouse keyboard	same same
GUI	desktop WIMP	desktop WIMP	same

[partly based on Beaudouin-Lafon 2004]

Recent Changes and Opportunities in HCI

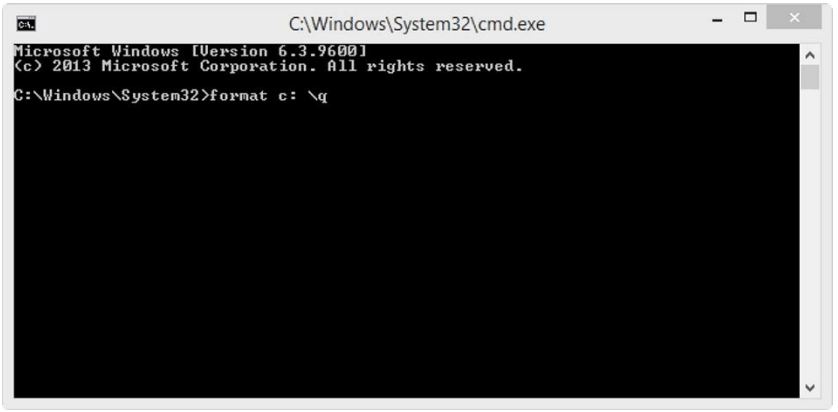
- Advances in graphical interfaces, speech, gesture and handwriting recognition
- Emergence of the Internet, cell phones, wireless networks, sensor technologies as well as large and small screens
  - *innovative interaction* with digital information and services
  - *combining the physical and digital* in new ways
    - mixed reality, cross-media spaces, tangible interfaces, wearable computing, ...
  - *collaborative interfaces* with social interaction

Interface Types

- Command-based
- WIMP and GUI
- Multimedia
- *Virtual reality*
- Information visualisation
- Web
- Consumer electronics
- Mobile
- *Speech (Voice)*
- *Pen*
- *Touch*
- *Mid-air gestures*
- Haptic
- *Multimodal*
- Shareable
- *Tangible*
- *Augmented and mixed reality*
- Wearable
- Robotic
- Brain computer

Command-based Interfaces

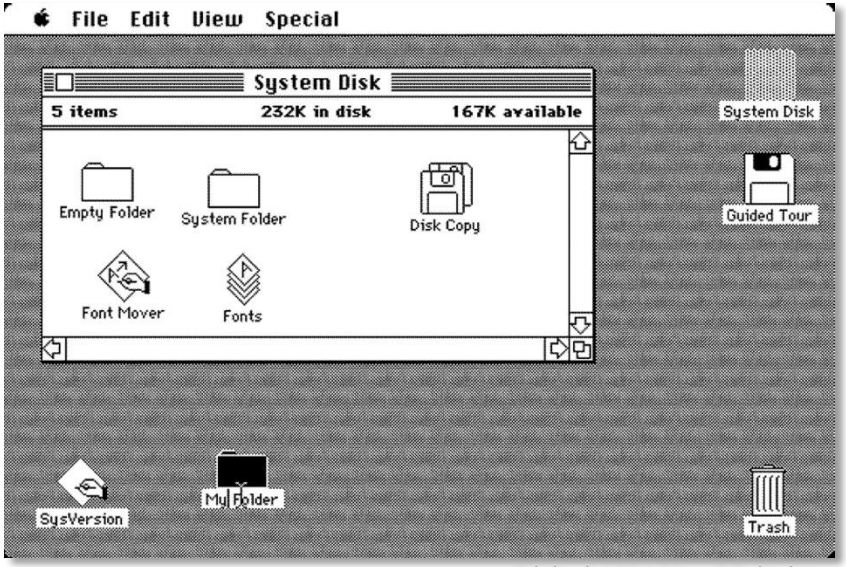
- Typing commands such as `ls` or `rm` in command line
- Combination of keys such as `Ctrl + c` and `Ctrl + v`
- Superseded by GUIs
- Still used by experts
  - batch processing
- Alternative to GUIs for visually impaired users
  - e.g. command-line interface for Second Life



- *Syntax* (e.g. how to combine commands)
- Which *names* can be remembered best
- *Consistency* in labeling and naming of commands

WIMP and GUI

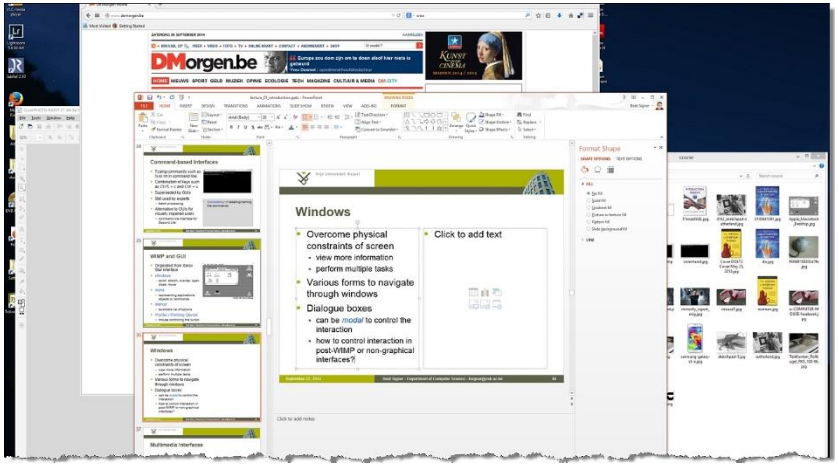
- Originated from Xerox Star interface
- *Windows*
  - scroll, stretch, overlap, open, close, move
- *Icons*
  - representing applications, objects or commands
- *Menus*
  - scrollable list of options
- *Pointer / Pointing Device*
  - mouse controlling the cursor



Original 1984 Mac OS desktop

Windows

- Overcome physical screen constraints
  - view more information
  - perform multiple tasks
- Various forms to navigate through windows
- Dialogue boxes
  - can be *modal* to control the interaction
  - how to control interaction in post-WIMP or non-graphical interfaces?



- *Window management* to move between different windows and screens
- *Design principles* of spacing, grouping and simplicity to present information

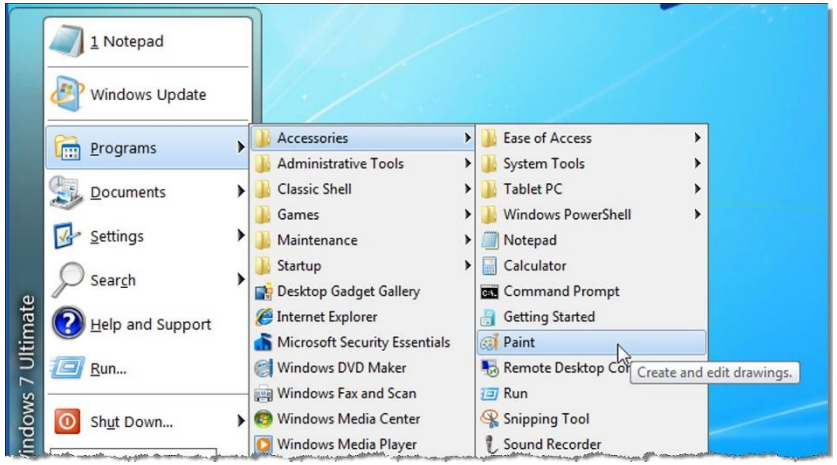
Icons

- Easier to learn and re-member than text labels
  - objects and operations
- Can easily be arranged on screen
- Different styles
  - photo-realistic images
  - logo-style images
- Also used in consumer products (e.g. digital cameras)

- Various *guidelines* and *style guides* for icon design
- Icons can be used in *combination with labels*
  - e.g. for toolbars with small icons

Menus

- Different menu interface styles
  - flat lists, drop-down, pop-up, scrolling, contextual, expanding, …
- Often *nested* list of options
- Scrolling through long lists can be frustrating
  - new controls such as mouse scroll wheel



- Carefully think about the *best terms* for menu options
- Choose *menu type* based on application and display size
  - flat menus vs. expanding menus

Multimedia Interfaces

- Combines different media
  - graphics, text, video, sound and animation
- Rapid access to *multiple representations* of information
  - multimedia encyclopaedias or digital libraries
  - training, education and entertainment
  - danger of fragmented interactions

BioBLAST multimedia project

- Guidelines on *how to best combine multiple media* for different kinds of tasks
  - e.g. audio for stimmulating imagination, movies for action information and text to provide details

Virtual Reality Interfaces

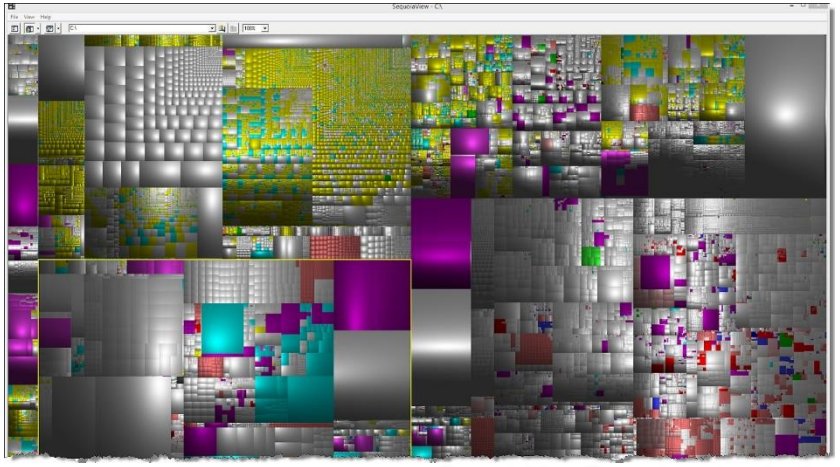
- Computer-generated graphical simulations
  - *illusion of participation* in a virtual environment (VE)
- Use of CAVEs (Cave Automatic Virtual Environment) or headsets
- New ways of navigating in 3D space
- *First-person* view or *third-person* perspective

Oculus Rift virtual reality headset

- How to prevent users from experiencing *nausea*
- Identify most effective ways for *navigation*
- *Best ways to interact* with information

Information Visualisation

- Amplify human cognition, enabling users to see *patterns in complex data*
- Different techniques
  - zoomable, 3D, interactive maps, trees, treemaps, …
- Helps expert users to *understand and make sense of vast amounts of* dynamically changing domain *data*

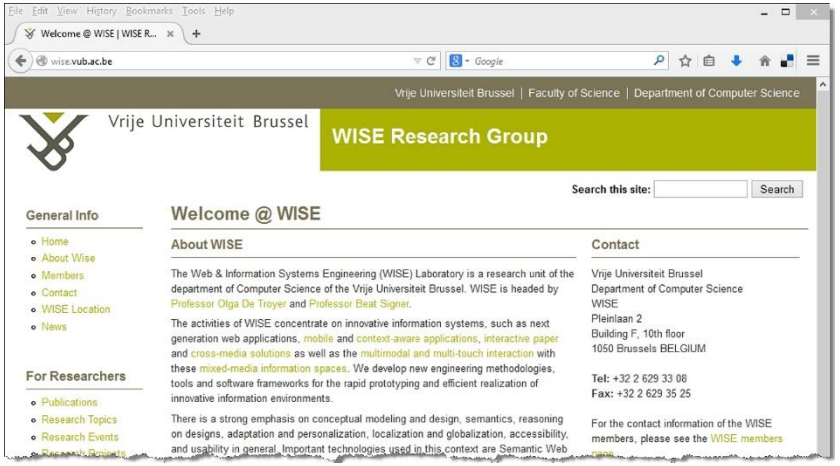


SequoiaView file system visualisation

- Algorithms and techniques to explore and visualise data
- Use of *animations*, *colour codings* or *2D* vs. *3D*
- Navigation
  - e.g. panning vs. zooming

Web Interfaces

- Website should be
  - aesthetically pleasing
  - usable
  - easy to maintain
- Users do *often not read all the content on a page* before following a link
- Bring the desktop to the browser
  - HTML5 and JavaScript
  - AJAX
  - …



- Emphasis on *content* and the use of *links* for navigation
- *Where am I? What's here? Where can I go?*
- Web Content Accessibility Guidelines (WCAG)

Consumer Electronics and Appliances

- Machines and devices for everyday use in the home, public place, car, …
  - remote controls
  - digital clocks
  - DVD players
  - washing machines
  - …
- Get specific tasks done in a short period of time
  - less time to read a manual or explore the interface

- Interfaces for *short interactions*
- *Simplicity*
- *Visibility* of status information
- Physical controls vs. touch screens

Mobile Interfaces

- Main difference in *size and portability*
  - ready at hand 24/7
- *Real-time* access to *contextual information*
  - scanning product barcodes while shopping
  - scanning QR codes
- *Location-based* services and recommendations

- *Small screen* and *limited control space*
- Various guidelines on how to design mobile interfaces
- *Privacy issues*
  - location sharing applications

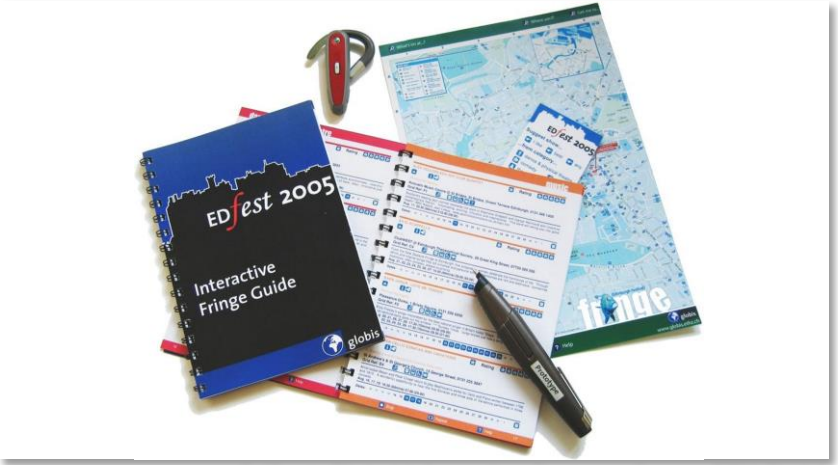
Speech (Voice) Interfaces

- Various applications
  - flight times or buying a ticket
  - replace touchtone navigation
  - real-time translators
- Supports visually impaired users
- Voice recognition and text-to-speech technology
  - specific grammars to improve recognition rate
  - barge-in

- *Natural interfaces* vs. voice-based *menu navigation*
- Type of voice actor
- Immediate *confirmation of requests*

Pen Interfaces

- Based on writing skills developed from childhood
  - digitalisation of handwriting
- Stylus on screen vs. digital pen and paper
- Quick and easy way to annotate documents
- Intuitive interfaces to integrate physical paper with digital information and services



EdFest, Global Information Systems Group, ETH Zurich

- *Switching* from writing, annotating or sketching to the execution of commands
  - context-sensitive menus
- *Feedback* for digital pen and paper interfaces

Touch Interfaces

- Already in use for quite some time
  - ticket machines, museum guides, ATMs
- More recently multi-touch interfaces for smartphones
  - swiping, tapping, pinching, …
- Use of gestures for interacting with digital content

Microsoft PixelSense technology

- *New forms of consuming, creating and searching digital content* compared to mouse and keyboard
  - e.g. swiping virtual keyboards

Mid-Air Gestures

- Tracking of people's body, arm and hand gestures
  - Nintendo Wiimote
  - Microsoft Kinect
  - …
- Mid-air gestures also used for controlling home appliances
- Sign language interpreters

Microsoft Kinect

- *Detection* (start/end) and *recognition* of mid-air gestures
  - continous input stream
- Gestures vs. unconscious gesticulation
- *Control device* vs. hands-free

Haptic Interfaces

- Various forms of haptic feedback
  - vibrating phone
  - actuators in clothing
- Used for *tactile feedback* in learning and sports training
- Improves experience in games
  - force feedback steering wheel
  - …

PHANTOM Omni haptic device

- Various issues regarding the actuators
  - where to place them on the body
  - *single* vs. *sequence* of tactile feeback
  - intensity and frequency

Multimodal Interfaces

- Enriched user experience by using multiple input and output modalities
  - speech and gesture
  - eye-gaze and gesture
  - pen input and speech
  - …
- Multiple modalities might be used *simultaneously* or *alternately*

Speeg2, WISE research lab

- *Recognition and calibration* of different aspects of a user's behaviour is *more difficult*
- Identify gains of combining different input and output modalities

Shareable Interfaces

- Multi-user interfaces for flexible group work and content creation
- *Shared point of reference*
- Some interfaces have become an integrated part of furniture
  - Café Table by Philips
  - Smart Furniture Initiative (SFI)

DiamondTouch tabletop

- *New forms of collaborative interaction* based on large shareable surfaces
- Effect of size, shape and orientation of surface
- *Shared* vs. *private space*

Tangible Interfaces

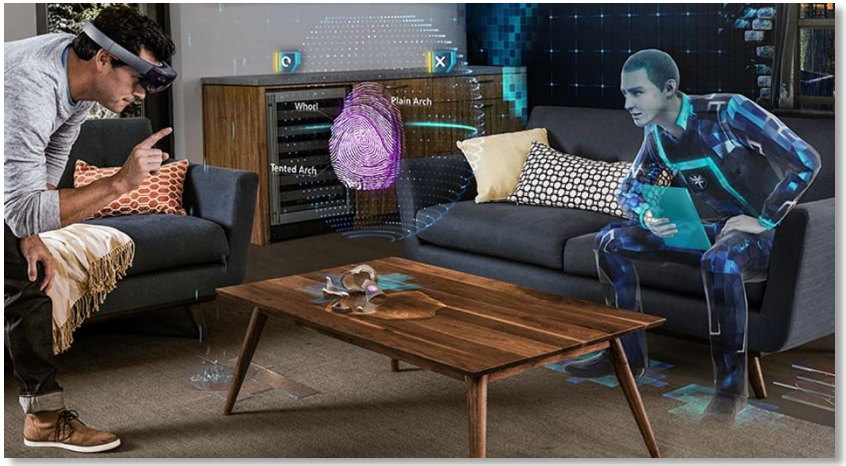
- Physical objects are coupled with digital representations
- *Sensing of physical objects* and feedback in digital or physical space
- Interplay of different devices and objects
  - no enforced sequencing and no modal interaction
- Affordances of interface objects guide the user

ArtVis, WISE research lab

- Coupling between physical action and effect
  - where to provide digital feedback
- What *kind of physical artefacts* should be used
  - bricks, cubes, sticky notes, …

Augmented and Mixed Reality

- Augmentation of the physical environment with digital information and services
- Information can be visualised (overlaid) in different ways
  - *head-mounted displays (HMDs)*
  - *handheld displays*
  - *fixed installations*

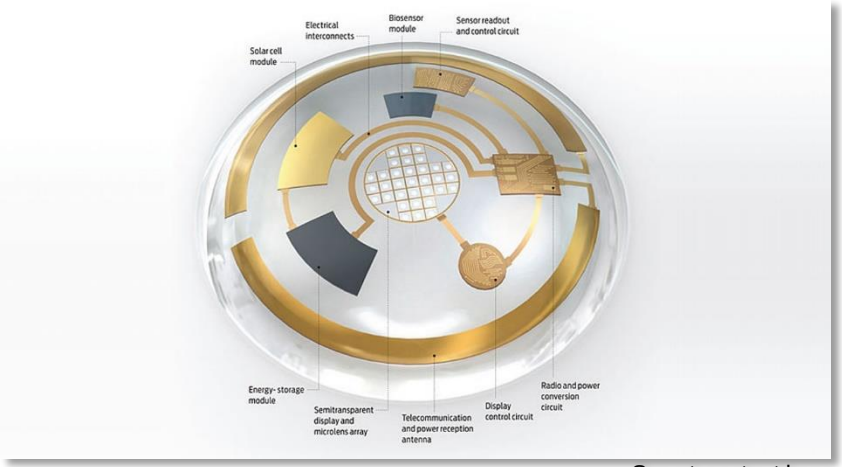


Microsoft HoloLens

- Form of the digital augmentation and when and where it should be applied
- Very different designs
  - playful learning experience
  - medical application

Wearable Interfaces

- Various new materials
  - flexible display technologies
  - e-textiles
- Glasses, jewellery, shoes or jackets as user interfaces
- Wearable technology for remote awareness
  - Hug Shirt by CuteCircuit for mobile phone calls

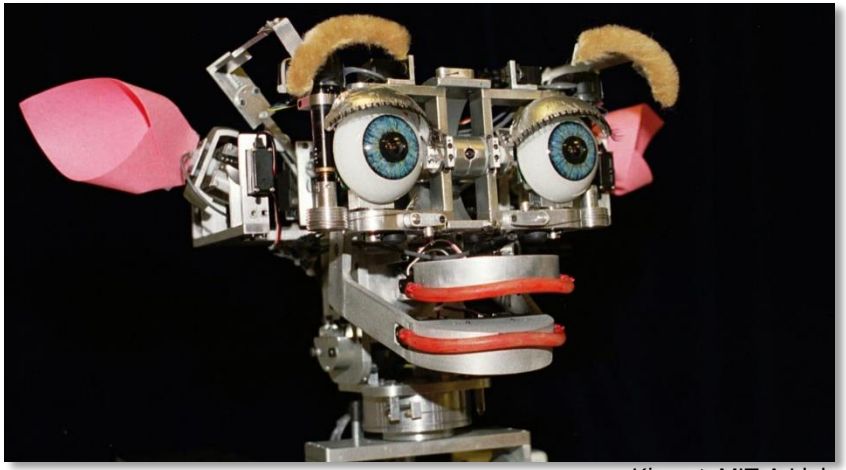


Smart contact lens

- Wearable interfaces have to be *comfortable*
- Hygiene is an issue
  - washing of e-textiles
- *Social acceptance* and *privacy*

Robots

- Originally used in manufacturing assembly lines and to investigate hazardous locations
- More recently domestic robots for cleaning and gardening
  - e.g. Roomba iRobot
- Pet robots and human-like robots used in therapies



Kismet, MIT A.I lab

- Ethical concerns
  - robots with human- or animal-like behaviour
- Communication with robots
  - human-”human” vs. human-machine interaction

Brain Computer Interfaces

- Communication between a user's brain waves and an external device
  - electrodes detect electric signals moving between neurons
- Brain computer interfaces (BCI) can also help disabled user's
  - interaction with computers
  - reconnect brain to muscles

EPOC, emotiv

- Brain computer interfaces should be *comfortable*
- Number of different actions/commands that can be executed

Towards Natural User Interfaces?

- *Natural User Interfaces (NUI)* enable a user to interact with a computer in the same way as they interact with the physical world
  - use of speech, touch, mid-air gestures, face recognition etc.
- How natural are natural user interfaces?
  - is it more natural to say “open” rather than to flick a switch to open door?
  - is it more natural to raise both arms rather than to press a button on a remote control to change a TV channel?
- NUIs are effective for certain domains but might not replace existing user interfaces

Which Interface Should We Use?

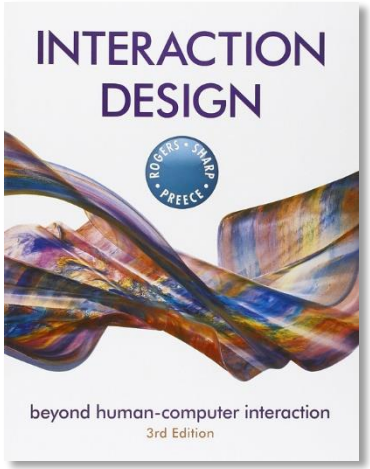
- In the last few years there is a significant increase in the number of user interface types
- How to decide which interface is preferable for a given task or activity?
  - multimedia vs. tangible interface for learning
  - speech vs. command-based interface
  - multimodal vs. monomodal interface
  - wearable vs. mobile interface
  - virtual reality vs. augmented reality
- Many of these questions are currently being researched
  - *this course will provide you some more insights about the design process and different types of interfaces*

Exercise 1

- Hands-on experience with Phidgets

Further Reading

- Parts of this lecture are based on the book *Interaction Design: Beyond Human-Computer Interaction*
  - chapter 6
    - Interface Types
    - Natural User Interfaces



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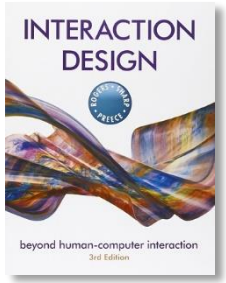

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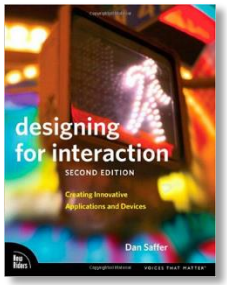

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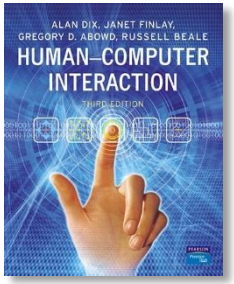

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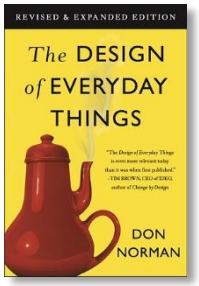

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- Microsoft Office Labs Vision 2019
  - `https://www.youtube.com/watch?v=Zp-_oUwdSeY`
- ACM SIGCHI Curricula for Human-Computer Interaction
  - `http://sigchi.org/cdg/cdg2.html`
- Videos of the NLS demo
  - `https://www.youtube.com/watch?v=yJDv-zdhzMY`

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Next Lecture

Interaction Design