# Programming of Interactive Systems

## Introduction & Definitions

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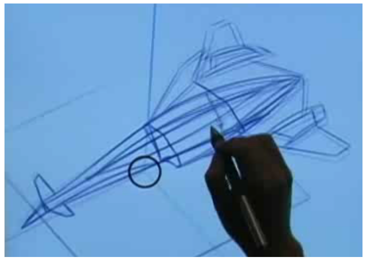
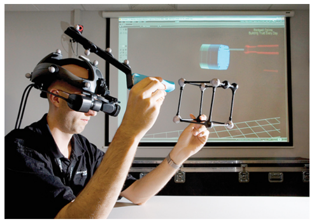
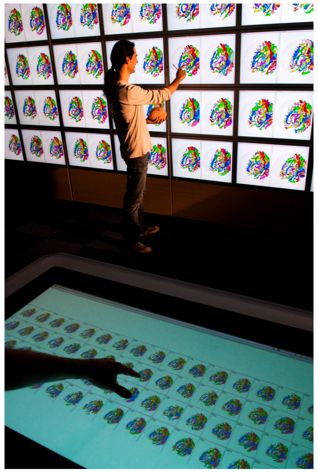
# Interactive systems





# Interactive systems

# Course objectives

Discover what interactive systems are and how they are developped

Familiarize with concepts concerning their design

- Input devices, models of interaction, interaction styles, interaction techniques, user interface widgets

Learn how to program interaction

Brief intro to methods, research & innovation in Human-Computer Interaction

# Content

Intro to HCI (brief history & importance)

User-interface programming (models & toolkits), UI widgets

Interaction modeling & design

Peripherals, input devices (mouse, touch, pen-based, gestures), interaction styles

Advanced interaction techniques & special UIs (e.g., sketching, multi-modal, mobile, Web)

Intro to 2D graphics (Java 2D)

Users (perception, cognition, motor performance)

Design and prototyping methods, user evaluation

# Course information

Tutorials (lab): programming exercises
  Java & some Javascript

Asistants: Cédric Fleury, Arnaud Prouzeau

2 programming assignments (34%)
+ 1 exam (66%)

Course web site:
  https://www.lri.fr/~fanis/teaching/ISI2014/

Email Contact: **[IS]** in the title

# Definitions

# User Interface (UI)

Part of an interactive system that:

- represents its internal state on output peripherals
- captures & manages input from input peripherals

All hardware and software that allows users to control, supervise and communicate with an interactive system

Interactive system = interface + functional layer

# Human-Computer Interaction (HCI)

"Human Computer Interaction is a discipline concerned with the design, evaluation and implementation of interacting computing systems for human use and with the study of major phenomena surrounding them."

ACM SIGCHI

# Definitions of HCI

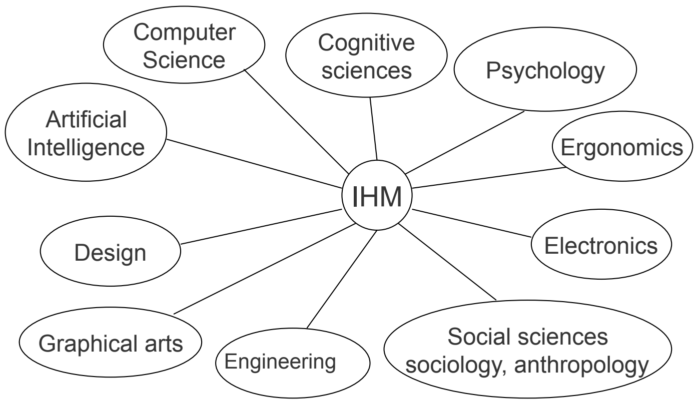
*Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them* (ACM SIGCHI, 1996)

*HCI is a study of how people design, implement and use interactive computer systems and how computers affect individuals, organizations and society* (Myers, Hollan, Cruz, 1996)

*HCI is the study of how people interact with computing technology* (Olson and Olson 2003)

*Designing interactive products to support the way people communicate and interact in their everyday and working lives* (Sharp, Rogers and Preece 2007)

# Multidisciplinary




# Interaction design

Design practices
- Graphic design
- Product design
- Industrial design
- Artist
- Design
- Film Industry

Academic disciplines
- Psychology & Cognitive science
- Ergonomics
- Sociology
- Computer Science
- Engineering
- Business
- Anthropology
- Graphic design

Interdisciplinary fields
- Cognitive Ergonomics
- HCI
- Information Systems
- Computer-Supported Collaborative Work
- Film Industry

# Ergonomics vs. HCI

**Ergonomics (human factors):**

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being, security, and overall system performance.

International Ergonomics Association

# Ergonomics

Influences

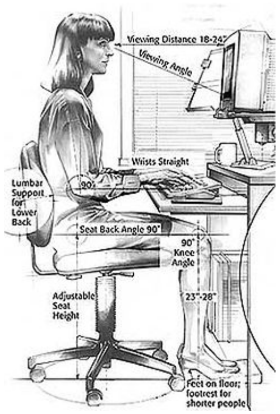
- mechanical engineering and physics
- psychology
- physiology and kinesiology

...

combined with observations and studies

# Ergonomics

Traditionally, its goal is to give **precise guidelines**




# Usability

« The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use »

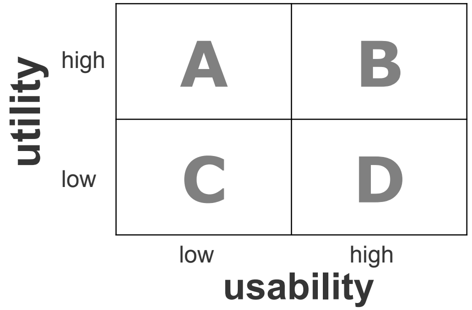
(ISO 9241)

A usable system is: easy to learn, easy to memorize, efficient, visually appealing and fast to recover from errors

# Utility

Reach specific needs and support real tasks

# Utility vs. Usability




Is D better than A? What do you think?

# Importance of HCI

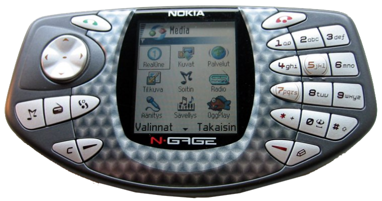
# Examples of bad design

Car park ticket payment machine at Tullamarine airport, Melbourne.
For a year, the machine required a uniformed attendant to help people!


Photographs courtesy of Penelope Sanderson

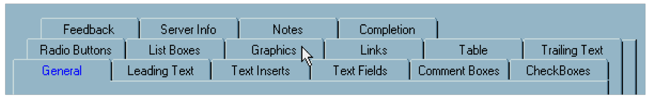

# Examples of bad design

Nokia N-Gage, Mobile and Handheld gaming device (2003)
Game console + mobile phone

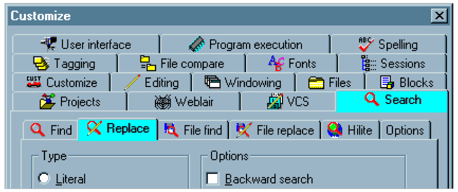





# Examples of bad design

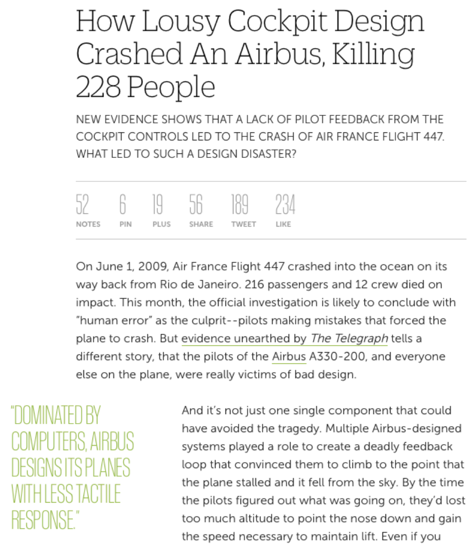



Tabbed dialogues with multiple layers:
clicking tabs reorganises position and row of tabs




Overuse/misuse of tabs, rows, icons and colors
Poor categorisation

# Why do we find bad designs?

How Lousy Cockpit Design Crashed An Airbus, Killing 228 People

NEW EVIDENCE SHOWS THAT A LACK OF PILOT FEEDBACK FROM THE COCKPIT CONTROLS LED TO THE CRASH OF AIR FRANCE FLIGHT 447. WHAT LED TO SUCH A DESIGN DISASTER?

52 NOTES 6 PIN 19 PLUS 56 SHARE 189 TWEET 234 LIKE

On June 1, 2009, Air France Flight 447 crashed into the ocean on its way back from Rio de Janeiro. 216 passengers and 12 crew died on impact. This month, the official investigation is likely to conclude with "human error" as the culprit--pilots making mistakes that forced the plane to crash. But evidence unearthed by *The Telegraph* tells a different story, that the pilots of the Airbus A330-200, and everyone else on the plane, were really victims of bad design.

"DOMINATED BY COMPUTERS, AIRBUS DESIGNS ITS PLANES WITH LESS TACTILE RESPONSE."

And it's not just one single component that could have avoided the tragedy. Multiple Airbus-designed systems played a role to create a deadly feedback loop that convinced them to climb to the point that the plane stalled and it fell from the sky. By the time the pilots figured out what was going on, they'd lost too much altitude to point the nose down and gain the speed necessary to maintain lift. Even if you


Engineers and computer scientists are *not* (by default) good interface designers: they (we) are expert computer users, and their (our) interest is the computer or the interface

What interests users is what the interface and the computer helps them do

We have to design FOR and WITH users

# Importance of user-centered design

Development cost
- Cost of user interfaces: ~50% of total cost

Cost of maintenance
- 20%: « bugs »
- 80%: unpredictable user needs

Cost of problem corrections
- $1 during the design stage
- = $10 during the development
- = $100 after the delivery

## Why is hard to design UIs?

« It is easy to make things hard. It is hard to make things easy »

Seems easy, common sense, but seldom done right. But once done right, it seems obvious!

User interface design is a creative process

Designers have difficulty thinking like users

- don't understand users' domain
- can't « unlearn »

(from Brad Myers' slides)

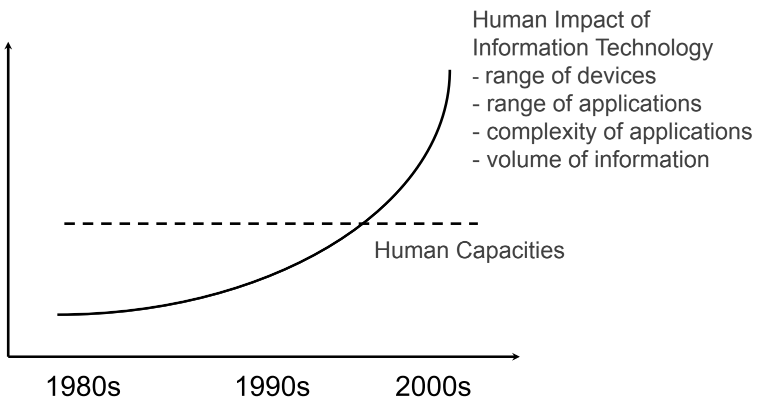
## Why is hard to design UIs? (2)

Software specifications are often wrong

> *"Only slightly more than 30% of the code developed in application software development ever gets used as intended by end-users. The reason for this statistic may be a result of developers not understanding what their users need."*
>
> Hugh Beyer and Karen Holtzblatt, "Contextual Design: A Customer-Centric Approach to Systems Design," *ACM Interactions*, 1997.

(from Brad Myers' slides)

## Why is hard to design UIs? (3)




## Why is hard to design UIs? (4)

Software becomes more and more complex
Word 1 (100 commands) vs. Word 2007 (>2000)

Theories & guidelines are not sufficient

- too general or too specific

UI design involves many tradeoffs

- standards
- graphic-design (artistic)
- performance isssues
- social factors (e.g., cost, existing practices)
- multiple platforms (e.g., hardware, browsers)
- legal issues (can't always copy other designs)

## Why is hard to program UIs?

They are reactive
- event-based programming, difficult to modularize

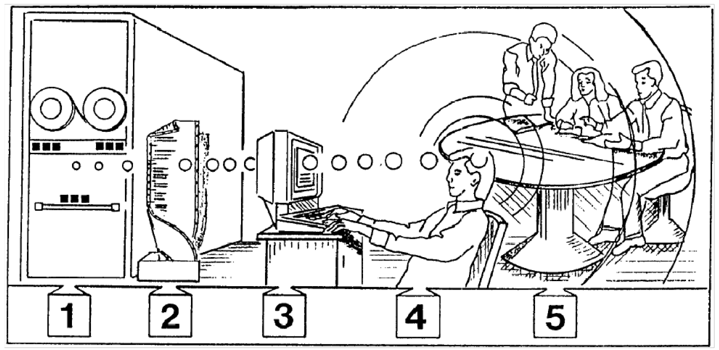
They require multi-processing
- deal with user events, aborts, window refreshing, multiple devices

Need for robustness
- no crashing, unexpected input, helpful error messages, aborts, undo, recovering mechanisms

Being responsive, real-time requirements
- Tracking input events, fast output
- Video, sound, multimedia

## Brief history of HCI

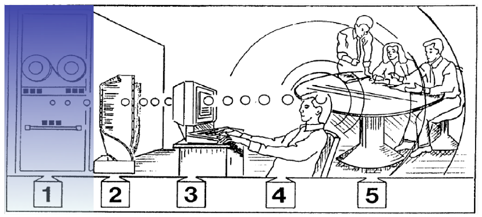
## The history of interfaces




Grudin (1990) The computer reaches out: The historical continuity of interface design

## The history of interfaces

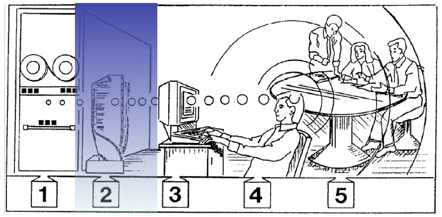
Phase 1 (Interface as hardware)
- 1950s
- Engineers / programmers
- Electrical engineering



## The history of interfaces

Phase 2 (Interface as software)

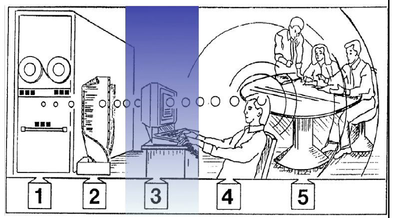
1960s-1970s
Programmers
Punched cards, batch processing
Users (indirect)
Computer Science




## The history of interfaces

Phase 3 (Interfaces as terminals)

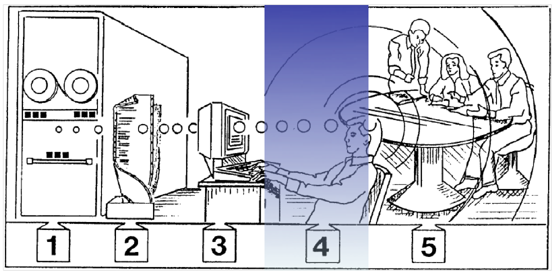
1970s-1990s
End users (time-sharing)
Human factors, cognitive psychology, graphic design
Time sharing creates the illusion of a personal machine
User can afford to think “at the terminal”
Focus on user behaviour and productivity
Computer mediated human-human interaction (CSCW)
Messages / Shared file systems




## The history of interfaces

Phase 4 (Interface as dialogue)

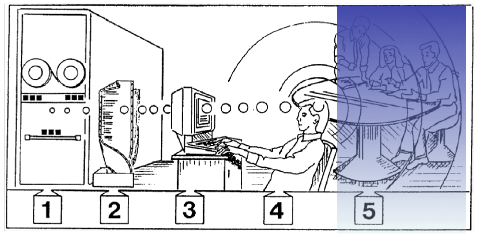
1980s-
Personal computers
Many end-users
More cognitive psychology, graphic design




## The history of interfaces

Phase 5 (Interface as work setting)

1990s-
Widespread use of networks
Groups of end users, communities
Social psychology, anthropology, organizational studies



# The history of interfaces

Phase 6 (?)

- 2000s-
- Mobile computing
- Mobile users, ad-hoc communities
- Pervasive / ubiquitous computing
- Domestic computing
- Social computing
- Anthropology, arts and drama

# Influences

Computer science

- Software engineering
- Technological advances

Human factors & psychology

- Computer programming and usage
- Work environments

Cognitive science

- Models, theories, frameworks

# Software Engineering

Software crisis (NATO Software Engineering Conference, 1968)

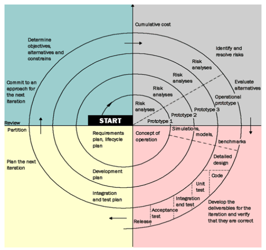
➔ Software engineering

Specifications

« Waterfall » and « Spiral » dev. models

Iterative development

Prototyping



Spiral model

# Evolution of technologies

Speed increase

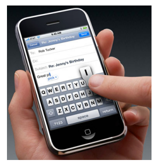
- Motivated more applications

Cost decrease

- Interfaces accessible to more people

New technologies

- New challenges & interaction needs



# Human Factors/Ergonomics

Guides for improving interface design
Guides for evaluating interfaces

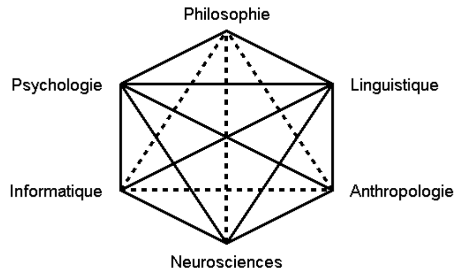
First psychological studies in HCI

- Programming psychology (Software psychology '60s)
- Behavior of programmers (Weinberg 1971)
- Comparison of batch processing and time-sharing (Sackman et al. 1968)
- Response time and productivity
- Individual differences among programmers (Sackman 1970)
- Design principles de (Hansen 1971)

# Cognitive sciences

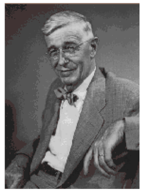
Study of perception, cognitive processes such as attention, memory, and learning

Provide guidance at early stages of the software development process



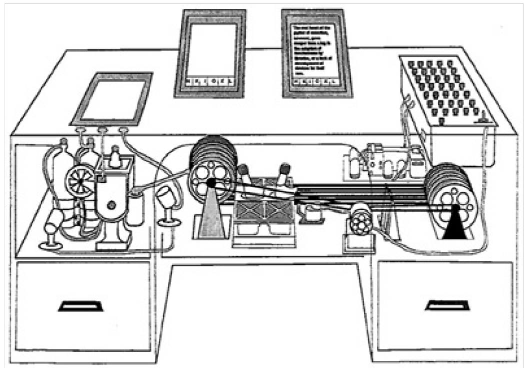

# History of HCI

***Technological visions - Vannevar Bush***



MEMEX and Hypertext (1945)

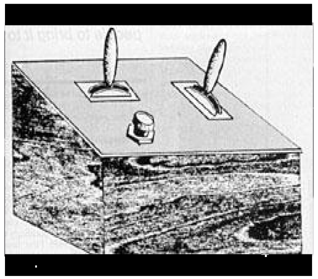
- Vannevar Bush: "As We May Think"



# Game interfaces

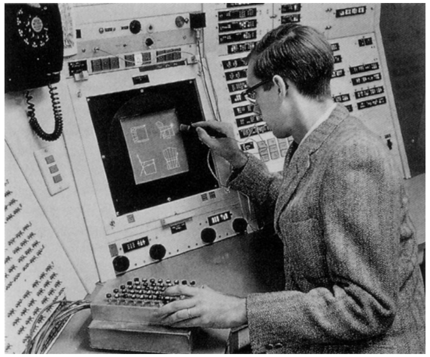
Spacewar!

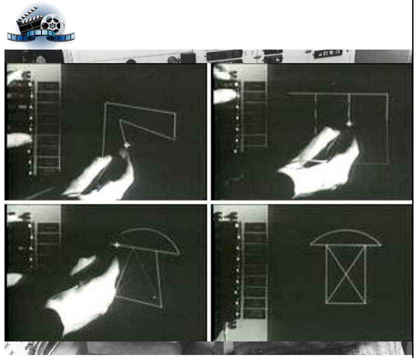
MIT - Steve "Slug" Russel et al. (1961-62)
DEC PD1 "mini-computer"



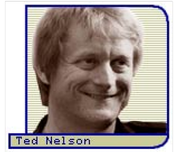
# History of HCI
***Technological innovations - Sketchpad***

Sketchpad – PhD thesis at MIT by Ivan Sutherland (1963)
- 1st graphical user interface
- Pointing gestures (optical pen), drawing, zooming, copy-paste





# History of HCI
***Technological innovations – Hypertext, Xanadu***




Coined the term hypertext (1965)

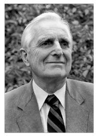
“non-sequential writing”

“Mr. Nelson pointed out that we often do not think in linear sequences but rather in "swirls" and in footnotes. He introduced the concept of the *hypertext*, which would be a more flexible, more generalized, non-linear presentation of material on a particular subject.

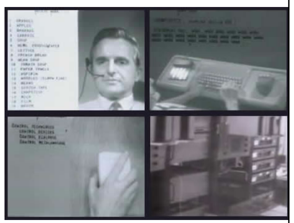
The educational possibilities in the use of the hypertext are vast. For example, it is possible that basic texts on a subject could be interindexed, so that the necessity and difficulty of tracing footnotes and rare sources would be eliminated. In this way the problems of information retrieval because of widespread writing today would be alleviated, making decisions in many fields easier.”

Leading to the sub-discipline of hypertext and hypermedia

# History of HCI
***Technological innovations - Douglas Engelbart***



**Augmentation not automation:** “increasing the capability of a man to approach a complex problem situation, to gain comprehension to suit his particular needs, and to derive solutions to problems”



NLS (Online system) tools (1968):
- Outline editor for idea development
- Hypertext linking
- Tele-conferencing
- Word processing
- E-mail
- User configurability and programmability

# History of HCI
***Technological innovations - Douglas Engelbart***

NLS (Online system) devices and concepts:
- The mouse pointing device for on-screen selection
- A one-hand chording device for keyboard entry
- Video-conferencing, document sharing
- On-line help systems
- The concept of consistency in user interfaces

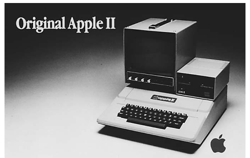
The first mouse (1963)

# Textual interfaces

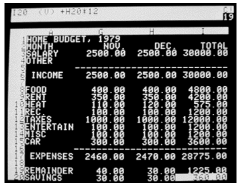
(1969 - 1983)

command line, menus and input screens

First text editor
WordStar (MicroPro, 1979)




Apple ][ (1977)



First spreadsheet: Visicalc
Dan Bricklin (1979)

# Xerox PARC ('70)

PARC: Palo Alto Research Center created in 1970

- Three researchers/engineers have won the Turing Award

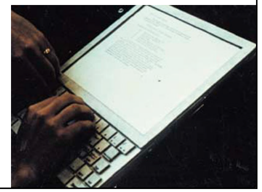
Object-oriented programming (Smalltalk)

Laser printer, Ethernet

WIMP: Windows, Icons, Menus & Pointers

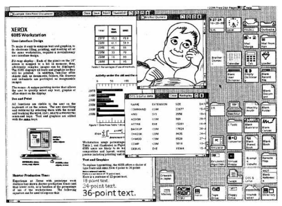
Portable computers: Dynabook (1968)

- Designed but never built



# Xerox Star (1981)

$16,500



Design influenced by software needs (based on task analysis, scenarios, 600-700 hours of video)

Native function on a network

GUI based on office/desk metaphor

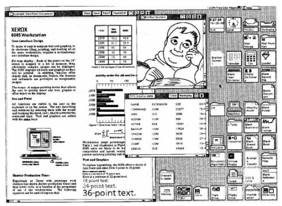
Use of icons and windows and the idea of WYSIWYG ("**What You See Is What You Get »)**

System focusing on documents (users do not know the applications)

...but market failure

# Xerox Star (1981)

$16,500



Too innovative, powerful, different

Target market missed (e.g, no spreadsheets)

Expensive ($16,500)

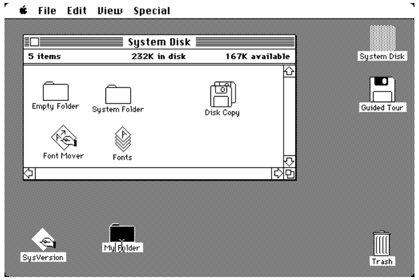
Closed architecture (impossible to develop applications outside Xerox)

Political reluctance to expand market beyond printers

...but it has greatly influenced future systems

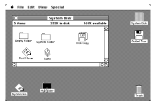
# Apple Macintosh (1984)

$2,495




# Apple Macintosh (1984)

$2,495



Commercial success, more mature and a more open public

Aggressive price ($2,500) accessible to larger public

Menu bar, modal dialog boxes and visible applications inherited from l'Apple ][

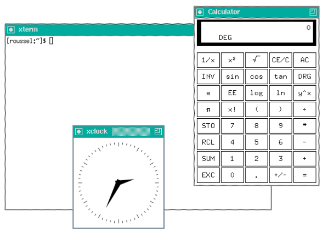
UI toolkit to help external developers

Detailed style guides to help consistence between apps

Three key applications: Finder, MacPaint, MacWrite

# X Windows (1984)

Athena project of MIT: connect 4000 UNIX machines, from different sponsors (DEC, IBM, Motorola, etc.)

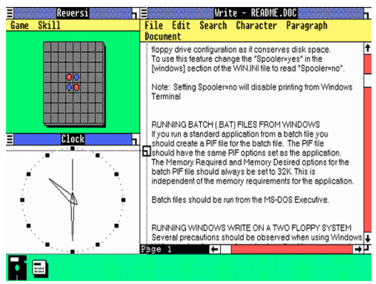


Client/server model:

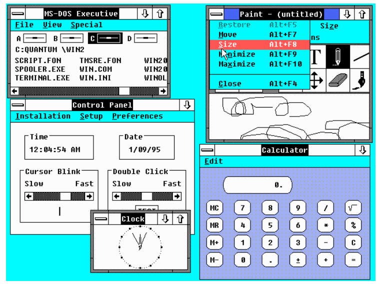
- division of what/how to facilitate portability
- transparent use of network that permits remote displaying

# MS Windows (1985)

Moved to overlapping windows



Microsoft Windows 1



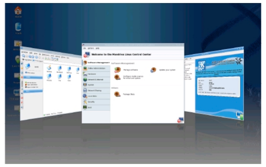
Microsoft Windows 2 (1987)

# Desktop interface (1984 - )

More power and new uses (network), but little change in interaction: WIMP (Window, Icon, Menu & Pointing)


Apple OS X 10.5


Microsoft Vista


Mandriva Linux 2008

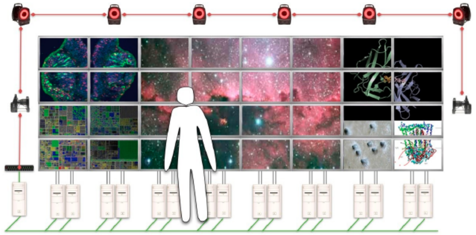
… this is not necessarily a bad thing!

# HCI

Does not follow Moor's law


| **Original Macintosh** | | **iMac 20"** |
|---|---|---|
| Jan 1984 - $2500 | x0.6 | Nov 2013 - $1500 |
| CPU 68000 - 0.7 MIPS<br>RAM 128kB<br>Floppy 400kB | x3000<br>x2000<br>x200000 | CPU G5 - 2250 MIPS<br>RAM 256MB<br>HD 80GB |
| 9" b&w 512x342<br>keyboard, mouse<br>WIMP desktop | x2 / x10<br>idem<br>idem | 20" colors, 1680x1050<br>keyboard, mouse<br>WIMP desktop |

# …WILD in LRI



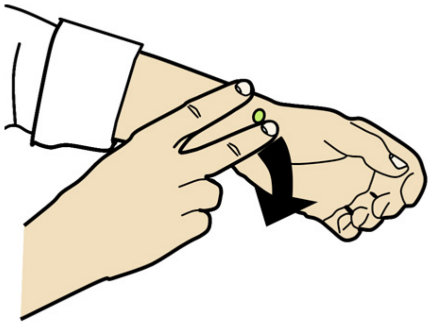
screen wall:
- 5.5m x 1.8m
- 20480 x 6400 = 131 million pixels
- 32 screens of 30", in a 8x4 configuration
- driven by a cluster of 18 PC,
- linked by a high speed network

3D motion capture system that tracks users in real time

Multi-touch interactive tables

INRIA, LRI, Université Paris-Sud – The Wild project

## But also: Disappearing devices

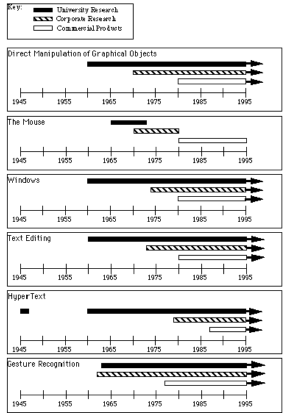


(Ni and Baudisch, 2009)

## HCI and research

Most innovations come from research labs (academic or industrial)

It takes time to reach commercial products




## Example 1: Touch displays

Touch displays
- IBM (1971)

MultiTouch
- U of Toronto (1982)

Gesture research
- Bell Labs (1983)

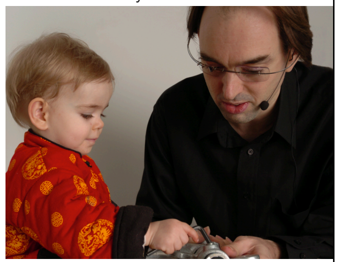
Mainstream
- Apple's iPhone, iPad, iTouch
- Microsoft Surface

## Example 2: Wearable computing

Evolution of Steve Mann's "wearable computer" invention


from http://www.eecg.toronto.edu/~mann/

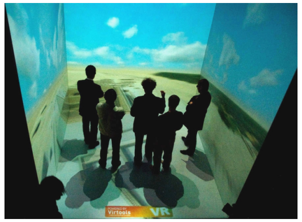
Steve Mann today...



Google Glasses

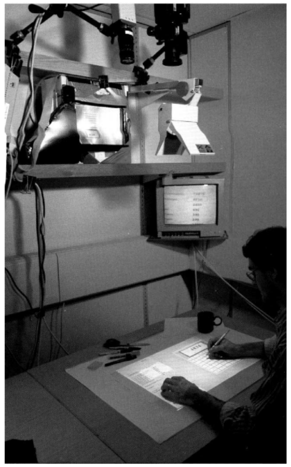
# virtual reality

user immersion (sensor + motor)
input? usually body tracking or speech

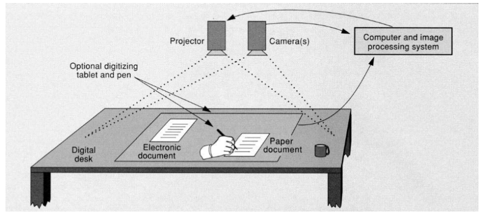


e.g., a head mounted display and a cave

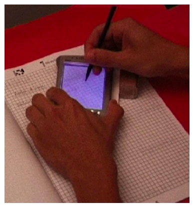
# DigitalDesk (Wellner, 1991-93)



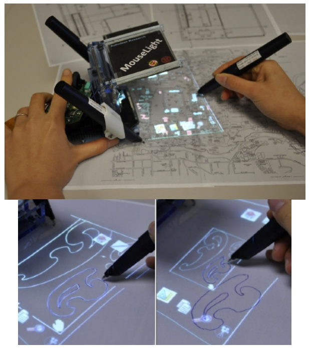
Augmented Reallity



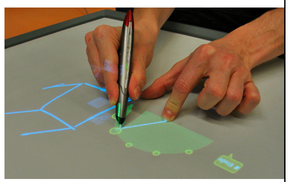

# Augmented paper



physical « Toolglass »
(Mackay, 2002)



Projection on paper with
pocket-projectors (Song, 2010)

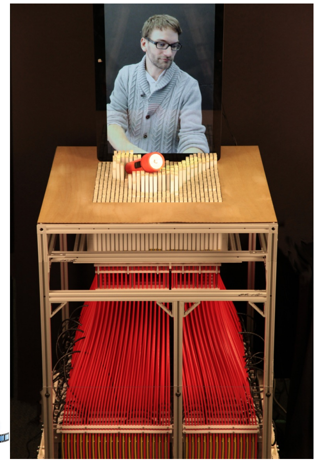


Paper and touch table
(Brandl, 2008)

# Tangible interfaces

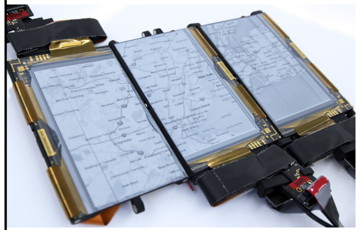
Reactable: Tangible music interface

Dynamic Shape Display (MIT)



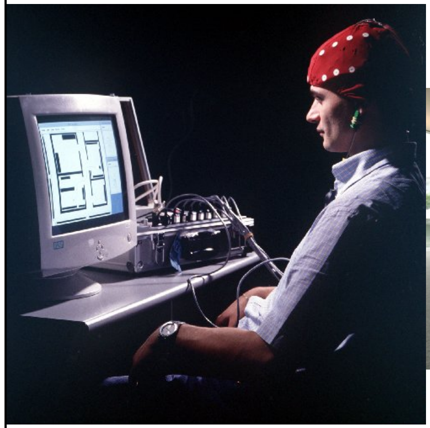
http://tangible.media.mit.edu/project/inform/

# Foldable interfaces




Vertegaal et al., Queen's University, Canada

# Brain interfaces



# HCI in popular culture

Minority Report (2002)

http://interaction.lille.inria.fr/~roussel/digital-library/media/2002-minority-report/2002-minority-report-clip.mov

http://vimeo.com/2229299

Her (2013)