Human-Computer interaction

Session 5

Methodological basis -- interface styles and technologies

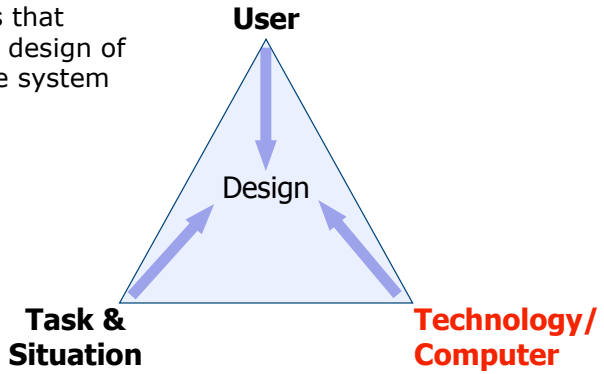
Outline

- **Psychological basis: human users as cognitive systems**
  - Perception
  - Memory & attention
  - Reasoning & acting
- **Methododological basis: building interfaces**
  - Traditional interface styles & technologies
  - Usability design process
  - Interface evaluation
- **Advanced interactions**
  - Natural spoken language
  - Dialog
  - Multimodal interfaces
  - Agent-based interfaces
  - Conversational agents
  - Social companions
  - User adaptation

Human-Computer Interaction

...is concerned with the design, evaluation and implementation of interactive systems for human use.

Three factors that influence the design of an interactive system



A typical computer system

?

- screen with text and graphics/windows
- speakers, microphone, web cam
- keyboard, mouse/trackpad
- in variations (desktop, laptop, PDA,...)

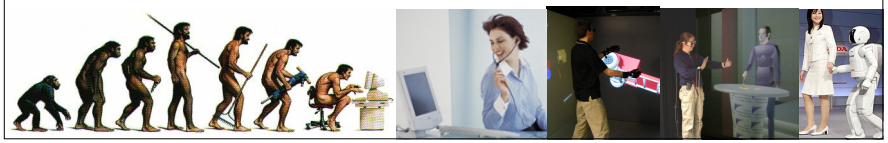
→ comes with **devices**

- **Devices** one can use enable and limit the styles of **interaction** one can realize
  - new interaction modes inspire the design of new devices
  - device's technical possibility as important limiting factor
  - use of different devices supports different styles of interaction, alternatively or in combination

What devices & interactions de we have traditionally? And why?

Evolution of interaction paradigms

Year	Paradigm	Implementation
1950s		*Switches, punched cards*
1970s	*Typewriter*	*Command-line interface*
1980s	*Desktop*	*Graphical user interface, direct manipulation*
1980s+	*Spoken Language*	*Speech recognition/synthesis, natural language processing, dialogue systems*
1990s+	*Natural interaction*	*Perceptual, multimodal, interactive, conversational, tangible, adaptive*
2000+	*Social interaction*	*Agent-based, anthropomorphic, social, emotional, affective, collaborative*

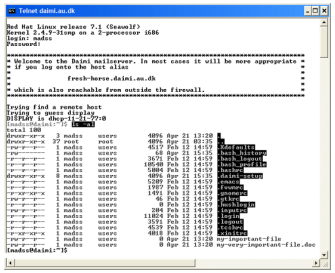


Interaction paradigm: typing-in
device: keyboard

Command line interface (CLI)

- way of expressing instructions to the computer directly (e.g. 438 commands in BSD Unix)

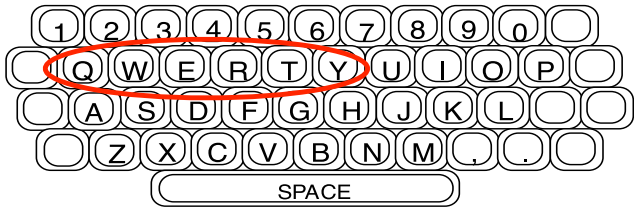
commands =
chars, abbreviations, words
command language =
commands + syntax
→ grammars, TAGs, etc.



- Cognitive burden: requires to recall names *and* syntax
  - "*afmtodit*" = create font files for use with "*groff*"
  - "*bc*" = arbitrary precision calculator language
  - "5" + "d" + "w" = delete five words in *vi*

Keyboards

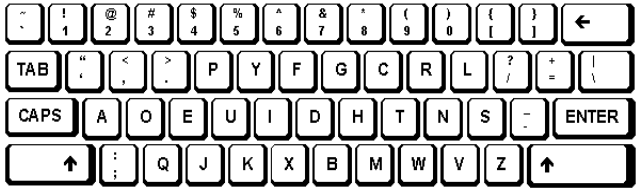
- Inherited from type writers, first keyboard in 1874 ("Remington No. 1")
- Standard layout: „QWERTY", but arrangement not optimal for typing!
  - meant to prevent typewriters jamming
  - but, common combinations of consecutive letters placed at different ends of the keyboard
  - Anecdote: try typing "typewriter"



Alternative keyboard layouts

Dvorak

- since 1932
- common letters under dominant fingers, but biased towards right hand
- common combinations of letters alternate between hands
- 10-15% improvement in speed, reduction in fatigue
- But large social base of QWERTY typists produce market pressures not to change



Special purpose keyboards

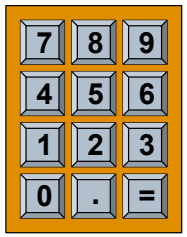
- designed to reduce fatigue and repetitive strain injury

Maltron left-handed keyboard for one handed use

Kinetics keyboard

Phone & num pads

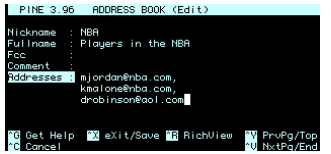
- use numeric keys with multiple presses
  - 2 – a b c 6 - m n o
  - 3 - d e f 7 - p q r s
  - 4 - g h i 8 - t u v
  - 5 - j k l 9 - w x y z
  - hello = 4433555[pause]555666
  - surprisingly fast, but not ergonomic
- T9 algorithm for predicting entries
  - type as if single key for each letter
  - use dictionary to guess right word
  - hello = 43556 …
  - give options when ambiguities like 26 -> 'am' or 'an'



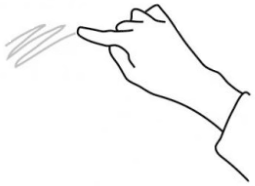
calculator/ keyboard

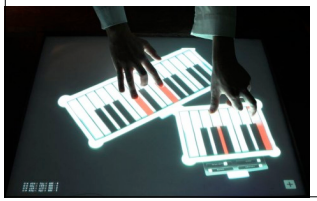
Form filling

- whole interface is form-based
  - data entered into fields
  - few keys to navigate through fields and conclude form



- advantages:
  - simplifies data entry
  - shortens learning, fields need only be 'recognised'
  - good for non-expert users
- disadvantages:
  - limited in scope, useful only for structured information
  - consumes a lot of screen space
  - rigid, not very flexible





Interaction paradigms:
point & click, direct manipulation, touch & multi-touch

devices:
pointer, button, dials, manipulators

Computer point & click interfaces

- present options that can be selected
- user selects from predefined, pre-arranged selection of operations
- selection by
  - Text input: numbers, keys/letters, speech ("shortcuts")
  - Pointing: buttons, stylus, gesture
  - Positioning: arrow keys, mouse
  - Combination: mouse + "accelerator" key
- used widely: multimedia, web pages, hypertext, touch screens, mobiles, etc.

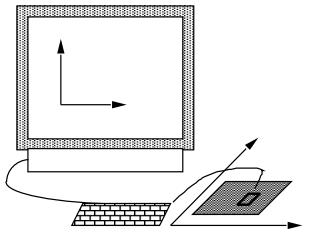
Input devices

Mouse
- very common, easy to use
- buttons (1-3 on top, wheel)
- Mechanical vs. optical

Trackball
- separate buttons for picking
- meant to reduce RSI

Joystick
- Absolute vs. isometric: pressure of stick = cursor velocity
- buttons for selection

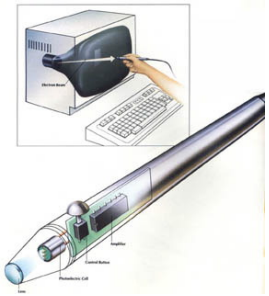
Mouse



- Located on desktop
  - requires physical space
  - little arm fatigue
- Only relative movement detectable
- Movement of mouse moves screen cursor
  - Cursor oriented in (x, y) plane,mouse movement in (x, z) plane …
- Indirect mapping pointing device
  - device itself doesn't obscure screen
  - accurate and fast
  - hand-eye coordination poses problems for novice users

Note, in practice every monitor has fingerprints!

Stylus & light pen



Stylus
- small pen-like pointer to draw directly on screen
- may use touch sensitive surface or magnetic detection

Light Pen
- detects light from screen
- does not work with LCDs
- now rarely used

both …
- *direct* pointing, obvious to use
- can obscure screen

Touch-sensitive screen

- Detect the presence of finger or stylus on the screen.
  - works by interrupting matrix of light beams, capacitance changes or ultrasonic reflections
  - *direct* pointing device
- Advantages:
  - fast, and requires no specialised pointer
  - good for menu selection
  - suitable for use in hostile environment, clean and safe from damage.
- Disadvantages:
  - finger can mark screen
  - Imprecise, finger is fairly blunt
  - lifting arm is tiring

Physical control - manipulation

- specialist controls for industrial controls, consumer products, etc.

large buttons

clear dials

easy-clean smooth buttons

multi-function control

tiny buttons

Example: BMW iDrive

- *single multi-purpose device* for controlling climate, navigation, entertainment, communication
- *haptic feedback*: feel small 'bumps' for each item
  - makes it easier to select options by feel
- slides backwards & forwards, rotates

Example: BMW iDrive

Design Continuum proposed a whole new way of thinking about driver-car interaction: haptic, or touch, feedback. ''Instead of visual feedback, we suggested controls that you feel,'' ... ''You can use the haptic channel in parallel to the visual -- that's why you can change gears without thinking about it.'

NY Times 12.2002

In the 745i, tuning the radio is an interactive experience at 75 m.p.h. After a bit of this, you may wonder what's the fuss over handheld cellphones. ... IDrive is capable of managing more than 700 functions... Even if a modern automobile is essentially a mobile computer, its operator's first concern is to keep it from crashing.

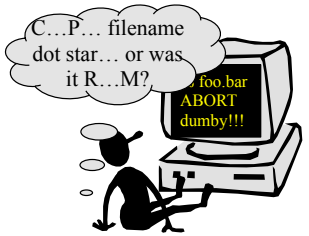
NY Times 5.2002

''I spent an hour experimenting in a simulator, and I got lost in the menus,'' says Don Norman, the author of ''The Design of Everyday Things.'' ..“The real culprit is not the knobs and controls,'' he says. ''It's the mind.'' Preliminary research by the Department of Transportation has shown that mentally challenging tasks, like counting backward by sevens or remembering lists of words, may impair driving ability.

Automobile Week

Direct manipulation (Shneiderman, 1982)

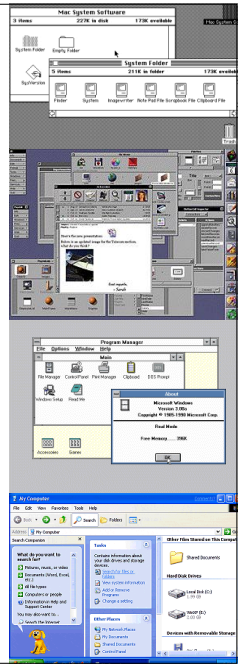
- *Metapher:* Directly manipulate the object of interest
  - objects must be visible and distinguishable in the UI
  - allows to act as if in a workplace
  - actions and feedback must be rapid, reversible, incremental → can see results as you go
- *Example*: resizing a rectangle by dragging its corners
- Enables different ways of thinking about the interaction



Graphical user interfaces (*GUI*)

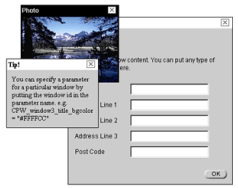
Interacting with a computer through a metaphor of manipulation of graphical images and widgets in addition to text.

- combines a lot of interaction styles in a consistent graphical interface
- **WIMP** interface: Windows, Icons, Menus, Pointers
- Widgets = Window gadget
  - bits that make the GUI
  - checkbooxes, menus, toolbars, buttons, etc.



Windows

- Areas of the screen that behave as if they were independent
  - can be moved, resized, overlap each other
  - scrollbars to move contents
- Pop up windows
  - take the user out of working context
  - user has to refocus attention
- Must be used carefully!
  - Tradeoff: time spent understanding & manipulating windows instead of on task
  - related tasks belong in the same window

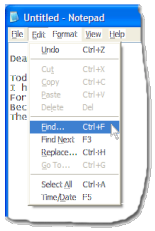


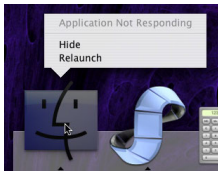
Icons

- small picture or image that resembles what it represents (cf. Peirce's semiotics)
  - Facilitate recognition, instead of recall
- can take many forms
  - from highly stylized…
  - …to realistic representations

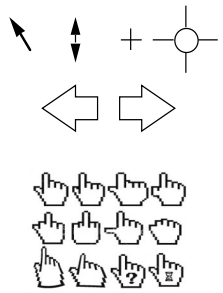
- *„iconifying":* closing down windows
  - small representation if many accessible windows

Menus





Pointers

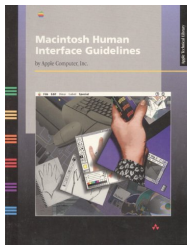


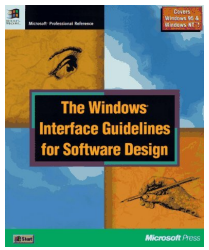
Buttons

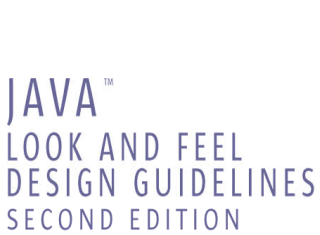
Scrollbars, …

Look and feel

- All WIMP systems have the same elements (windows, icons., menus, pointers, buttons, etc.)
- … but different GUIs behave differently!
- appearance + behaviour = *"look & feel"*

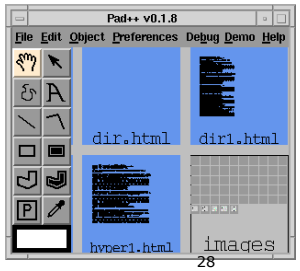






Enhanced graphical interfaces

- 3D workspaces
  - infinite virtual space
  - light, size, occlusion give depth impression
  - like WIMP, but point & click in 3D (how does a 3D button look like?)
- ZUI's: Zoomable UI's
  - Navigation like panning a video camera
  - Zooming in on objects
- Virtual & Augmented Reality
  - Immersive environments with control elements
  - Point & click and direct manipulation in 3D

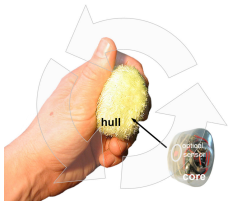


Positioning in 3D (6 DOF

- SpaceBall
- SpaceOrb
- Space Mouse

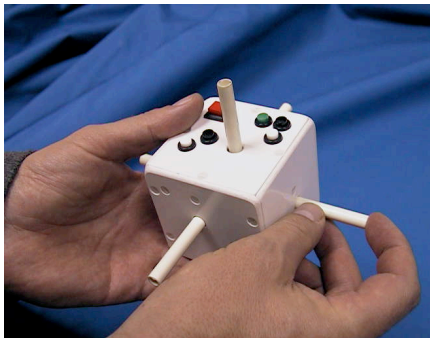
Pointing in 3D/Mid-air

Example: SOAP (HPI Potsdam)



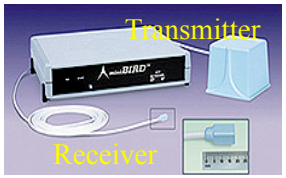
Cubic Mouse

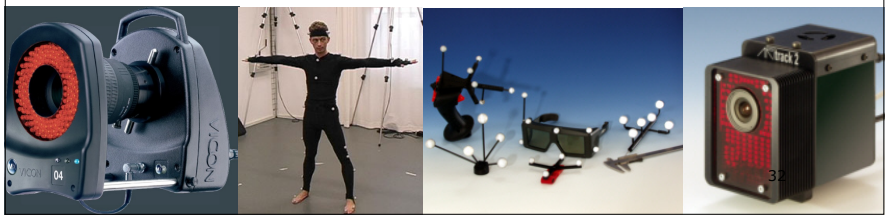
- 12 DOF input device
- Tracks position and rotation of rods using potentiometers
- Other shapes and implementations possible
  - Mini Cubic Mouse
  - …



Moving in 3D - Tracking systems

- Electromagnetic
  - Noisy, affected by metal
- Optical
  - Marker reflect IR light
  - Combined to unique spatial configuration per tracked position
  - >3 IR cameras needed to cope with occlusions





Tracking systems

- Acoustic (ultrasound)
  - Distance inferred from travel time of sound
  - No interference, inexpensive, sensitive to air temperature & noises
- Inertia
  - Only 3 DOFs (orientation)
  - Use gyroscopes & accelerometers
  - Less noise, lag
- Hybrids
  - Inertia (orient.)
  - acoustic (pos.)

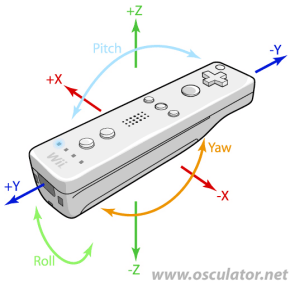
Intersense IS-300

Tracked point & click devices

- Space Mouse
- Ring Mouse
- Fly Mouse
- Wand

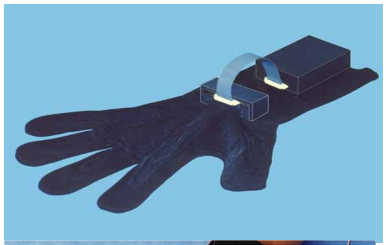
Wii controller

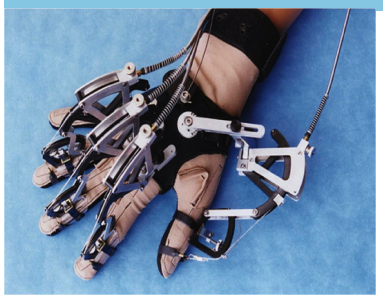
- Infrared camera
- Accelerometers
- Buttons
- Transmission to Wii console via Bluetooth



Data Gloves

- Tracks the user's finger postures and movements
- Bi-metal, fibre optics, exoskeleton, etc.
- Common types
  - CyberGlove
    - 18 sensors
    - 22 sensors
  - 5DT Glove
    - 5 sensors
    - 16 sensors

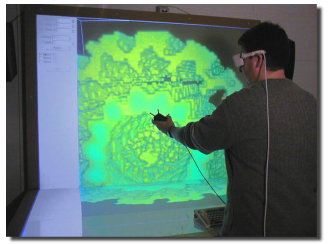




Haptic feedback

- touch and feeling important
  - in games … vibration, force feedback
  - in simulation … feel of surgical instruments
  - called *haptic* devices

Output devices for point & click, direct manipulation



Sensorama

- Morton Heilig designed the first multisensory virtual experiences in 1956 (patented in 1961)
- The Sensorama combined projected film, audio, vibration, wind, and odors.
- The five "experiences" included
  - a motorcycle ride through New York
  - a bicycle ride
  - a ride on a dune buggy
  - a helicopter ride over Century city
  - a dance by a belly dancer.

Head-mounted display (Sutherland, 1968)

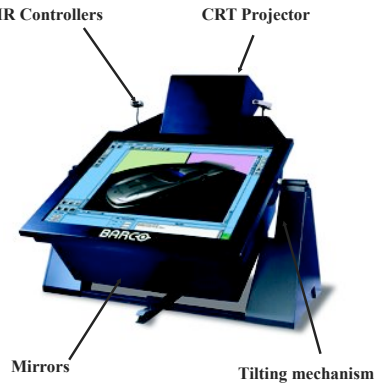
- small TV screen for each eye
- slightly different angles
- (Mechanical) tracking

Head-mounted displays

- Main advantages
  - Scene completely surrounds user
  - sharp and brisk
- Classical disadvantages
  - Field of view (FOV) is narrow
  - Early devices heavy, cause fatigue
  - Can't see others
- Now, light-weight see-through HMDs

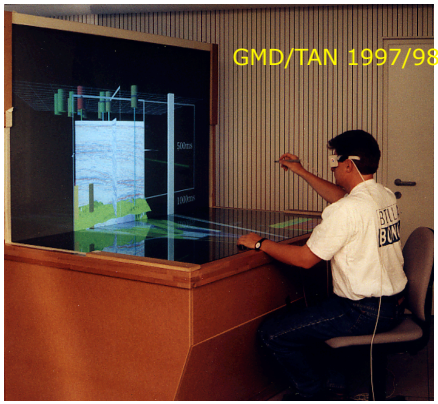
Workbench

- table-top metaphor
- change display orientation
- integrate real & virtual
- **Problems**:
  - Less immersion
  - Occlusion/cancellation
  - $$$



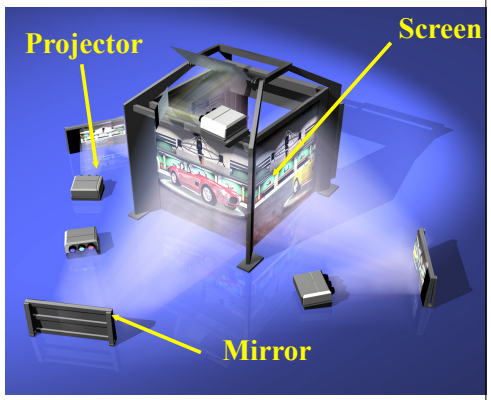
Two-Sided Workbench

- workbench with volume view
- can display larger objects in 3D
- telepresence
- **Problems:**
  - Edge-blending
  - Still, cancellation
  - $$$



CAVE

- multi-wall (usually>3)
- wider field of view
- allows to see other people
- ...but who has the correct 3D scene?
- **Problems**:
  - missing walls break illusion
  - reduced brightness
  - $$$

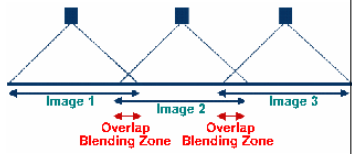


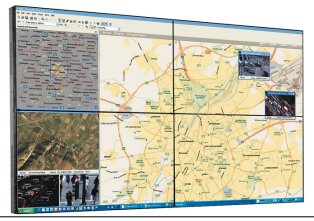
VR motion sickness

- 3D scene must be constantly adapted to position & orientation of the head/gaze direction
  - time delay between movement and visual feedback (>100ms) creates conflicting sensations
- Problems with virtual depth perception on physical screens
  - objects presented at different stereo distances
  - but all focused in same plane (monitor)
  - conflict: eye angle vs. lense focus
- conflicting cues => sickness

Large scale displays

- used for meetings, design, lectures, etc.
- technologies
  - plasma – usually wide screen
  - video walls – lots of small screens together
  - powerwalls
    - lots of projectors
    - usually back-projected

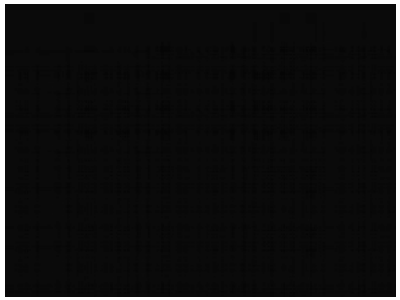




BOOM (Binoccular Omni Orientation Monitor)

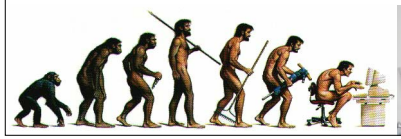
- High resolution
- Wide Field of View
- User must not carry heavy weight
- tracking with minimal lag

- Limited user movement
- Requires the user to hold onto the BOOM for control



Evolution of HCI

Year	Paradigm	Implementation
1950s		*Switches, punched cards*
1970s	*Typewriter*	*Command-line interface*
1980s	*Desktop*	*Graphical user interface, direct manipulation*
1980s+	*Spoken Language*	*Speech recognition/synthesis, natural language processing, dialogue systems*
1990s+	*Natural interaction*	*Perceptual, multimodal, interactive, conversational, tangible, adaptive*
2000+	*Social interaction*	*Agent-based, anthropomorphic, social, emotional, affective, collaborative*



Hand-written language

- Text can be input into the computer using a pen and a digesting tablet
- Lots of technical problems:
  - capturing all useful information - stroke path, pressure, etc., in a natural manner
  - segmenting into individual letters
  - interpreting individual letters
  - coping with different styles of handwriting
  - speed

- Used in PDAs and tablet computers, leave the keyboard on the desk!
- But…

Natural language

- *Just say* what you want the machine to do
  - familiar and intuitive
  - spoken or written
- Problems
  - linguistic complexity (phonology, syntax, semantics, pragmatics)
  - inherently vague, ambiguous, situated
- Solutions
  - restrict to sub-language or only few fixed keywords
  - enable dialogue with feedback, repairs, etc.
  - allow adaptation

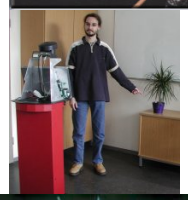
Example: speech recognition

- Almost every device comes with a mic
- ASR inherently difficult, most successful when:
  - adapted to user – initial training and learned peculiarities
  - adapted to limited vocabulary systems
  - used with headset or telephone
- Still, problems with
  - external noise interfering
  - imprecision of pronunciation, speed, varying prosody
  - large vocabularies
  - different speakers and dialects

Dictate directly to your Mac with ViaVoice, but remember to speak slowly and clearly.

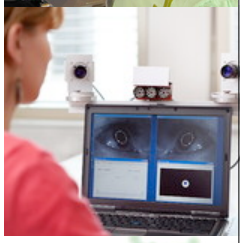
Multimodal interfaces

- idea: interacting is easier when using multiple modes in parallel
- allow multiple means and styles of interacting in combination
  - e.g. point & click plus speech
- employ various input and output technologies



Eye/Gaze-Tracking

- use gaze information to
  - control interface, e.g., look at menu item to select it
  - get important additional information about state of user, e.g., fatigue, attention, cognitive load
- technology:
  - laser or infrared light reflected off retina
  - high accuracy requires headset
  - cheaper and lower accuracy devices available, sit under the screen like a small webcam
- now often used for design evaluation



- many other specialized input devices around
  - iris scanners, body temperature, heart rate, galvanic skin response, blink rate, ...
- appied for emotion recognition (affective computing), life signal monitoring, fatigue monitoring, ...

Next session:
How to use all this (and more) to build a usable systems?