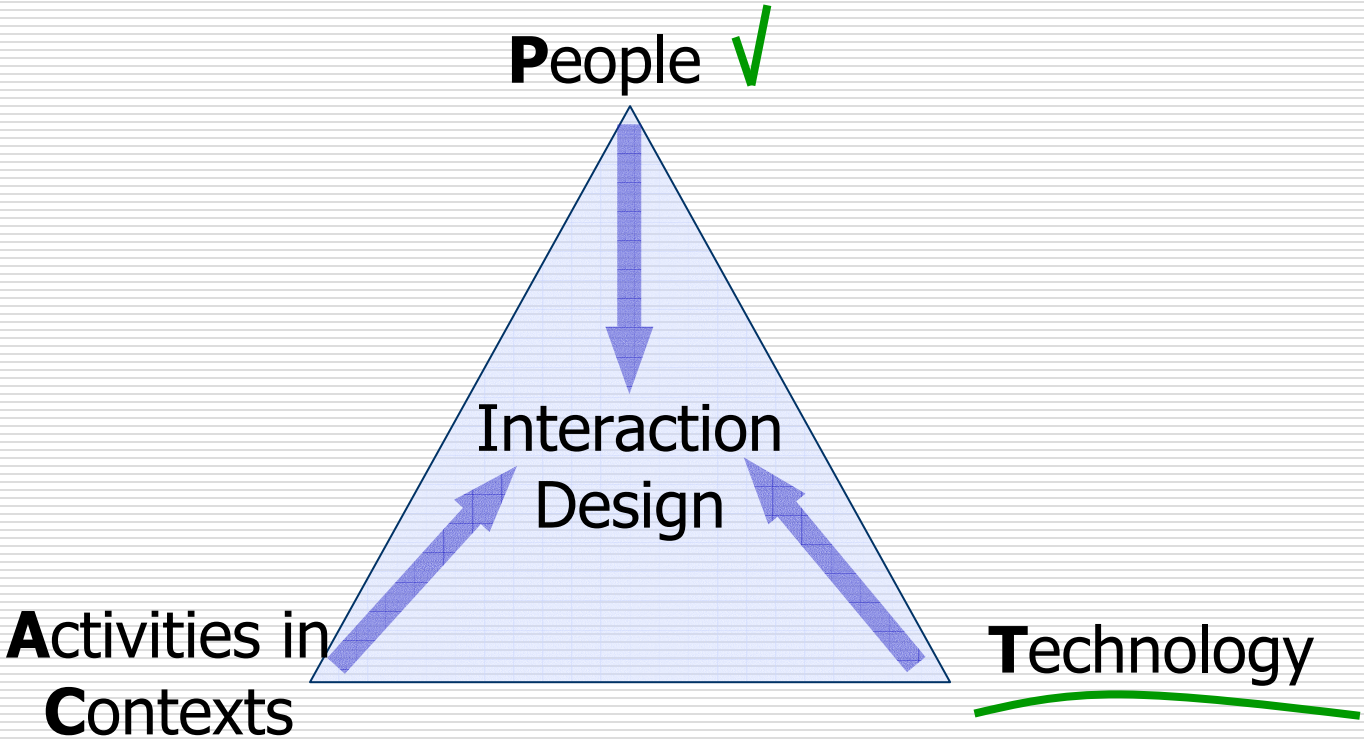
Human-Computer Interaction

Termin 4: The Computer

Designing interactive systems

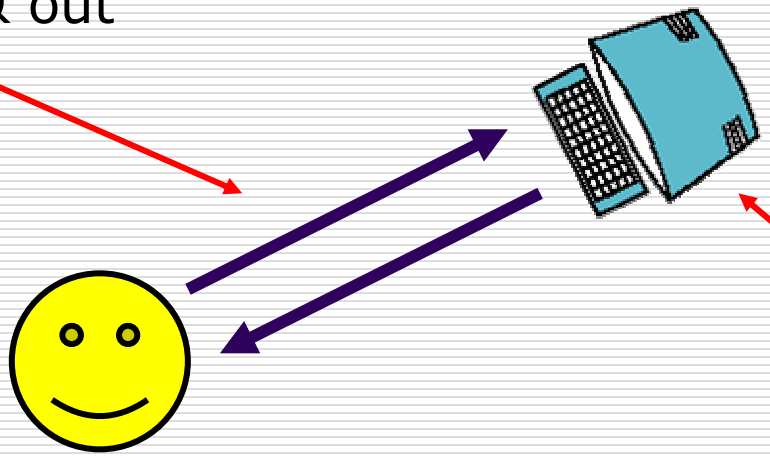
The **PACT** framework (*Benyon et al., 2005)*



Interacting with computers

to understand human–*computer* interaction
… need to understand computers!

what goes in & out
devices, paper,
sensors, etc.



what can it do?
memory, processing,
networks

The computer

a computer system is made up of various elements

each of these elements affects the interaction

- input devices – text entry and pointing
- output devices – screen (small&large), digital paper, virtual reality
- physical interaction – e.g. sound, haptic, bio-sensing
- memory, processing, ...

How many computers …

in your house?

- PC
- TV, VCR, DVD, HiFi, cable/satellite TV
- microwave, cooker, washing machine
- central heating
- security system

can you think of more?

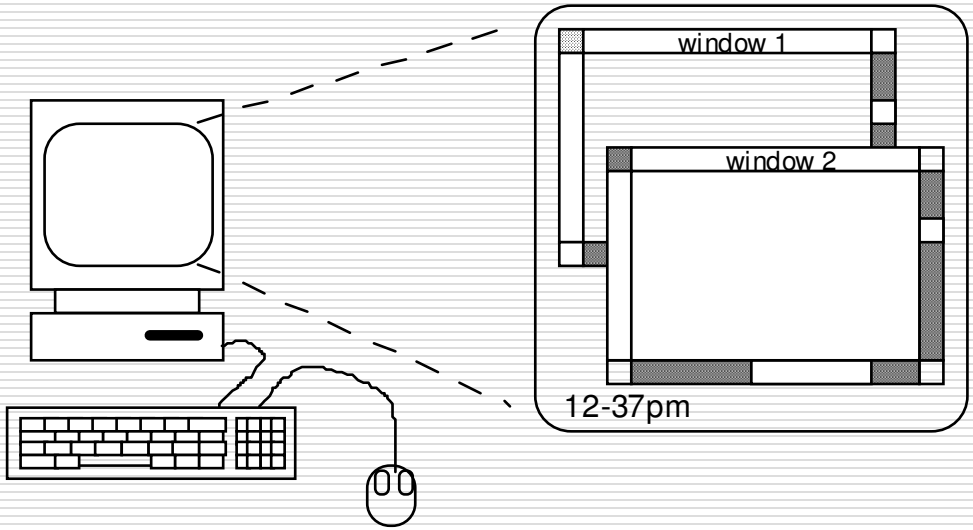
in your pockets?

- PDA
- phone, camera
- smart card, card with magnetic strip?
- electronic car key
- USB pen drive

try your pockets and bags

A ‘typical’ computer system

- screen, or monitor, on which there are text and windows
- keyboard
- mouse/trackpad
- variations
  - desktop
  - laptop
  - PDA



- Devices vs. interaction
  - existing devices dictate the supported styles of interaction
  - devices especially designed for certain interaction modes
  - if we use different devices, then the interface can support different styles of interaction

Input devices: text entry

keyboards

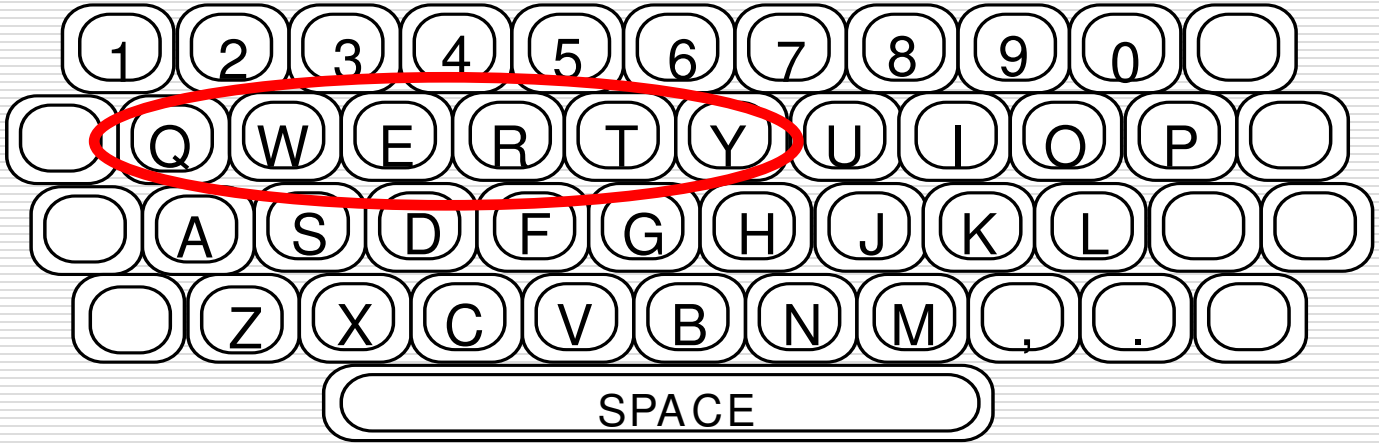
chord keyboards, phone pads

handwriting, speech

Keyboards

- Most common text input device
- Allows rapid entry of text by experienced users (faster than hand-writing)
- Keypress closes connection, causing a character code to be sent
- Connected by cable or wireless
- Inherited from type writers, first keyboard in 1874 (“Remington No. 1”)

layout – *QWERTY*



layout – *QWERTY*

- Standardised layout, but …
  - non-alphanumeric keys are placed differently
  - accented symbols needed for different scripts
  - differences between languages

- Everybody uses QWERTY, but arrangement not optimal for typing!
  - layout to prevent typewriters jamming
  - common combinations of consecutive letters placed at different ends of the keyboard
  - Anecdote: try typing “typewriter”

- Alternative designs allow faster typing, but large social base of QWERTY typists causes reluctance to change

alternative keyboard layouts

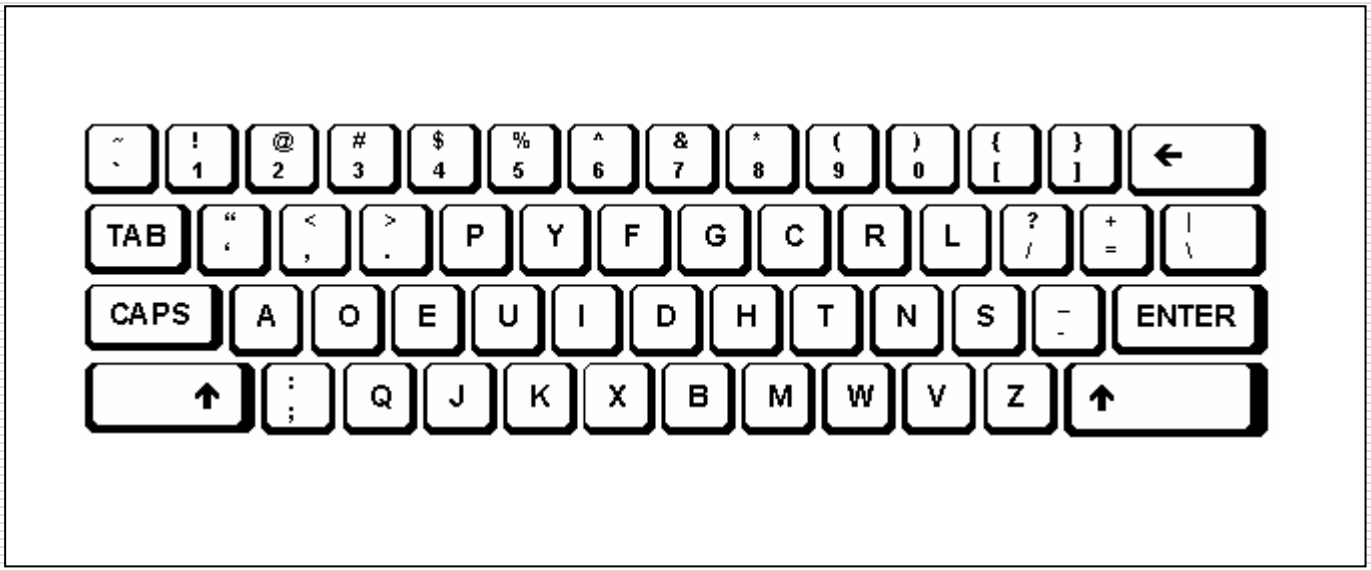
Alphabetic

- keys arranged in alphabetic order
- not faster for trained typists, not for beginners either

Dvorak

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

layout - *Dvorak*



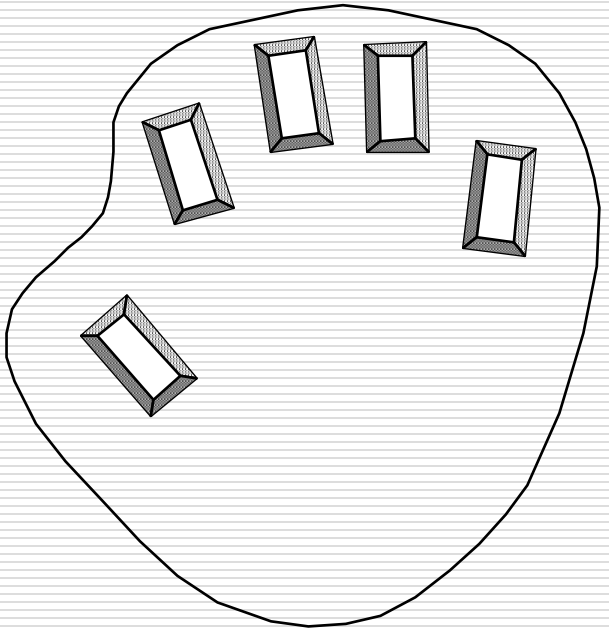
special keyboards

- designed to reduce fatigue for *repetitive strain injury* (RSI)

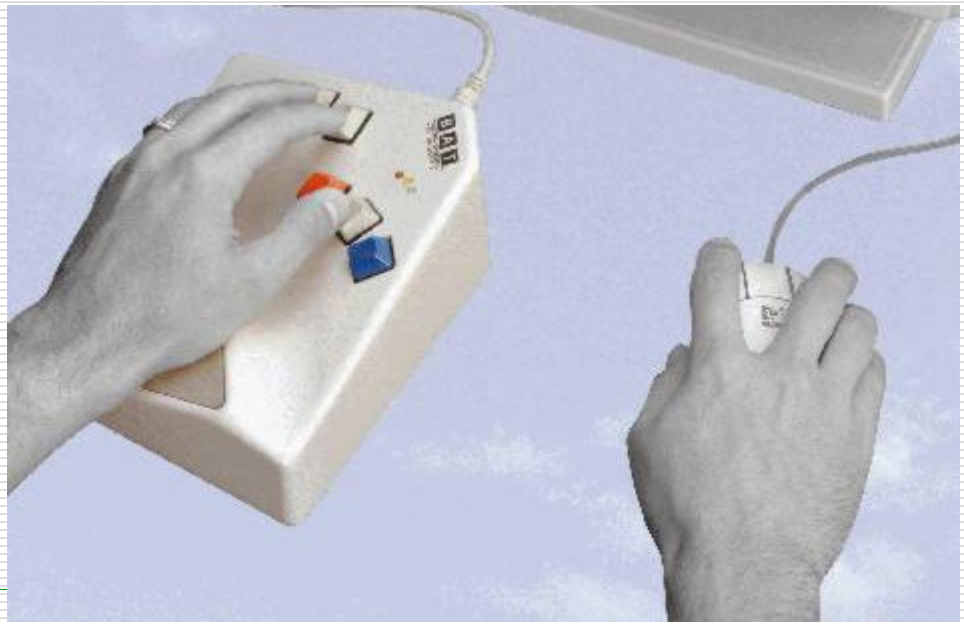
Maltron left-handed keyboard for one handed use

Kinetics keyboard

Chord keyboards



- only a few keys (4-5)
- letters as combination of keypresses
- compact size - ideal for portable applications
- short learning time – keypresses reflect letter shape
- Fast once you have trained
- Social resistance, plus fatigue after extended use
- Niche market for some wearables



Phone pads and T9 entry

- 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!

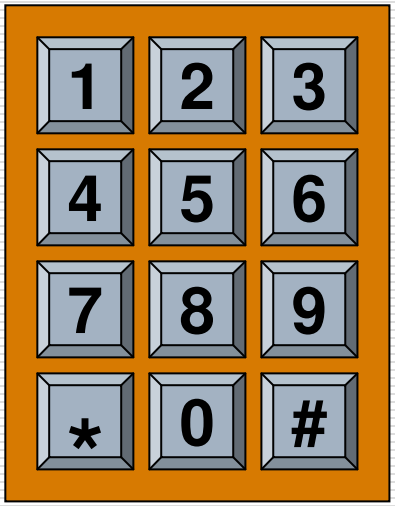
- T9 algorithm for predicting entries
  - type as if single key for each letter
  - use dictionary to guess right word
  - hello = 43556 …
  - give options when ambiguities like 26 -> ‘am’ or ‘an’

Numeric keypads

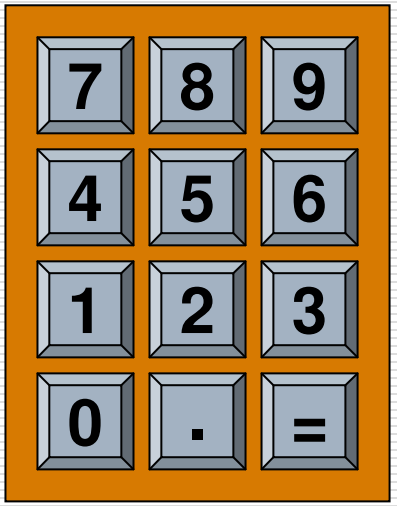
for entering numbers quickly

- calculator, PC keyboard
- Telephone, ATM

not the same!!



telephone



calculator/
keyboard

Handwriting recognition

- 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…

Speech recognition

- Almost every device comes with a mic
- Improving rapidly
- Most successful when:
  - single user – initial training and learns peculiarities
  - limited vocabulary systems
  - used with headset or telephone
- 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.

Input devices: pointing and drawing

mouse, touchpad
trackballs, joysticks etc.
touch screens, tablets
eyegaze

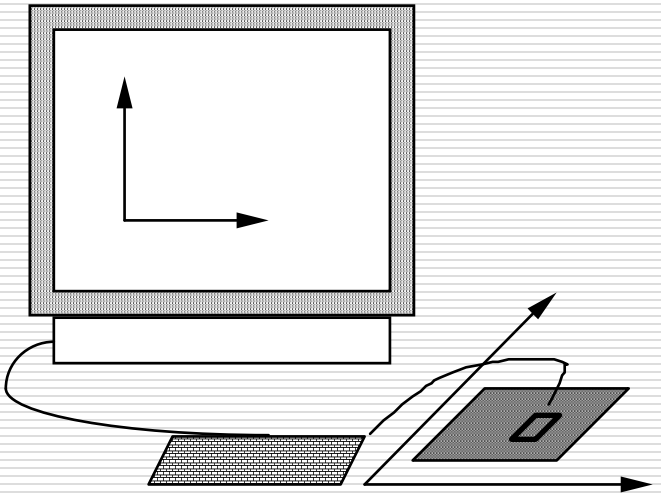
Mouse

- Handheld pointing device
  - very common
  - easy to use
- Two characteristics
  - planar movement
  - buttons

    usually from 1 to 3 buttons on top, used for making a selection, indicating an option, or to initiate drawing, etc.
- Mechanical vs., optical

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* manipulation device
  - device itself doesn't obscure screen
  - accurate and fast
  - hand-eye coordination problems for novice users

…in practice, every monitor has fingerprints.

Touchpad

- small touch sensitive tablets
- ‘stroke’ to move mouse pointer
- used mainly in laptop computers

- good ‘acceleration’ settings important
  - fast stroke
    - lots of pixels per inch moved
    - initial movement to the target
  - slow stroke
    - less pixels per inch
    - for accurate positioning

- combined with keypad functions

Trackball and thumbwheels

Trackball

- ball is rotated inside static housing
  (like an upside down mouse)
- relative motion moves cursor
- *indirect* manip. device, fairly accurate
- separate buttons for picking
- used in some portable and notebook computers
- meant to reduce RSI

Thumbwheels …

- for accurate CAD – two dials for X-Y cursor position
- for fast scrolling – single dial on mouse

Joystick & trackpoint

Joystick

- Absolute vs. isometric
- Isometric: pressure of stick = velocity of cursor movement
- buttons for selection on top or on front like a trigger
- often used for computer games and 3D navigation

Keyboard trackpoint ("nipple")

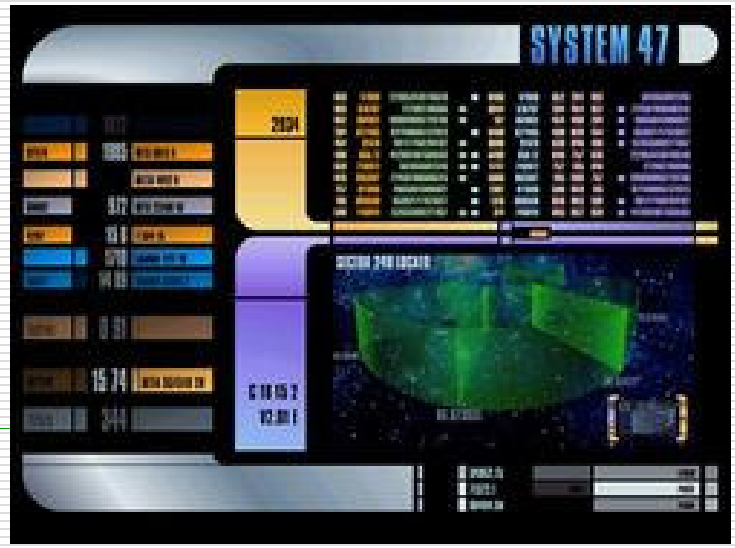
- for laptop computers
- miniature joystick in the middle of the keyboard

Discrete positioning controls

- in phones, TV controls etc.
  - cursor pads or mini-joysticks
  - discrete left-right, up-down
  - mainly for menu selection

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



Stylus & light pen

Stylus

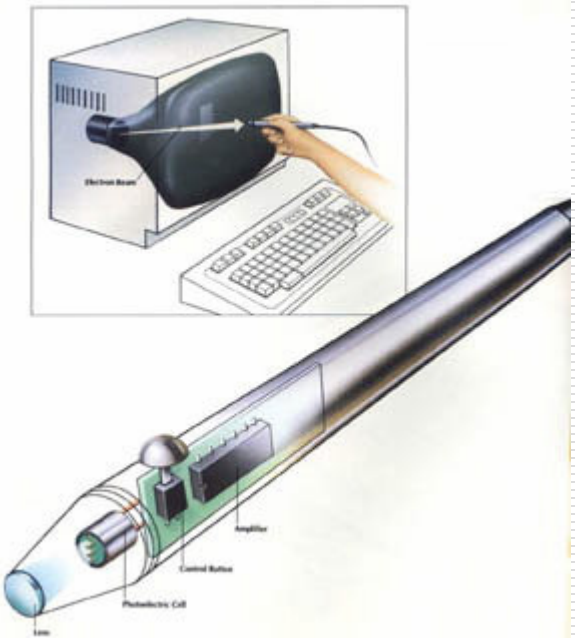
- small pen-like pointer to draw directly on screen
- may use touch sensitive surface or magnetic detection
- used in PDA, tablets PCs and drawing tables

Light Pen

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

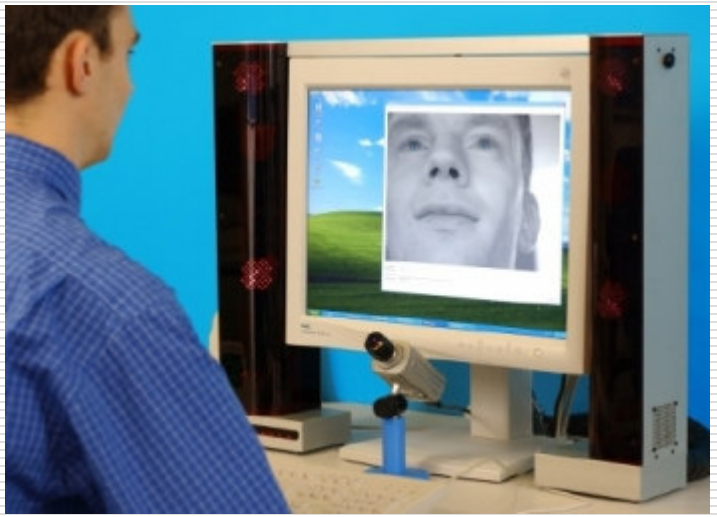
both …

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



Eyegaze

- control interface by eye gaze dir.
  - e.g. look at menu item to select it
- uses laser beam or infrared light reflected off retina
- mainly used for evaluation
- potential for hands-free control
- high accuracy requires headset
- cheaper and lower accuracy devices available, sit under the screen like a small webcam



Output devices: displays

bitmap screens (CRT & LCD)

large & situated displays
digital paper

bitmap displays

- screen is vast number of coloured dots
  - Resolution
    - number of pixels, SVGA 1024 x 768, PDA 240x400
    - density of pixels (dots per inch), 72-96 dpi
  - aspect ratio (between width and height)
    - 4:3 for most screens, 16:9 for wide-screen TV
  - colour depth
    - number of different colours for each pixel
    - 8 bits each for red/green/blue = millions of colours
- CRT vs. LCD

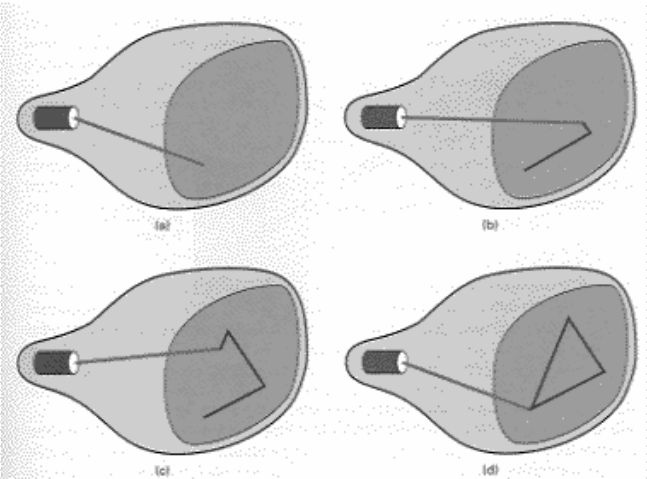
CRT – health hazards!

- X-rays: largely absorbed by screen (but not at rear!)
- UV- and IR-radiation from phosphors: insignificant levels
- Radio frequency emissions, plus ultrasound (~16kHz)
- Electrostatic field - leaks out through tube to user
  - Intensity dependant on distance and humidity. Can cause rashes by accelerating dirt particles.
- Electromagnetic fields (50Hz-0.5MHz). Create induction currents in conductive materials! Two types of effects:
  - visual system - high incidence of cataracts in operators
  - concern over miscarriages and birth defects
- Do not…
  - sit too close, use very small fonts, use for long periods without a break, place directly in front of a bright window, work in not well-lit surroundings
- Take extra care if pregnant

special displays

Random Scan (Directed-beam refresh, vector display)

- draw the lines to be displayed directly
- no jaggies (“Treppeneffekt”)
- lines need to be constantly redrawn
- rarely used except in special instruments



Direct view storage tube (DVST)

- Similar to random scan, but with semi-permanent storage grid underneath phosphors
- Persistent, no flicker
- Can be incrementally updated but not selectively erased
- Used in some analogue oscilloscopes

large displays

- used for meetings, lectures, etc.
- technologies
  - plasma – usually wide screen
  - video walls – lots of small screens together
  - projected – RGB lights or LCD projector
  - back-projected - frosted glass + projector behind
  - powerwalls - lots of projectors

situated displays

- displays in ‘public’ places
  - large or small
  - very public or for small group
- display only
  - for information relevant to location
- or interactive
  - use stylus, touch sensitive screen
- in all cases … the location matters
  - meaning of information or interaction is related to the location

Hermes (Lancaster Univ.)

- small displays beside office doors
- handwritten notes left using stylus
- office owner reads notes using web interface

small displays beside office doors

Handwritten notes left using stylus

office owner reads notes using web interface

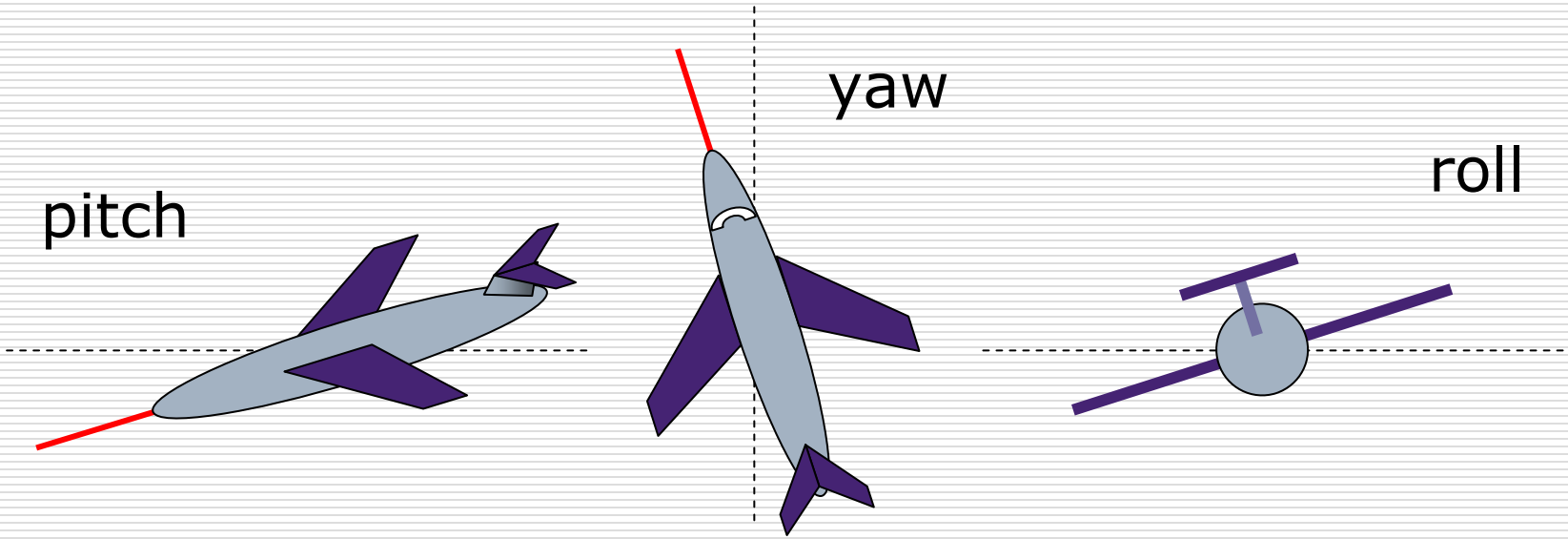
Output & input devices: Virtual Reality

positioning in 3D space
moving and grasping
seeing 3D (HMDs and caves)

positioning in 3D

Measure position and/or orientation

- 6 degrees of freedom in space: x, y, z + roll, pitch, yaw

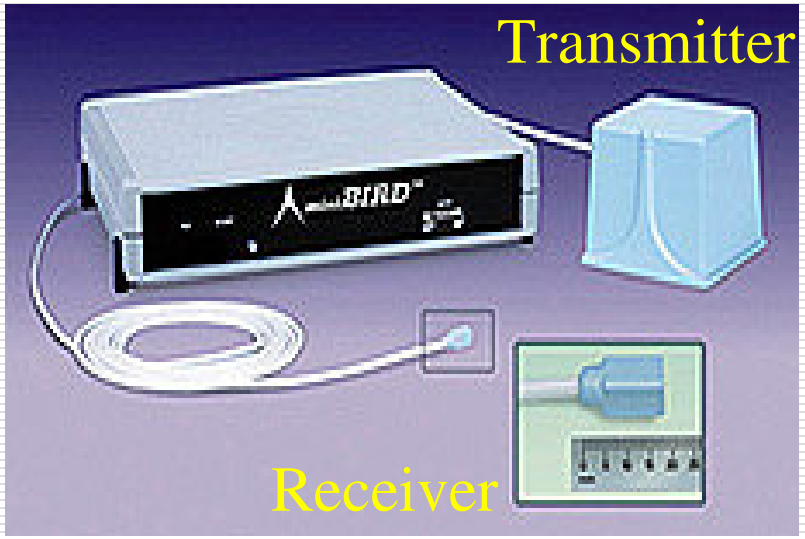


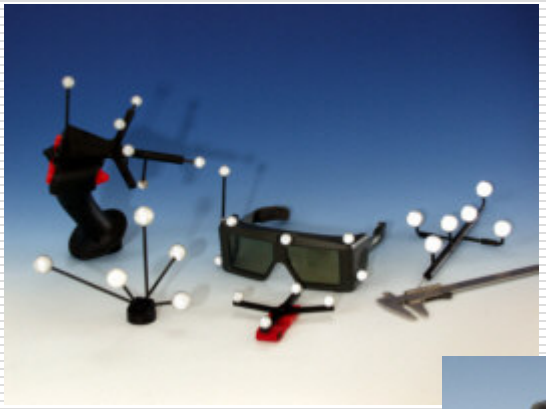
positioning in 3D

- SpaceBall
- SpaceOrb
- Space Mouse

Moving in 3D - Tracking systems

- Electromagnetic
  - Transmitter creates low-frequency magnetic fields
  - Receiver(s) with antennas, distance inferred from induced currents
  - Noisy, affected by metal
- Optical
  - Marker reflect IR light
  - Combined to unique spatial configuration per tracked position
  - > 3 IR cameras





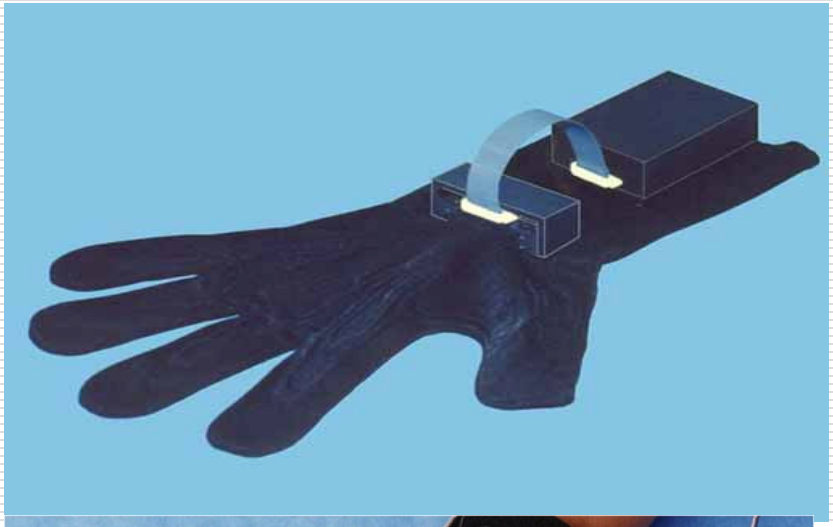
Tracking systems

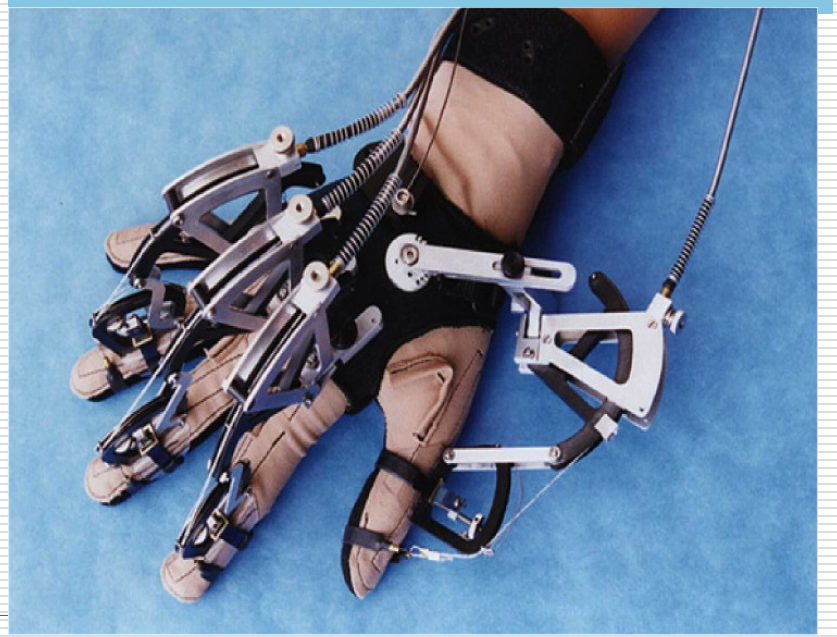
- Acoustic
  - Uses ultrasound
  - Typical setup for 3 DOF: 3 mics, 1 speaker
  - Distance is inferred from travel time of sound
  - No interference, inexpensive, sensitive to air temperature & noises
- Intertia
  - Only 3 DOFs (orientation)
  - Use gyroscopes & accelerometers
  - Less noise, lag
- Hybrid
  - Inertia (orient.)
  - acoustic (pos.)

Intersense IS-300

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

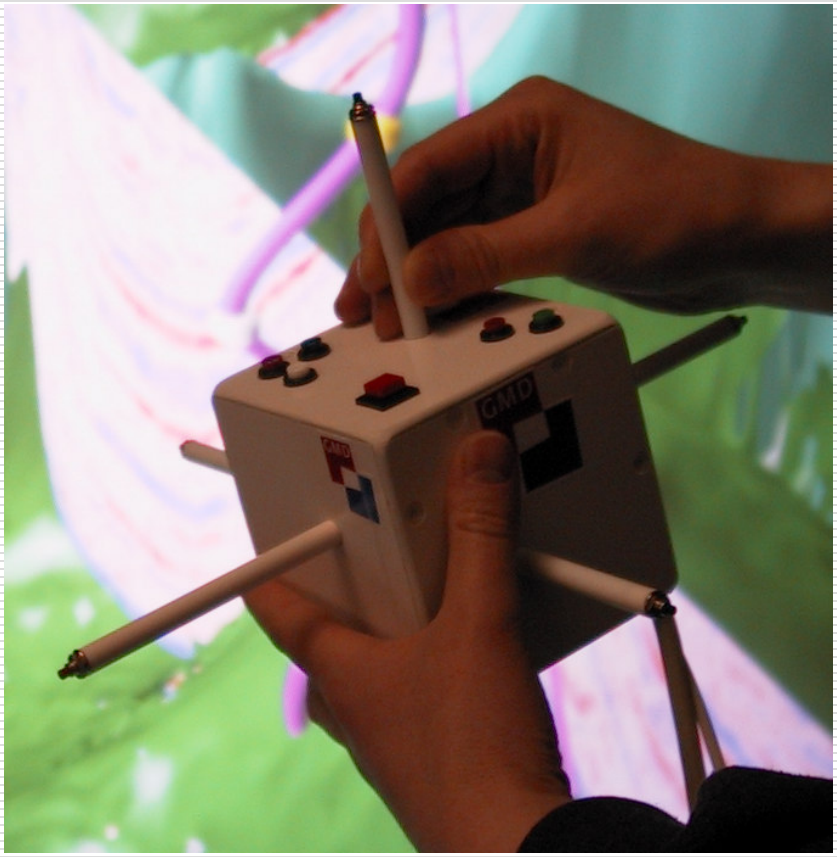


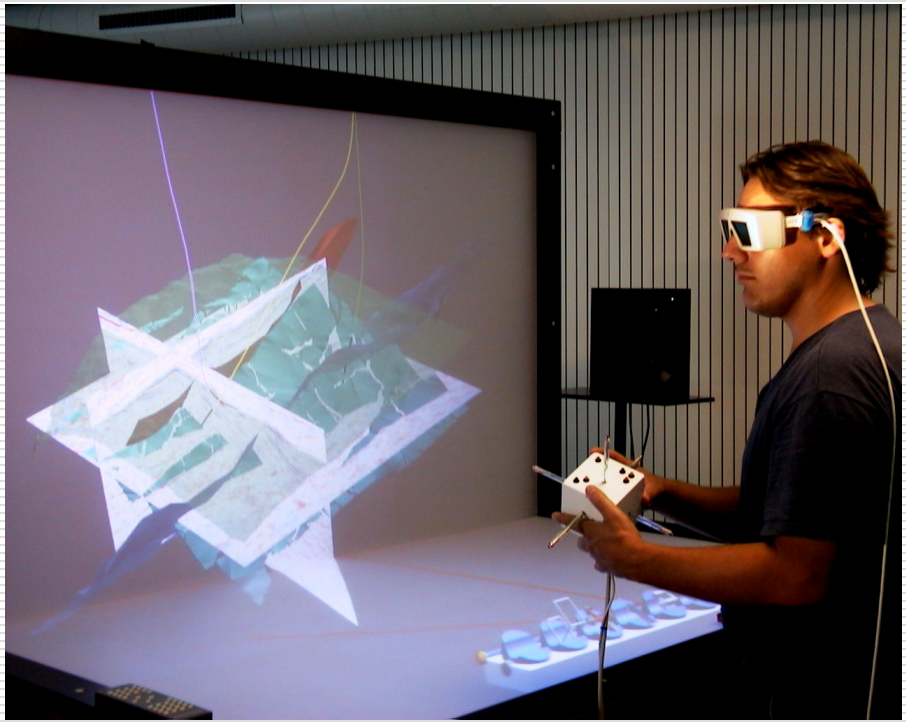


tracked mouse type devices

- Space Mouse
- Ring Mouse
- Fly Mouse
- Wand

Cubic Mouse

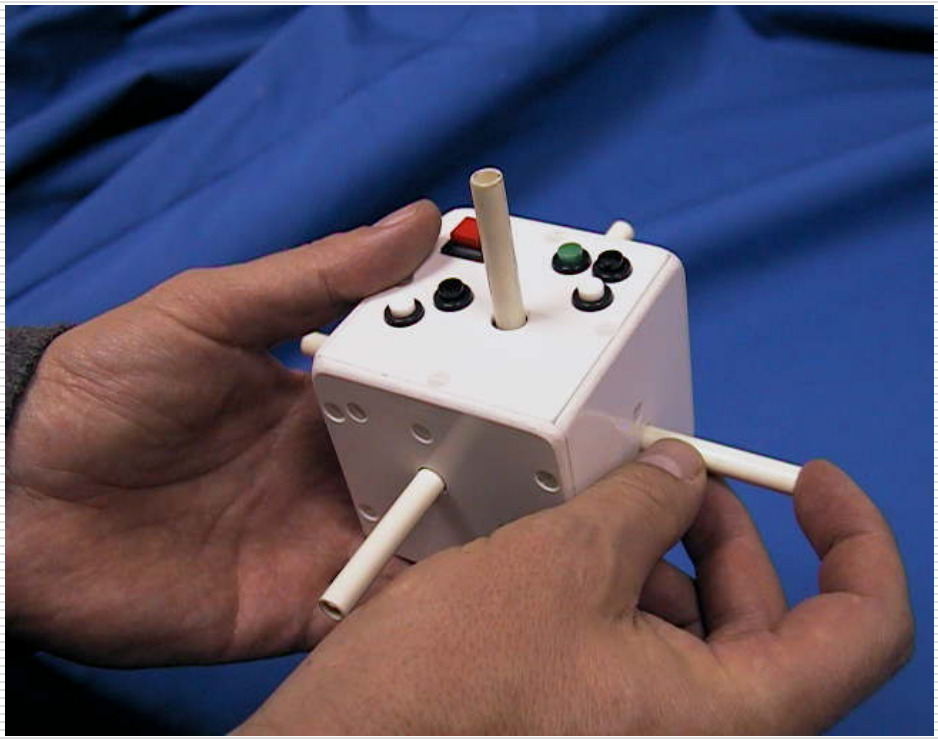




Cubic Mouse

- First 12 DOF input device
- Tracks position and rotation of rods using potentiometers

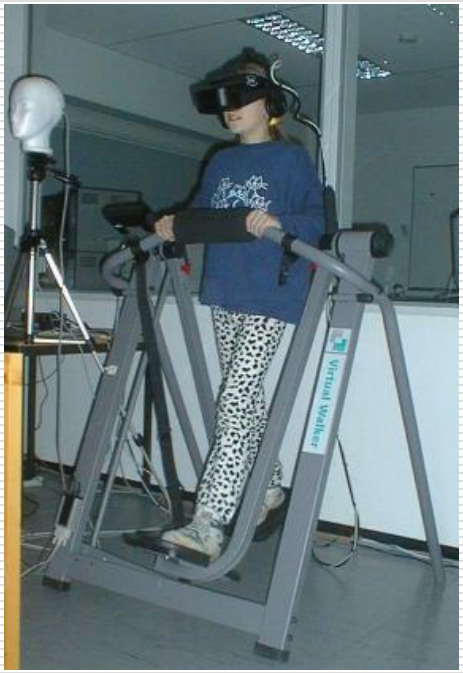
- Other shapes and implementations possible
  - Mini Cubic Mouse
  - …

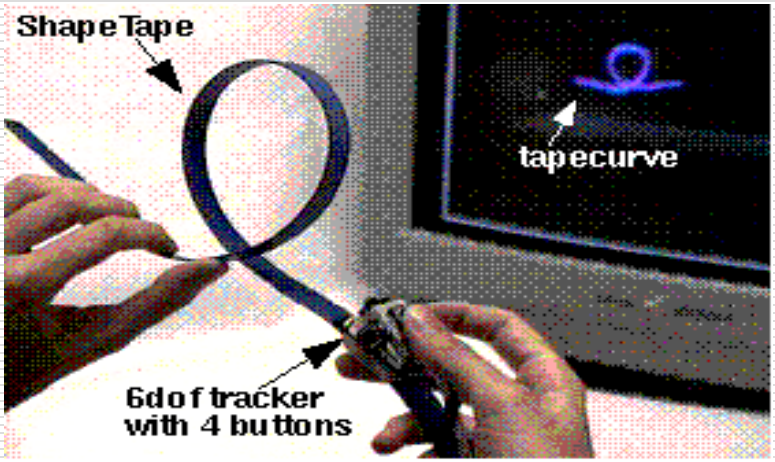


More fancy input devices

Cyberglove with haptics

Treadmill types (e.g. bicycles)





Shape tape

3D displays

- seeing in 3D
  - use stereoscopic vision
  - try to simulate depth cues
  - 2nd lecture – recall from LTM!

also see extra slides on 3D vision

Desktop VR

- Monitor-based systems
- mouse or keyboard control
- can be sterescopic but need not be
  - perspective and motion give 3D effect
  - usually no head tracking
  - often not immersive
- variety of modes
  - non-stereo, non-immersive ordinary desktop display
  - stereo to screen and shutter glasses
  - stereo to polarizing screen overlay and polarized glasses

Sensorama

- Morton Heilig began designing 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 in 1960
  - a dance by a belly dancer.

Head-mounted display (Sutherland, 1968)

FIGURE 3—The mechanical head position sensor in use

FIGURE 4—The ultrasonic head position sensor in use

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

Head-mounted displays

- Scene completely surrounds user
- Graphics are sharp and bright

- Field of view (FOV) is narrow
- Devices are heavy, causes fatigue
- Can’t see other people, although see-through HMDs

BOOM (Binoccular Omni Orientation Monitor)

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

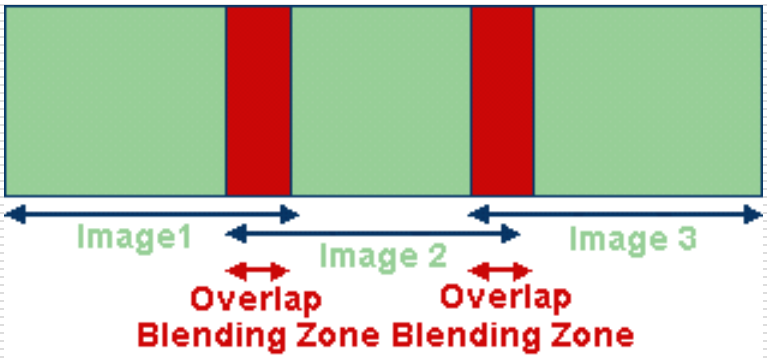
- Limited user movement
- Requires the user to hold onto the BOOM for control

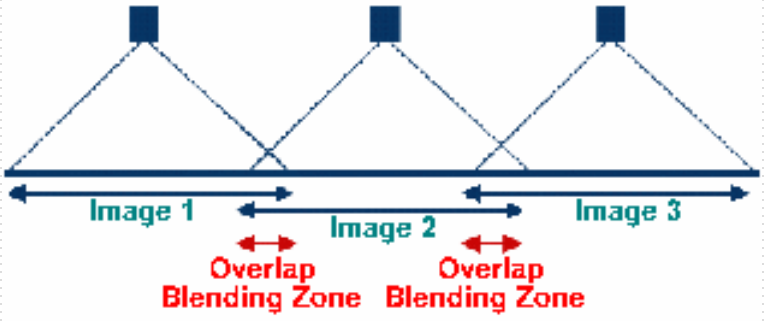
VR motion sickness

- time delay (>100ms)
  - move head … lag … display moves
  - *conflict:* head movement vs. eyes
- depth perception
  - objects presented at different stereo distances
  - but all focused in same plane (monitor)
  - *conflict:* eye angle vs. focus
- conflicting cues => sickness
  - motivate improvements in technology

Projection Walls

- Multi-projector systems, require overlap
- Head-tracking

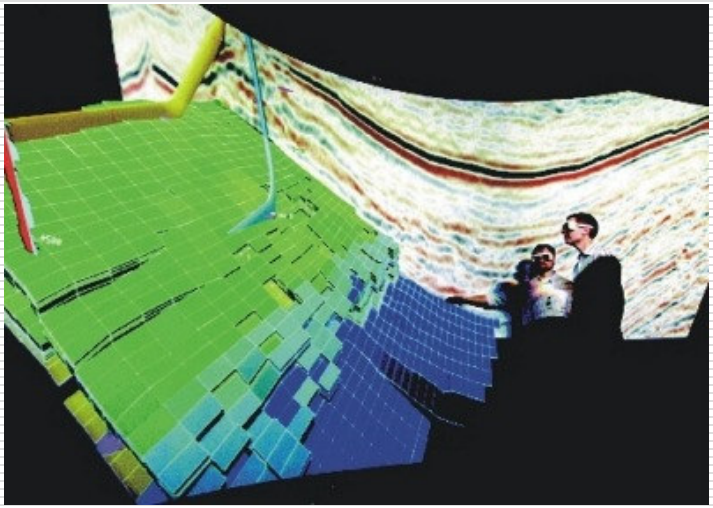


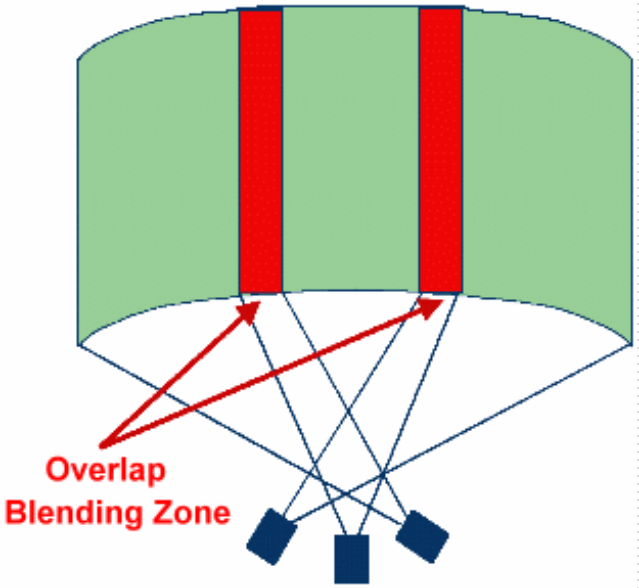


Pictures courtesy TAN

Cylindrical Screen Configurations

- Common in industry
- Head tracking difficult, requires distortion correction

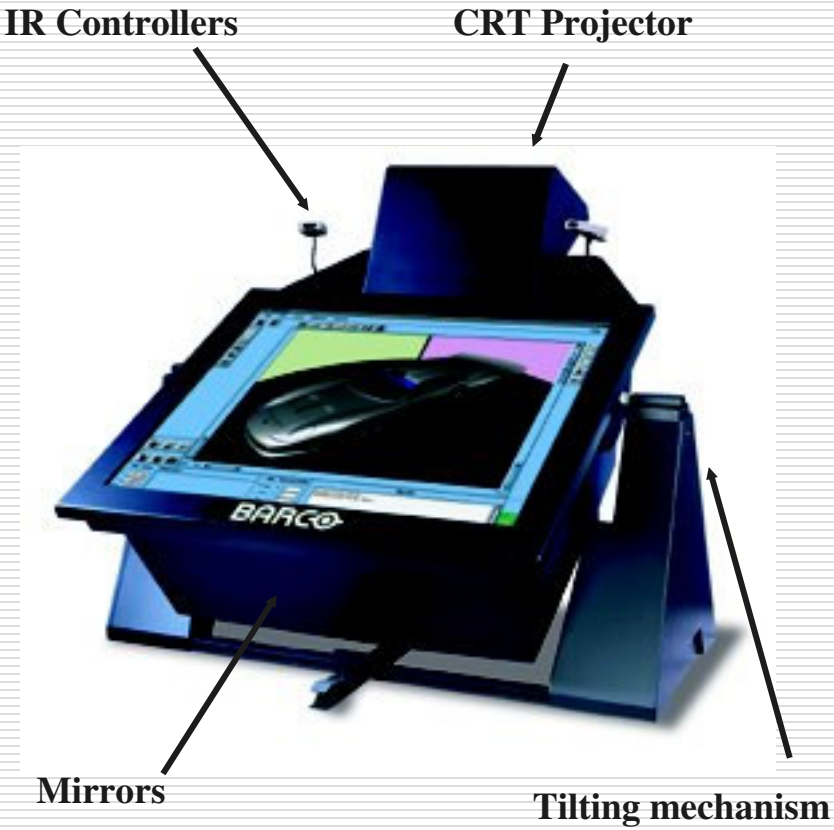




Workbench

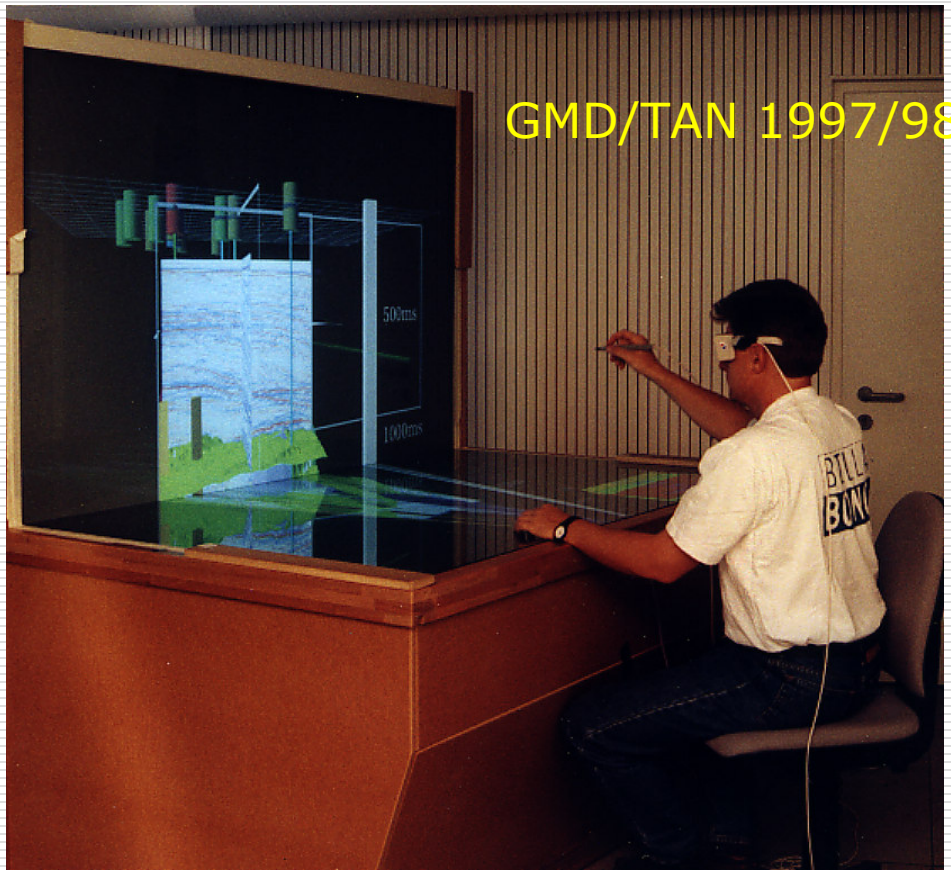
- Table-top metaphor
- Change display orientation
- Integrate real & virtual

- Less immersion
- Occlusion/cancellation
- $$$



Two-Sided Workbench

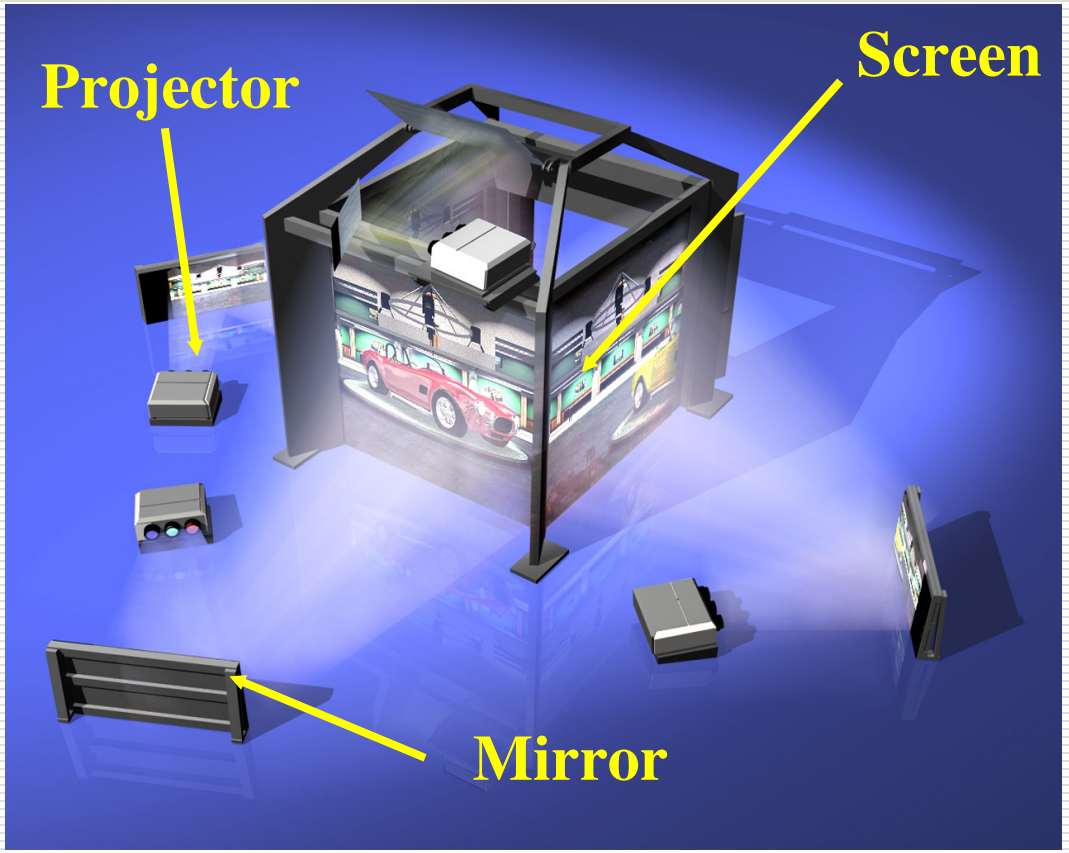
- View volume
- Telepresence
- $$$



CAVE

- Multi-wall (usually 4)
- Provides wide FOV
- Can see other people
- Stereo more realistic

- Missing walls break illusion
- Brightness
- $$$



Input & output devices: physical controls, sensors, etc.

special displays and gauges

touch, feel, smell

physical controls

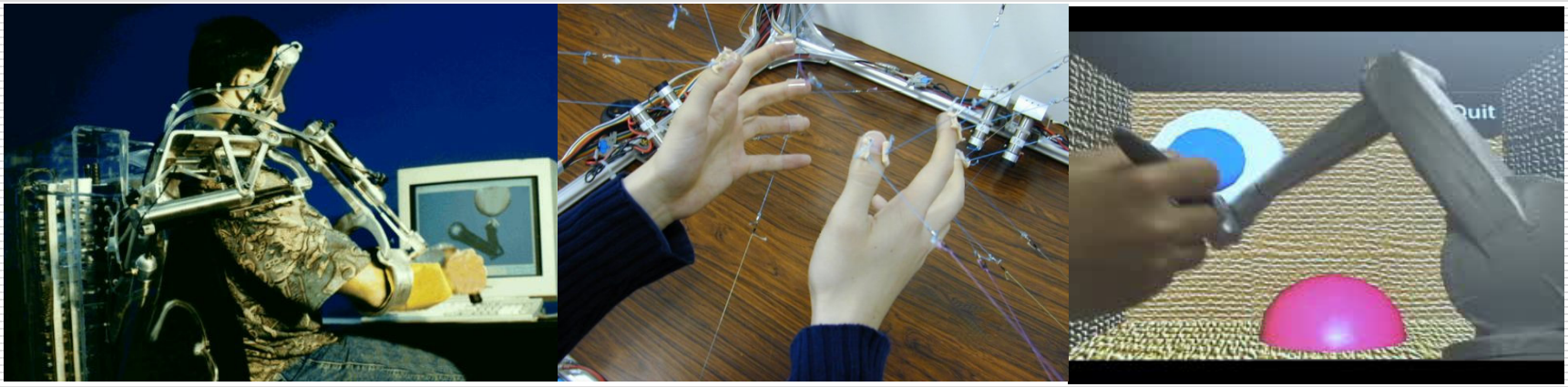
environmental and bio-sensing

dedicated displays

- analogue representations:
  - dials, gauges, lights, etc.
- digital displays:
  - small LCD screens, LED lights, etc.
- head-up displays
  - found in aircraft cockpits
  - show most important controls
  - depending on context

Touch, feel, smell

- touch and feeling important
  - in games … vibration, force feedback
  - in simulation … feel of surgical instruments
  - called *haptic* devices
- texture, smell, taste
  - current technology very limited



physical controls

- specialist controls needed …
  - industrial controls, consumer products, etc.

large buttons

clear dials

tiny buttons

multi-function control

easy-clean smooth buttons

Example: BMW iDrive

- single multi-purpose device for controlling menus
- haptic feedback: feel small ‘bumps’ for each item
- makes it easier to select options by feel
- slides backwards & forwards, rotates

Environment and bio-sensing

- sensors all around us
  - car lights turn on – small switch on door
  - ultrasound detectors – security, washbasins
  - RFID security tags in shops
  - temperature, weight, location
- … and even (our own) bodies …
  - iris scanners, body temperature, heart rate, galvanic skin response, blink rate, goniometry
  - possible applications: emotion recognition (affective computing), life signal monitoring, etc.

Limitations on interactive performance

Computation bound

- Computation takes time, causing frustration for the user

Storage channel bound

- Bottleneck in transference of data between storages

Graphics bound

- Updating displays requires effort - sometimes helped by adding a graphics co-processor to take on the burden

Network capacity

- Many computers networked - shared resources and files, access to printers etc. - but interactive performance can be reduced by slow network speed

Finite processing speed

- Designers tend to assume fast processors, and make interfaces more and more complicated
- But problems occur, because processing cannot keep up with all the tasks it needs to do
  - cursor overshooting because system has buffered keypresses
  - *icon wars* - user clicks on icon, nothing happens, clicks on another, then system responds and windows fly everywhere
- Also problems if system is too fast - e.g. help screens may scroll through text much too rapidly to be read

Next: *Interaction*

- Design principles, paradigms, basics
- Different kinds
  - Text-based, commando languages
  - WIMP and GUIs
  - Natural language
  - Multimodal
  - 3D interaction in VR
  - Agent- and Avatar-based
  - …