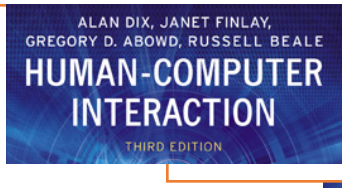


Human-Computer Interaction

Dr. Ibrar Hussain

Week: 05

The Computer

A computer system is made up of various elements

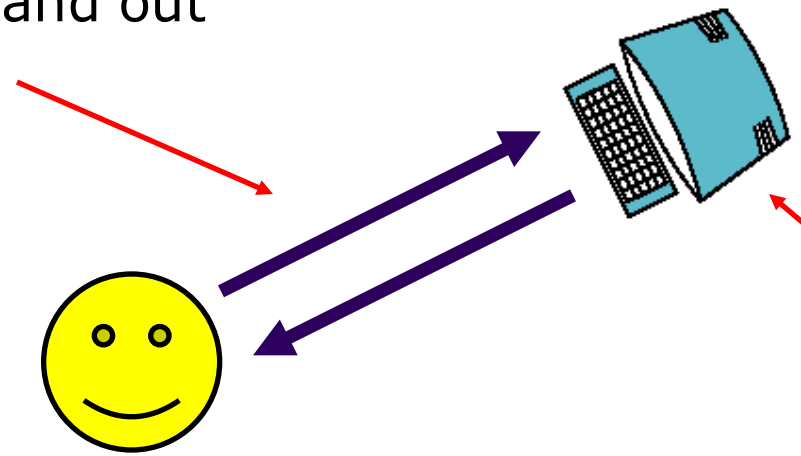
each of these elements affects the interaction

- input devices – text entry and pointing
- output devices – screen (small&large), digital paper
- virtual reality – special interaction and display devices
- physical interaction – e.g. sound, haptic, bio-sensing
- paper – as output (print) and input (scan)
- memory – RAM & permanent media, capacity & access
- processing – speed of processing, networks

Interacting with computers

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

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

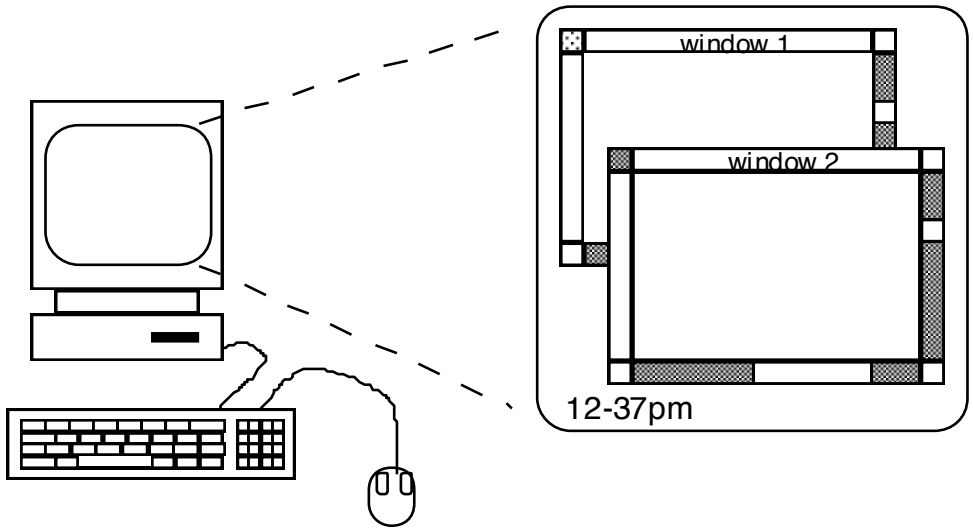


what can it do?
memory, processing, networks

A 'typical' computer system

?

- screen, or monitor, on which there are windows
- keyboard
- mouse/trackpad



- variations
  - desktop
  - laptop
  - PDA

The devices dictate the styles of interaction that the system supports.

If we use different devices, then the interface will support a different style of interaction

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 memory

try your pockets and bags

Interactivity?

Long ago in a galaxy far away … *batch* processing

- punched card stacks or large data files prepared
- long wait ….
- line printer output

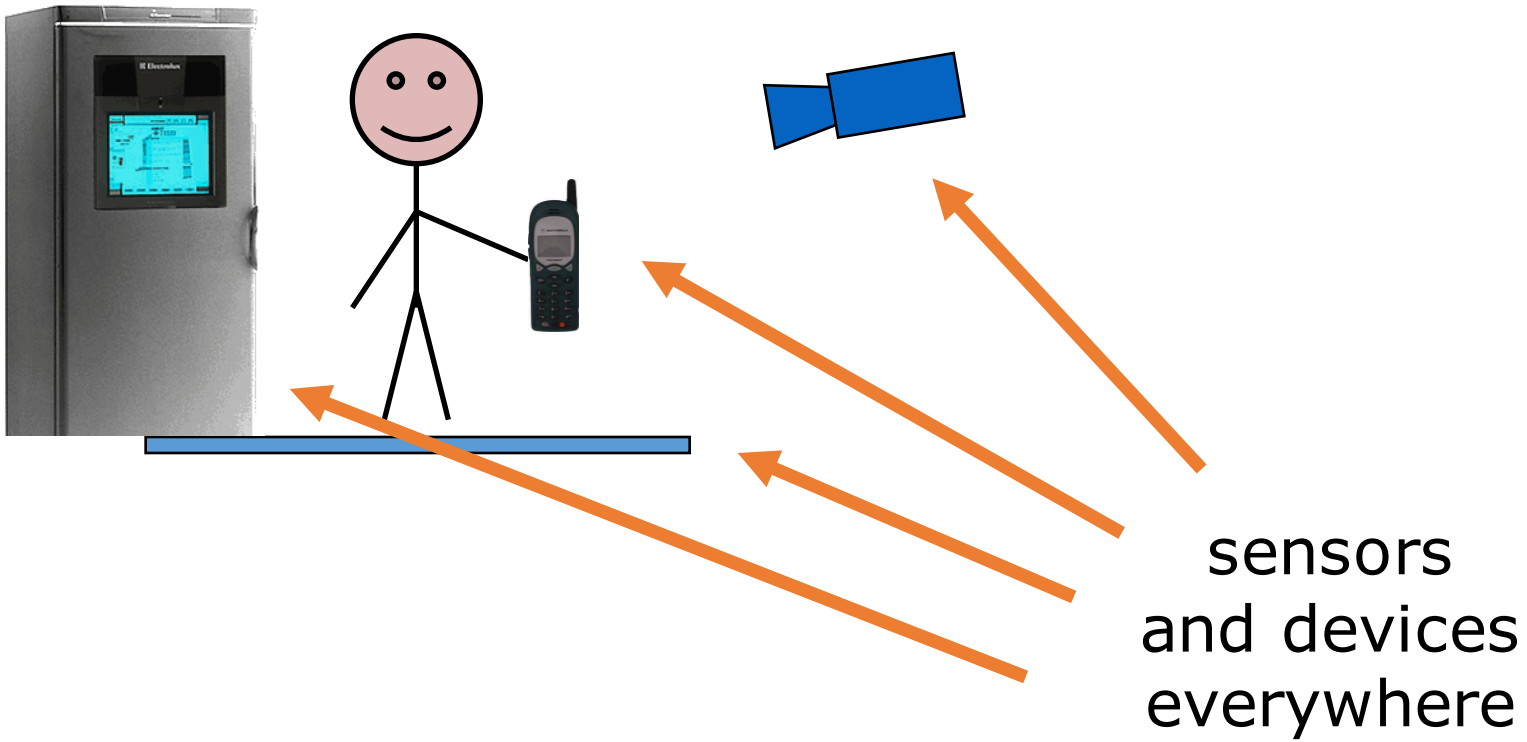
… and if it is not right …

Now most computing is interactive

- rapid feedback
- the user in control (most of the time)
- doing rather than thinking …

Is faster always better?

Richer interaction



Text Entry Devices

keyboards (QWERTY et al.)

chord keyboards, phone pads

handwriting, speech

Keyboards

- Most common text input device
- Allows rapid entry of text by experienced users
- Keypress closes connection, causing a character code to be sent
- Usually connected by cable, but can be wireless

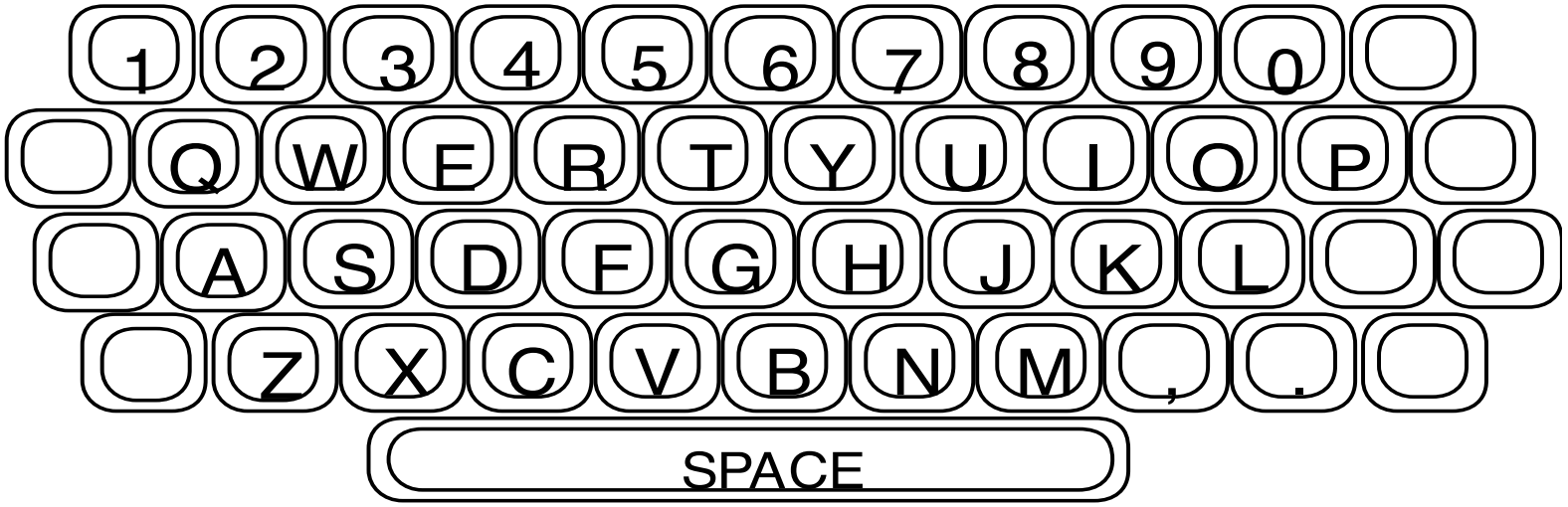
layout – QWERTY

- Standardised layout

  but …
  - non-alphanumeric keys are placed differently
  - accented symbols needed for different scripts
  - minor differences between UK and USA keyboards

- QWERTY arrangement not optimal for typing
  – layout to prevent typewriters jamming!
- Alternative designs allow faster typing but large social base of QWERTY typists produces reluctance to change.

QWERTY (ctd)



Alternative keyboard layouts

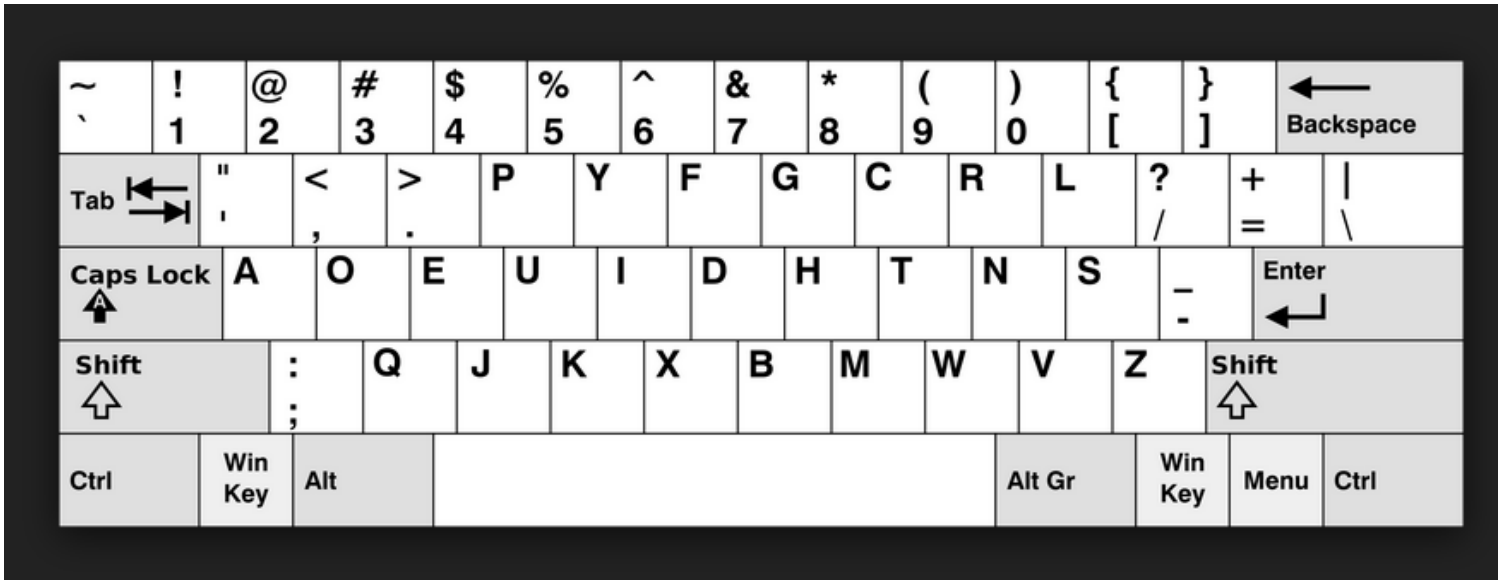
Alphabetic

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

Dvorak

- common letters under dominant fingers
- biased towards right hand (almost 56% of the keystrokes are made with the 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

Alphabetic Keyboard Layout

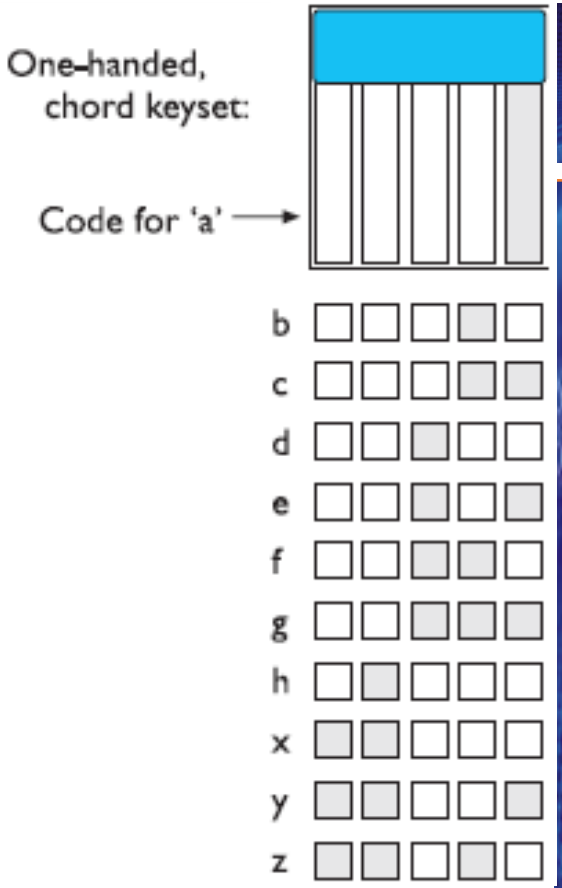


Dvorak Keyboard Layout

special keyboards

- Designs to reduce fatigue for RSI (Repetitive Strain Injury)
- For one handed use
  e.g., the Maltron left-handed keyboard

Chord keyboards



only a few keys - four or 5

letters typed as combination of keypresses

compact size

– ideal for portable applications

short learning time

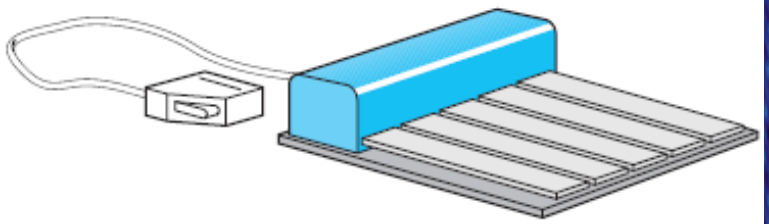
– keypresses reflect letter shape

fast

– once you have trained

BUT - social resistance, plus fatigue after extended use

NEW – niche market for some wearables



Numeric keypads

- For entering numbers quickly:
  - calculator, PC keyboard
- For telephones

not the same!!

ATM like phone

calculator

ATM

phone

Phone pad 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 predictive entry
  - type as if single key for each letter
  - use dictionary to ‘guess’ the right word
  - hello = 43556 …
  - but 26 -> menu ‘am’ or ‘an’

Handwriting recognition

- Text can be input into the computer, using a pen and a digesting tablet
  - natural interaction

- **Technical problems:**
  - capturing all useful information - stroke path, pressure, etc. in a natural manner
  - segmenting joined up writing into individual letters
  - interpreting individual letters
  - coping with different styles of handwriting

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

Speech recognition

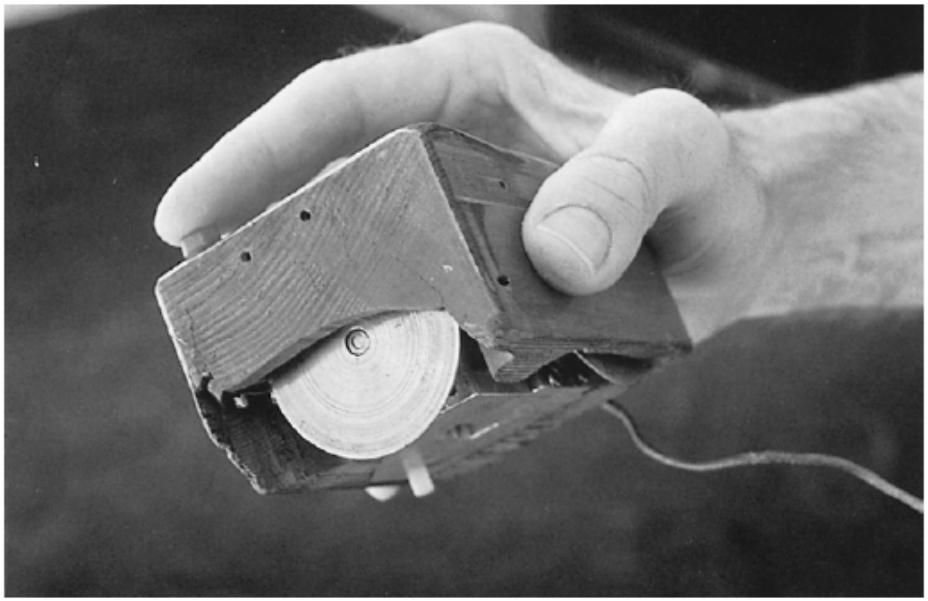
- Improving rapidly
- Most successful when:
  - single user – initial training and learns peculiarities
  - limited vocabulary systems

- Problems with
  - external noise interfering
  - imprecision of pronunciation
  - large vocabularies
  - different speakers
- One letter in error in approximately every 30, or one spelling mistake every six or so words

Positioning, pointing and drawing

- Mouse, touchpad
  trackballs, joysticks etc.
- Touch screens, tablets
  eyegaze, cursors

The Mouse



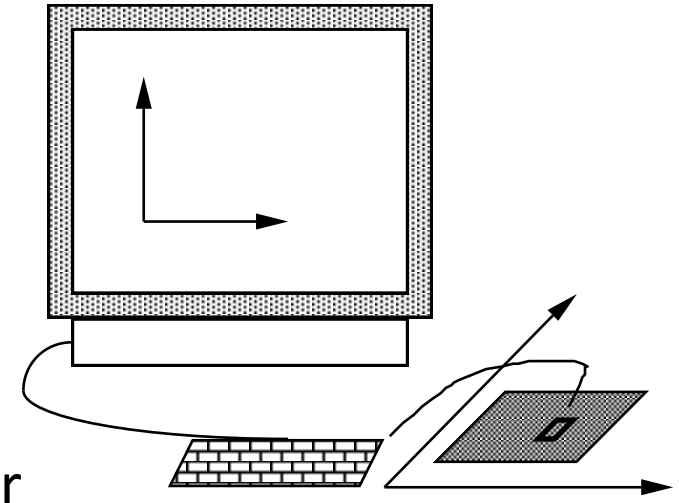
- Handheld pointing device
  - very common
  - easy to use
- Two characteristics
  - planar movement
  - Buttons

  (usually from 1 to 3 buttons on top, used for making a selection, indicating an option, or to initiate drawing etc.)

The mouse (ctd)

Mouse located on desktop

- requires physical space
- no arm fatigue



Relative movement only is detectable.

Movement of mouse moves screen cursor

Screen cursor oriented in (x, y) plane,
mouse movement in (x, z) plane …

… an *indirect* manipulation device.

- device itself doesn't obscure screen, is accurate and fast.
- hand-eye coordination problems for novice users

How does it work?

Two methods for detecting motion

- Mechanical
  - Ball on underside of mouse turns as mouse is moved
  - Rotates orthogonal potentiometers
  - Can be used on almost any flat surface

- Optical
  - light emitting diode on underside of mouse
  - may use special grid-like pad or just on desk
  - less susceptible to dust and dirt
  - detects fluctuating alterations in reflected light intensity to calculate relative motion in (x, z) plane

Even by foot …

- some experiments with the *footmouse*
  - controlling mouse movement with feet …
  - not very common :-)

- but foot controls are common elsewhere:
  - car pedals
  - sewing machine speed control
  - organ and piano pedals

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

Trackball and thumbwheels

Trackball

- ball is rotated inside static housing
  - like an upsdie down mouse!
- relative motion moves cursor
- indirect device, fairly accurate
- separate buttons for picking
- very fast for gaming
- used in some portable and notebook computers.

Thumbwheels …

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

Joystick

Joystick

- indirect
  pressure of stick = velocity of movement
- buttons for selection
  on top or on front like a trigger
- often used for computer games
  aircraft controls and 3D navigation

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 a fairly blunt instrument!)
    - difficult to select small regions or perform accurate drawing
  - lifting arm can be tiring

Stylus and 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

- now rarely used
- uses light from screen to detect location

BOTH …

- very direct and obvious to use
- but can obscure screen

Digitizing tablet

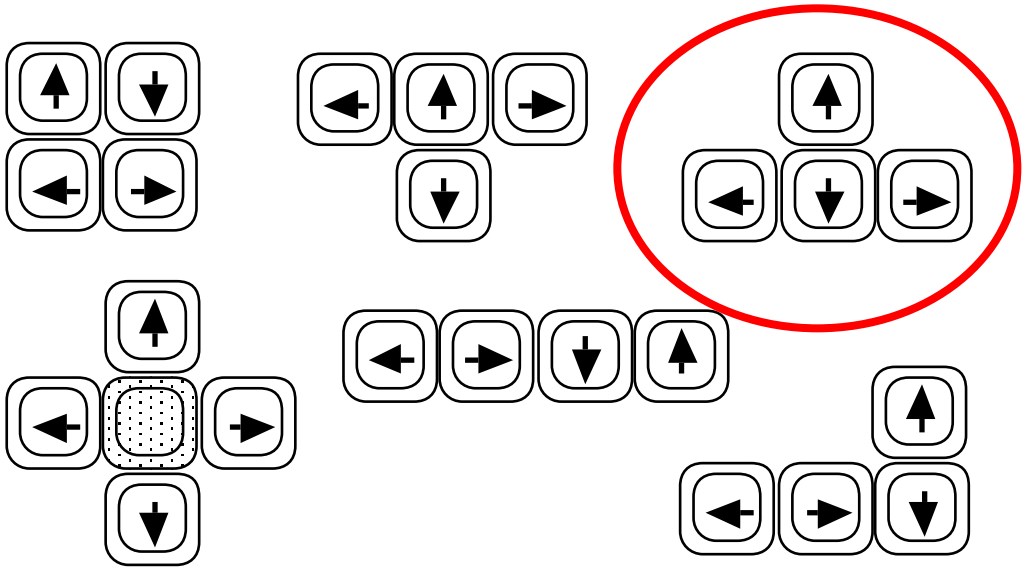
- Mouse like-device with cross hairs
- used on special surface
  - rather like stylus
- very accurate
  - used for digitizing maps

Eyegaze

- control interface by eye gaze direction
  - e.g. look at a menu item to select it
- uses laser beam reflected off retina
  - … a very low power laser!
- mainly used for evaluation (ch x)
- potential for hands-free control
- high accuracy requires headset
- cheaper and lower accuracy devices available
  sit under the screen like a small webcam

Cursor keys

- Four keys (up, down, left, right) on keyboard.
- Very, very cheap, but slow.
- Useful for not much more than basic motion for text-editing tasks.
- No standardised layout, but inverted “T”, most common



Discrete positioning controls

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

Display Devices

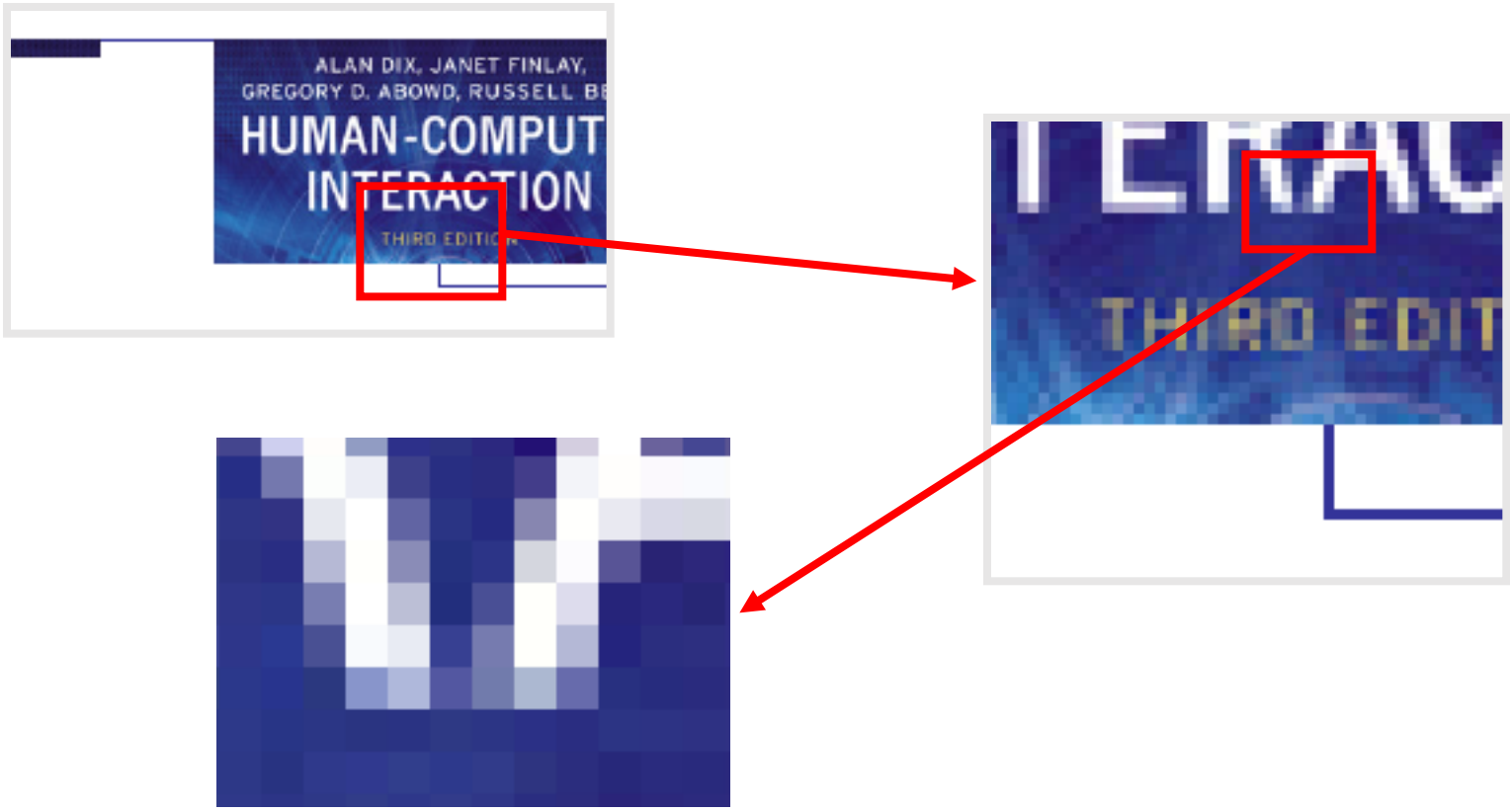
Bitmap screens (CRT & LCD)

Large & Situated Displays

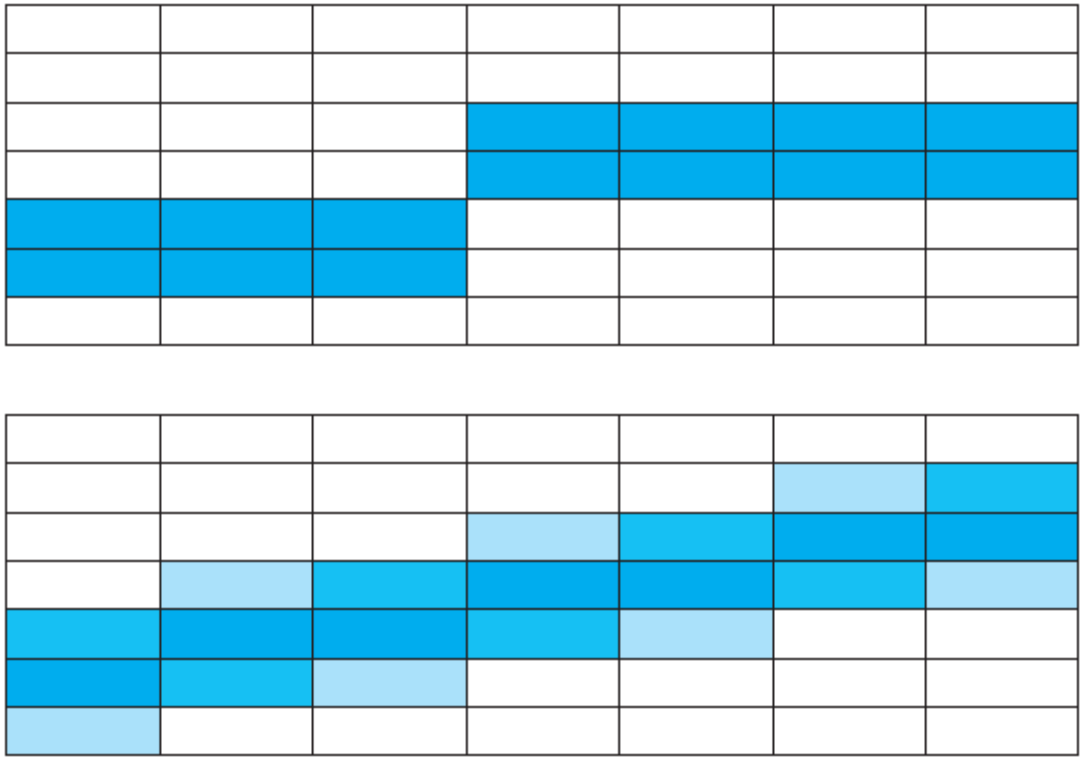
Digital paper

Bitmap Displays

- Screen is vast number of coloured dots



- **Anti-aliasing:** softens the edges of line segments, blurring the discontinuity.

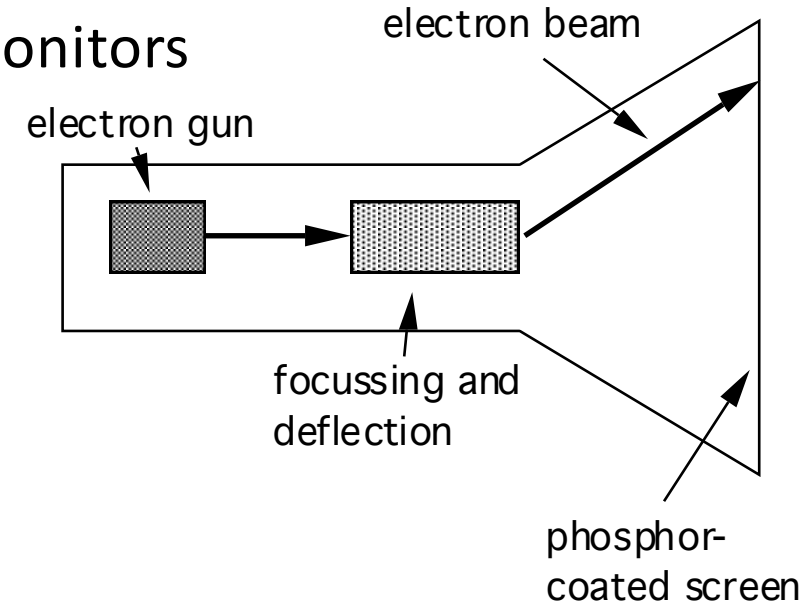


Resolution and Colour Depth

- **Resolution** … used (inconsistently) for
  - number of pixels on screen (width x height)
    - e.g. SVGA 1024 x 768, PDA perhaps 240x400
  - density of pixels (in pixels or dots per inch - dpi)
    - typically between 72 and 96 dpi
- **Aspect ratio**
  - ration between width and height
  - 4:3 for most screens, 16:9 for wide-screen TV
- **Colour depth**
  - how many different colours for each pixel?
  - black/white or greys only
  - 256 from a pallete
  - 8 bits each for red/green/blue = millions of colours

Cathode Ray Tube

- Stream of electrons emitted from electron gun, focused and directed by magnetic fields, hit phosphor-coated screen which glows.
- used in TVs and computer monitors



Health hazards of CRT !

- 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.
- Electromagnetic fields (50Hz-0.5MHz). Create induction currents in conductive materials, including the human body. Two types of effects attributed to this: visual system - high incidence of cataracts in VDU operators, and concern over reproductive disorders (miscarriages and birth defects).

Health hints …

- do not sit too close to the screen
- do not use very small fonts
- do not look at the screen for long periods without a break
- do not place the screen directly in front of a bright window
- work in well-lit surroundings

★ but also posture, ergonomics, stress

Liquid Crystal Displays

- Smaller, lighter, and … no radiation problems.
- Found on PDAs, portables and notebooks,
  … and increasingly on desktop and even for home TV
- also used in dedicated displays:
  digital watches, mobile phones
- How it works …
  - Top plate transparent and polarised, bottom plate reflecting.
  - Light passes through top plate and crystal, and reflects back to eye.
  - Voltage applied to crystal changes polarisation and hence colour
  - N.B. light reflected not emitted => less eye strain

Special Displays

Random Scan (Directed-beam refresh, vector display)

- draw the lines to be displayed directly
- lines need to be constantly redrawn
- rarely used except in special instruments

Direct view storage tube (DVST)

- Similar to random scan but persistent => no flicker
- Can be incrementally updated but not selectively erased
- Used in analogue storage oscilloscopes

Large displays

- used for meetings, lectures, etc.
- technology
  - plasma – usually wide screen
  - video walls – lots of small screens together
  - projected – RGB lights or LCD projector
    - –hand/body obscures screen
    - –may be solved by 2 projectors + clever software
  - back-projected
    - –frosted glass + projector behind

Large displays

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 a situated display

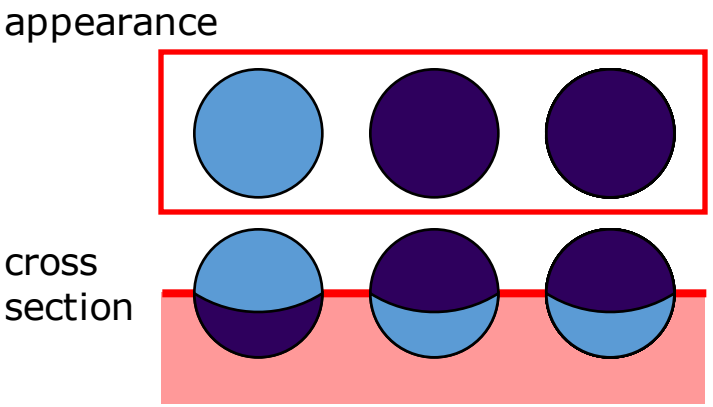
small displays beside office doors

handwritten notes left using stylus

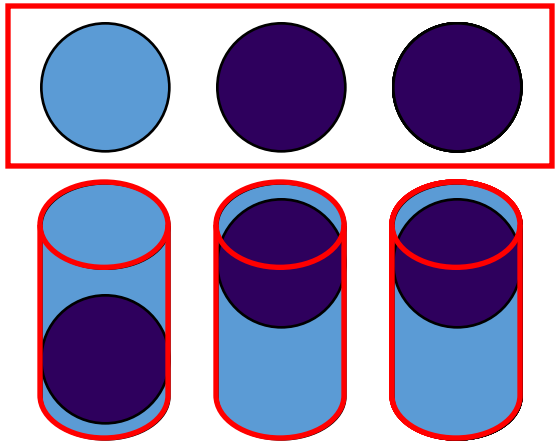
office owner reads notes using web interface

Digital paper

- what?
  - thin flexible sheets
  - updated electronically
  - but retain display



- how?
  - small spheres turned
  - or channels with coloured liquid and contrasting spheres
  - rapidly developing area



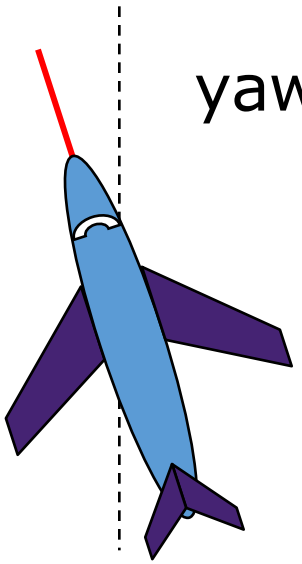
Virtual Reality and 3D Interaction

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

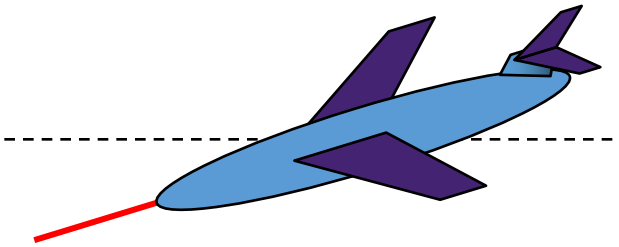
Positioning in 3D space

- cockpit and virtual controls
  - steering wheels, knobs and dials … just like real!
- the 3D mouse
  - six-degrees of movement: x, y, z + roll, pitch, yaw
- data glove
  - fibre optics used to detect finger position
- VR helmets
  - detect head motion and possibly eye gaze
- whole body tracking
  - accelerometers strapped to limbs or reflective dots and video processing

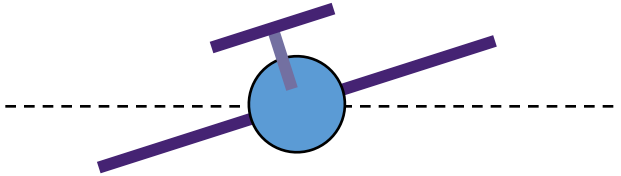
- **Pitch:** Up/down angle.
- **Yaw:** Left/right orientation.
- **Roll:** The amount it is twisted about its own axis.



yaw



pitch



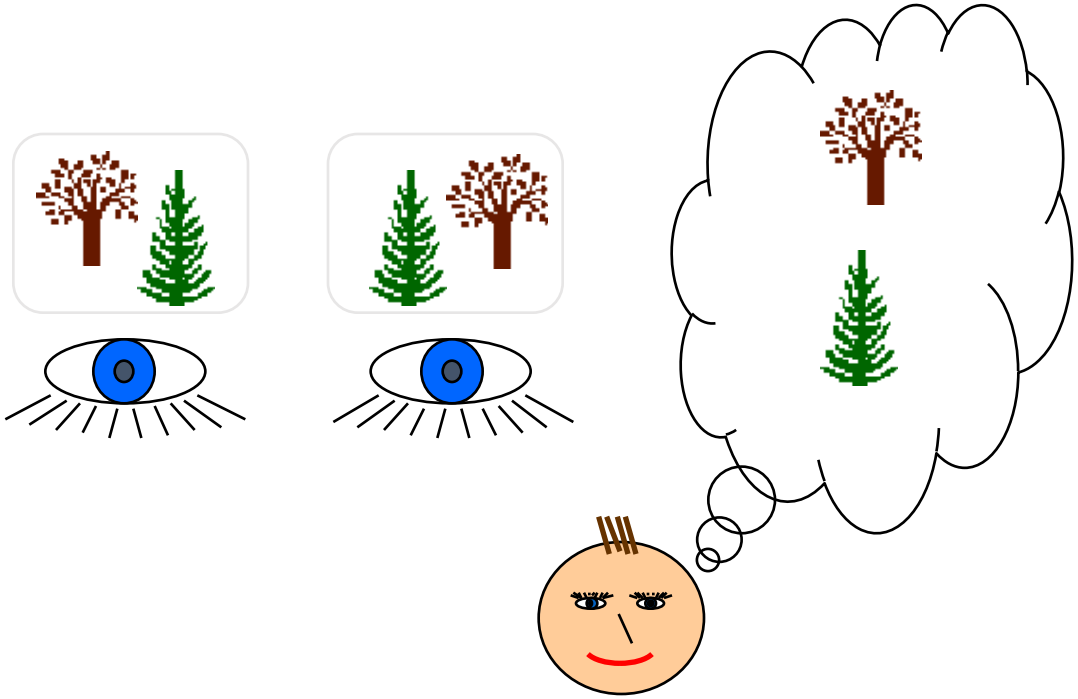
roll

3D displays

- desktop VR
  - ordinary screen, mouse or keyboard control
  - perspective and motion give 3D effect
- seeing in 3D
  - use stereoscopic vision
  - VR helmets
  - screen plus shuttered specs, etc.

VR headsets

- small TV screen for each eye
- slightly different angles
- 3D effect



Data Gloves

Head mounted display

3d Mouse

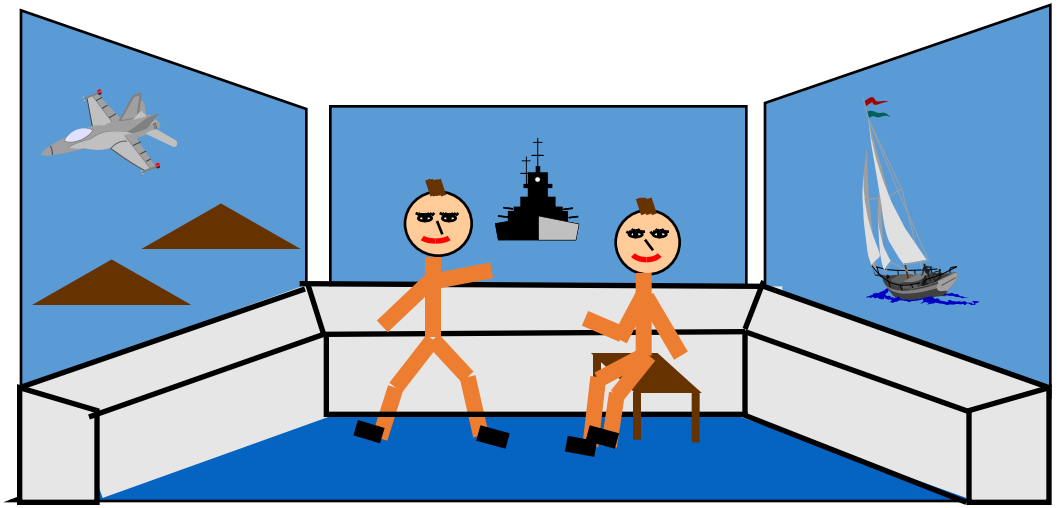
Whole body tracking

VR motion sickness

- time delay
  - move head … lag … display moves
  - *conflict:* head movement vs. eyes
- depth perception
  - headset gives different stereo distance
  - but all focused in same plane
  - *conflict:* eye angle vs. focus
- conflicting cues => sickness
  - helps motivate improvements in technology

simulators and VR caves

- scenes projected on walls
- realistic environment
- hydraulic rams!
- real controls
- other people



physical controls, sensors etc.

special displays and gauges

sound, 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

Sounds

- beeps, bongs, clonks, whistles and whirrs
- used for error indications
- confirmation of actions e.g. keyclick

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

BMW iDrive

- for controlling menus
- feel small 'bumps' for each item
- makes it easier to select options by feel
- uses haptic technology from Immersion Corp.

Physical controls

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

large buttons

clear dials

easy-clean smooth buttons

multi-function control

tiny buttons

Environment and bio-sensing

- sensors all around us
  - car courtesy light – 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

processing and networks

finite speed

limits of interaction

networked computing

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

Moore's law

- computers get faster and faster!
- 1965 …
  - Gordon Moore, co-founder of Intel, noticed a pattern
  - processor speed doubles every 18 months
  - PC … 1987: 1.5 Mhz, 2002: 1.5 GHz
- similar pattern for memory
  - but doubles every 12 months!!
  - hard disk … 1991: 20Mbyte : 2002: 30 Gbyte
- baby born today
  - record all sound and vision
  - by 70 all life's memories stored in a grain of dust!

/e3/online/moores-law/

The myth of the infinitely fast machine

- implicit assumption … no delays
  an infinitely fast machine
- what is good design for real machines?
- good example … the telephone :
  - type keys too fast
  - hear tones as numbers sent down the line
  - actually an accident of implementation
  - emulate in deisgn

Limitations on interactive performance

Computation bound

- Computation takes ages, causing frustration for the user

Storage channel bound

- Bottleneck in transference of data from disk to memory

Graphics bound

- Common bottleneck: updating displays requires a lot of effort - sometimes helped by adding a graphics co-processor optimised 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

Networked computing

Networks allow access to …

- large memory and processing
- other people (groupware, email)
- shared resources – esp. the web

Issues

- network delays – slow feedback
- conflicts - many people update data
- unpredictability

The internet

- history …
  - 1969: DARPANET US DoD, 4 sites
  - 1971: 23; 1984: 1000; 1989: 10000
- common language (protocols):
  - TCP – Transmission Control protocol
    - lower level, packets (like letters) between machines
  - IP – Internet Protocol
    - reliable channel (like phone call) between programs on machines
  - email, HTTP, all build on top of these