DIX
FINLAY
ABOWD
BEALE

chapter 2

the computer

The Computer

a computer system is made up of various elements

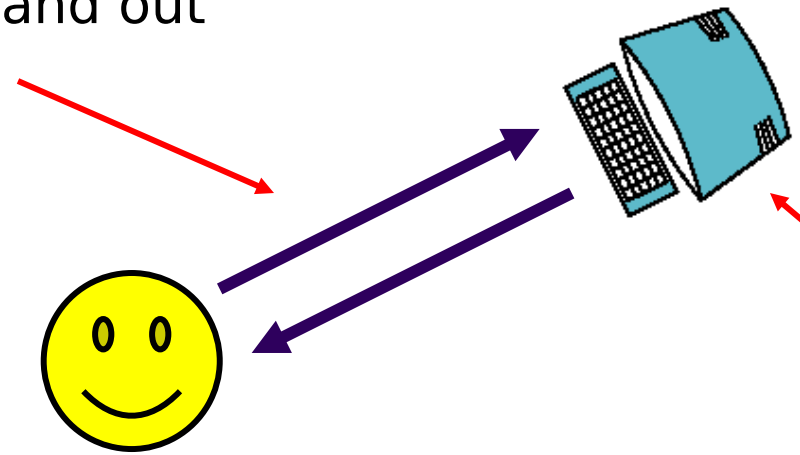
each of these elements affects the interaction

- 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.



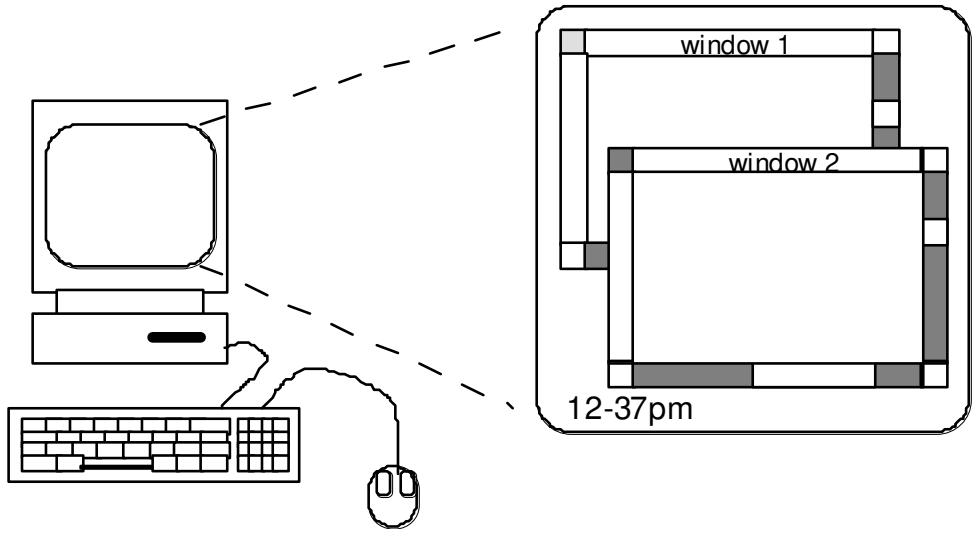
what can it do?
memory, processing,
networks

A 'typical' computer system

?

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

- variations
  - desktop
  - laptop
  - Mobile phones



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?
  - hands up, …
    … none, 1, 2 , 3, more!!

- computers in your pockets?

are you thinking …
… PC, laptop, PDA ??

How many computers …

in your house?

- PC
- TV, DVD, WiFi
- 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

Richer Interaction-Everywhere

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

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

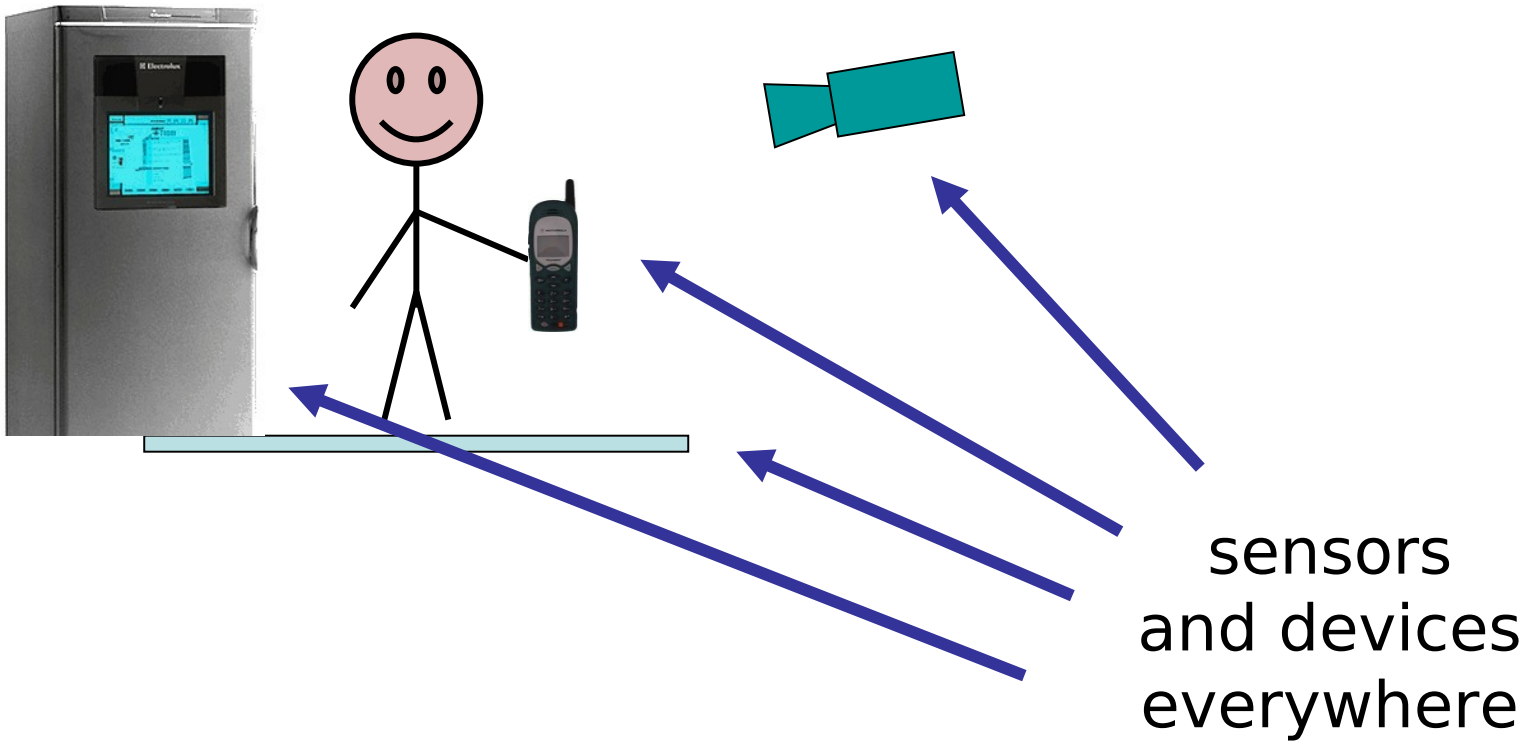
  … and if it is not right …

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

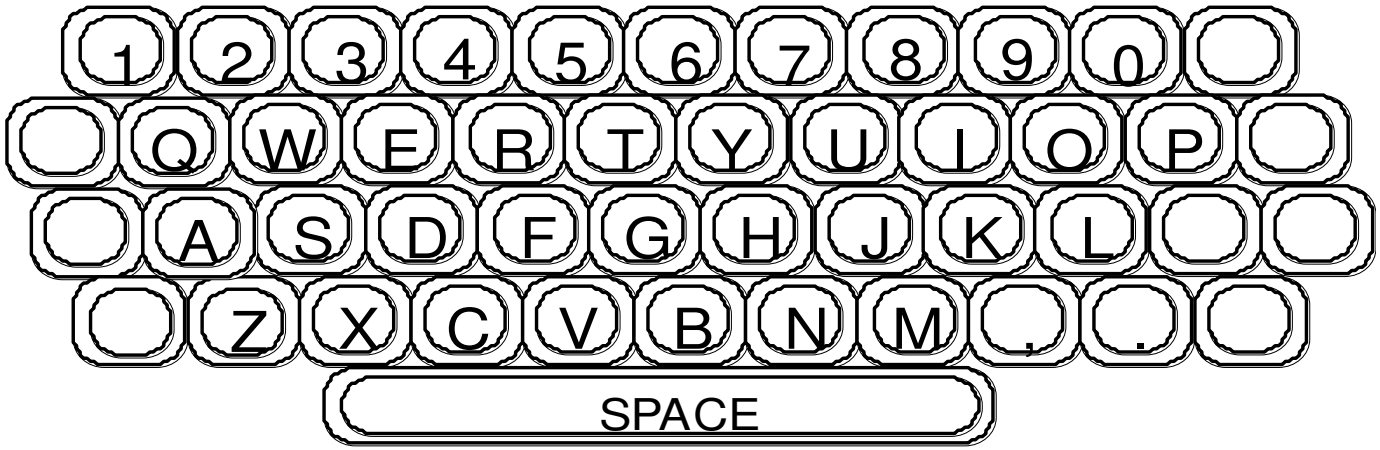
layout – QWERTY

- 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)



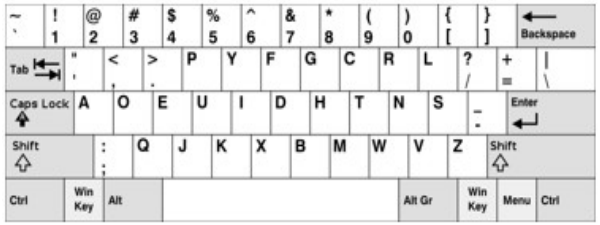
alternative keyboard layouts

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. 56% of keystrokes are made with the right hand
- 10-15% improvement in speed and reduction fatigue
- But - large social base of QWERTY typists produce market pressures not to change



special keyboards

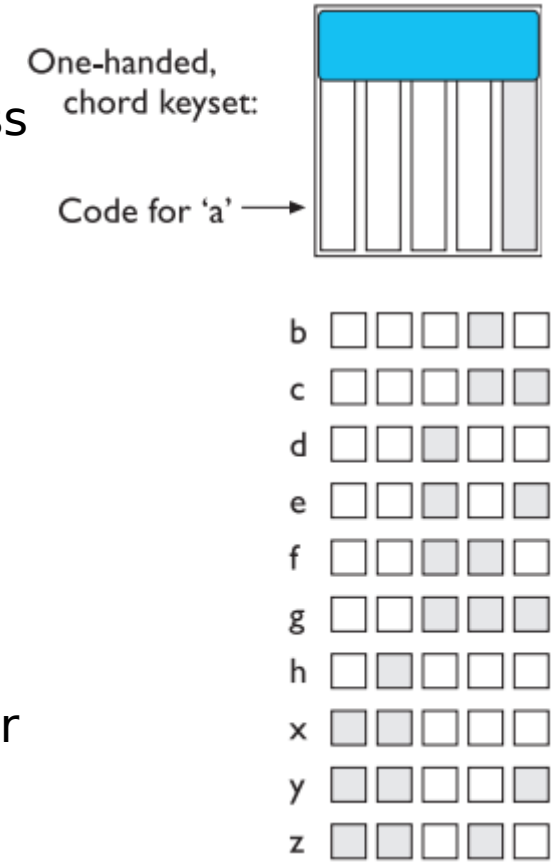
- designs to reduce fatigue for RSI
- for one handed use

  e.g. the Maltron left-handed keyboard

Chord keyboards

- Only a few keys
- Letters typed as combination of keypress
- 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



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 touch screens
  - natural interaction
- Used in PDAs, and tablet computers …
  … leave the keyboard on the desk!

Speech recognition

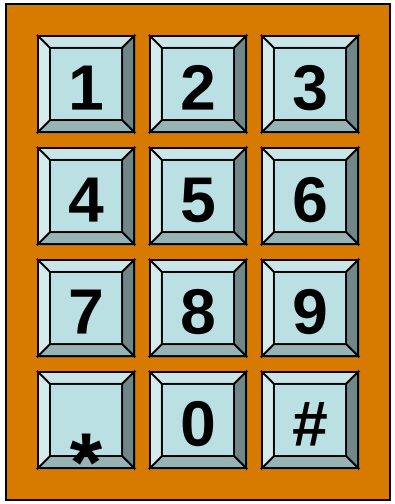
- Improving rapidly
- Most successful when:
  - single user – initial training and learns peculiarities
  - limited vocabulary systems
- Problems with
  - external noise interfering
  - imprecision of pronunciation
  - different speakers
  - Confidentiality would also be harder to maintain

Numeric keypads

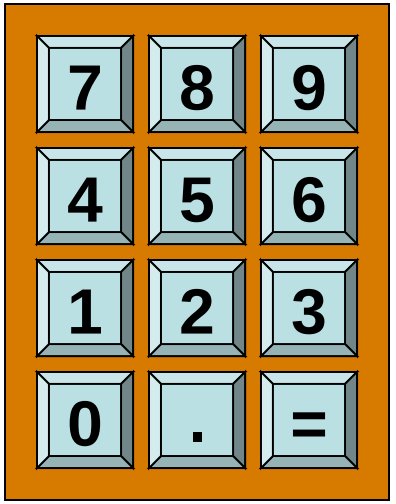
- for entering numbers quickly:
  - calculator, PC keyboard
- for telephones

not the same!!

ATM like phone



telephone



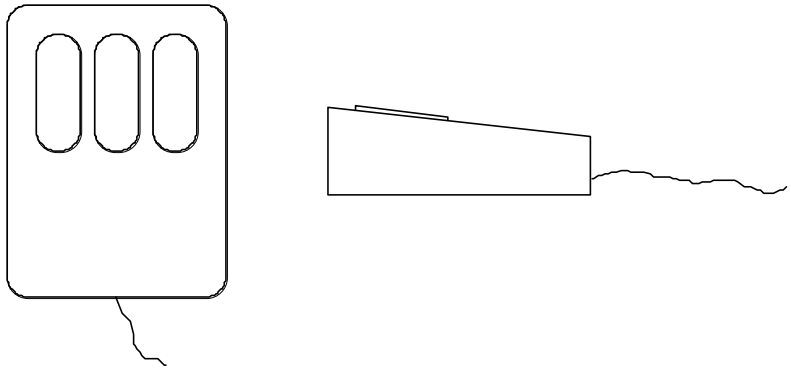
calculator

positioning, pointing and drawing

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

the Mouse

- Handheld pointing device
  - very common
  - easy to use

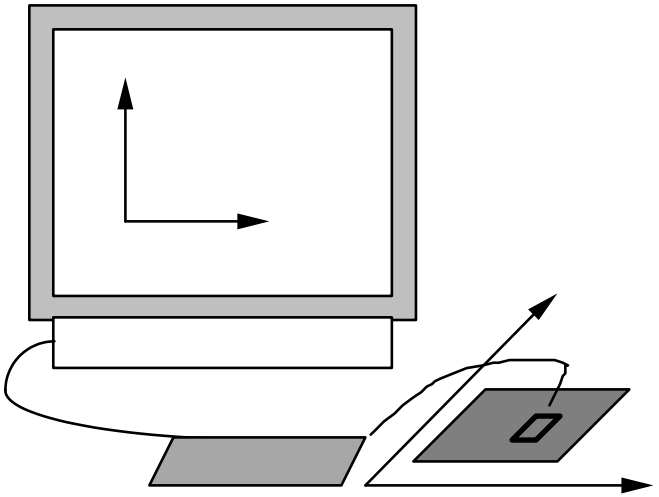


- Two characteristics
  - planar movement
  - buttons

    (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
  - 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 upside 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

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 …

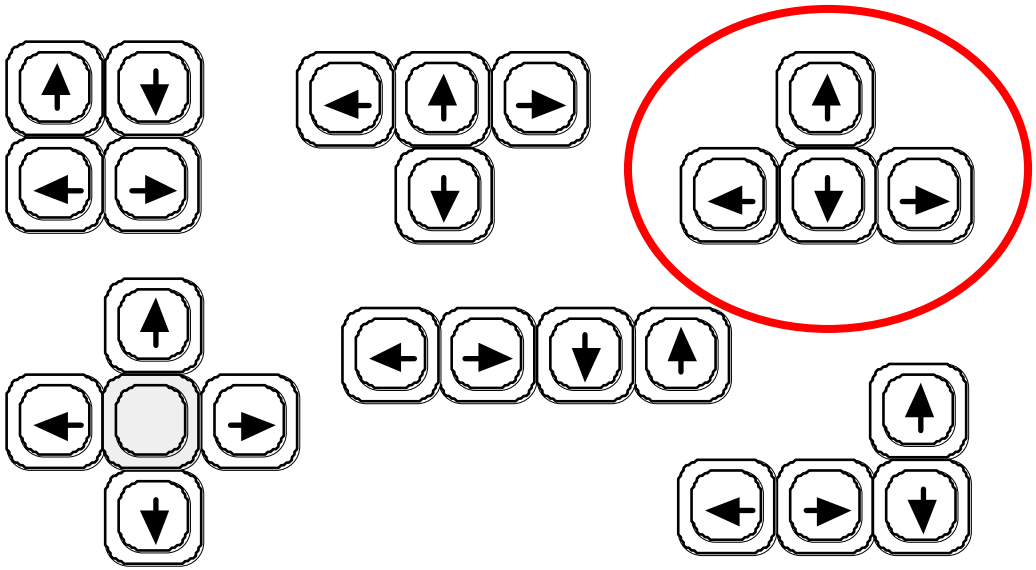
- very direct and obvious to use
- but can obscure screen

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!
- 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

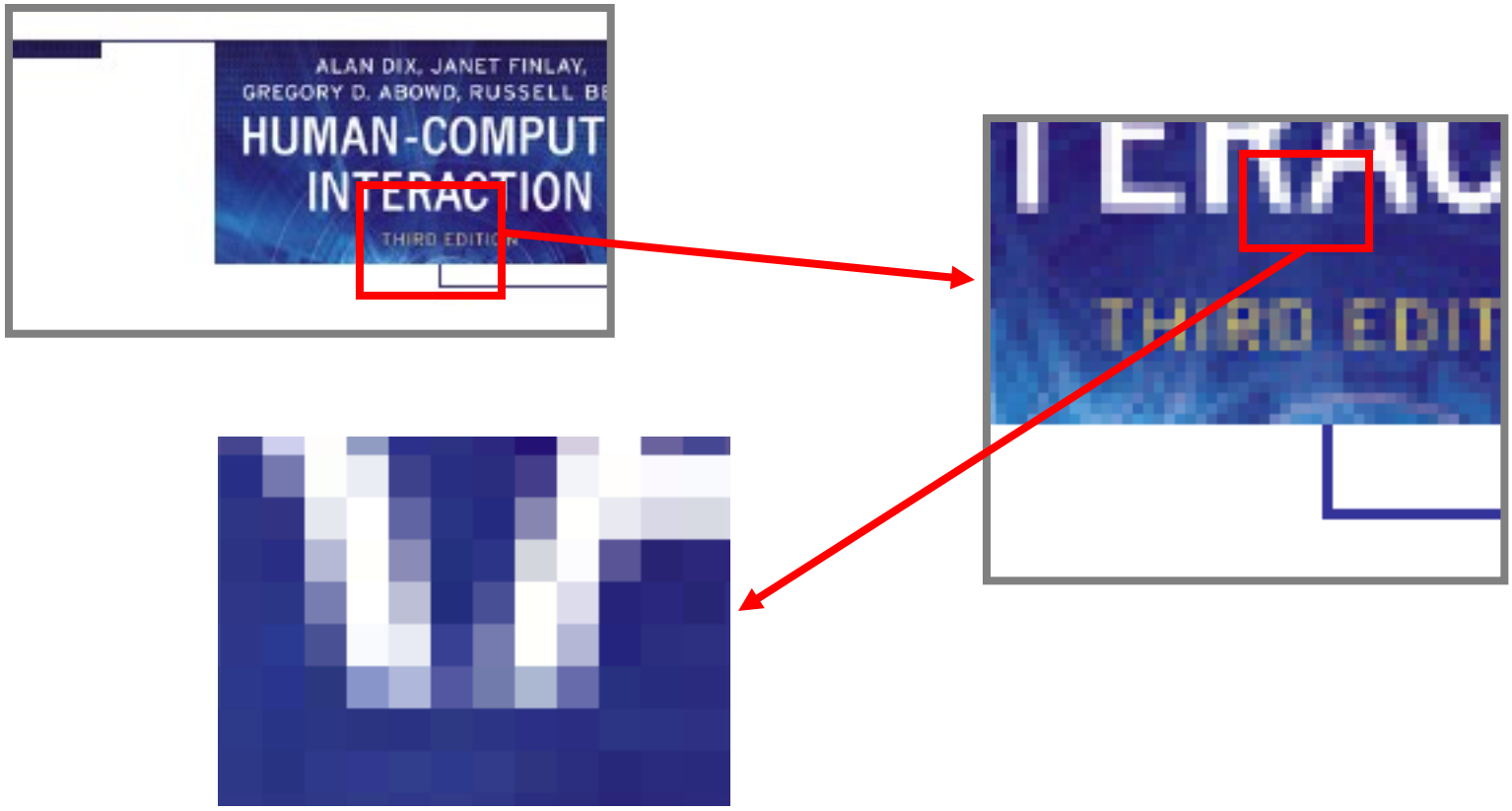
bitmap screens (CRT & LCD)

large & situated displays

digital paper

bitmap displays

- screen is vast number of coloured dots



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
  - 8 bits each for red/green/blue = millions of colours

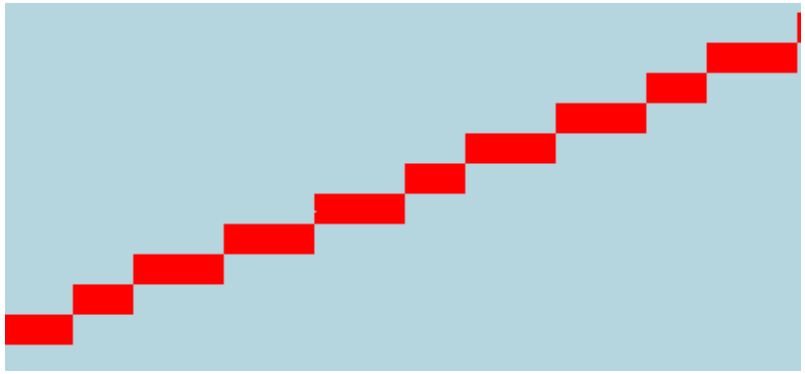
anti-aliasing

Jaggies

- diagonal lines that have discontinuities in due to horizontal raster scan process.

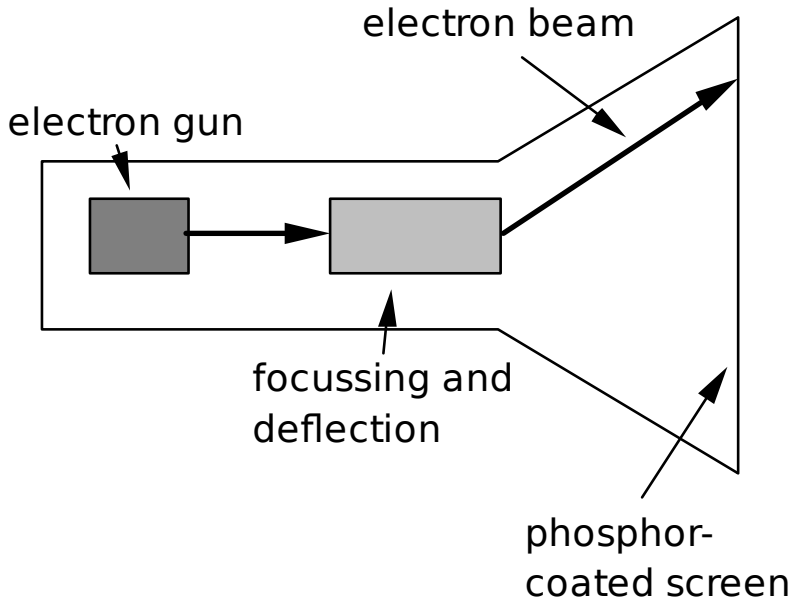
Anti-aliasing

- softens edges by using shades of line colour
- also used for text



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



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 dedicted displays:
  digital watches, mobile phones etc.

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

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

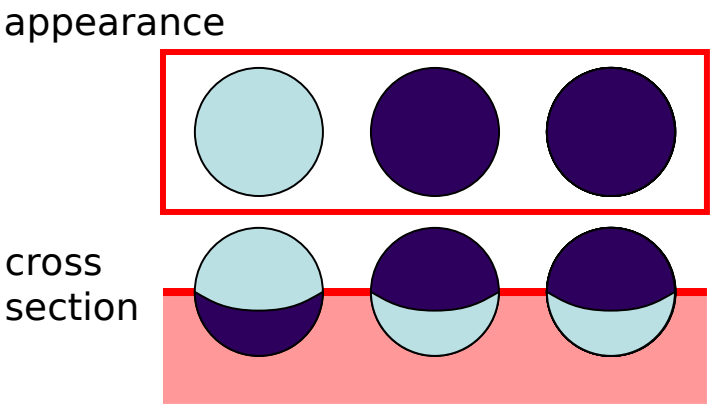
small displays beside office doors

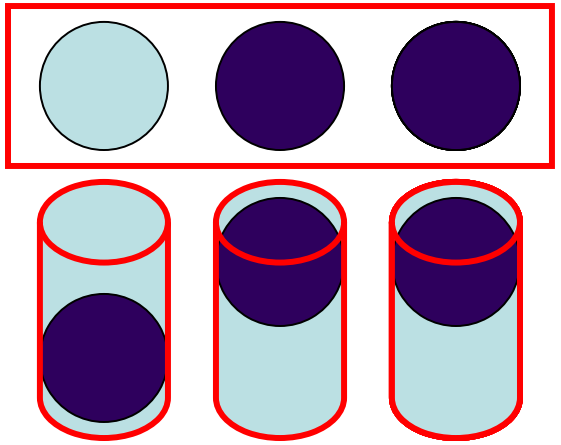
handwritten notes left using stylus

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





Video related to Digital Paper

- ....

virtual reality and 3D interaction

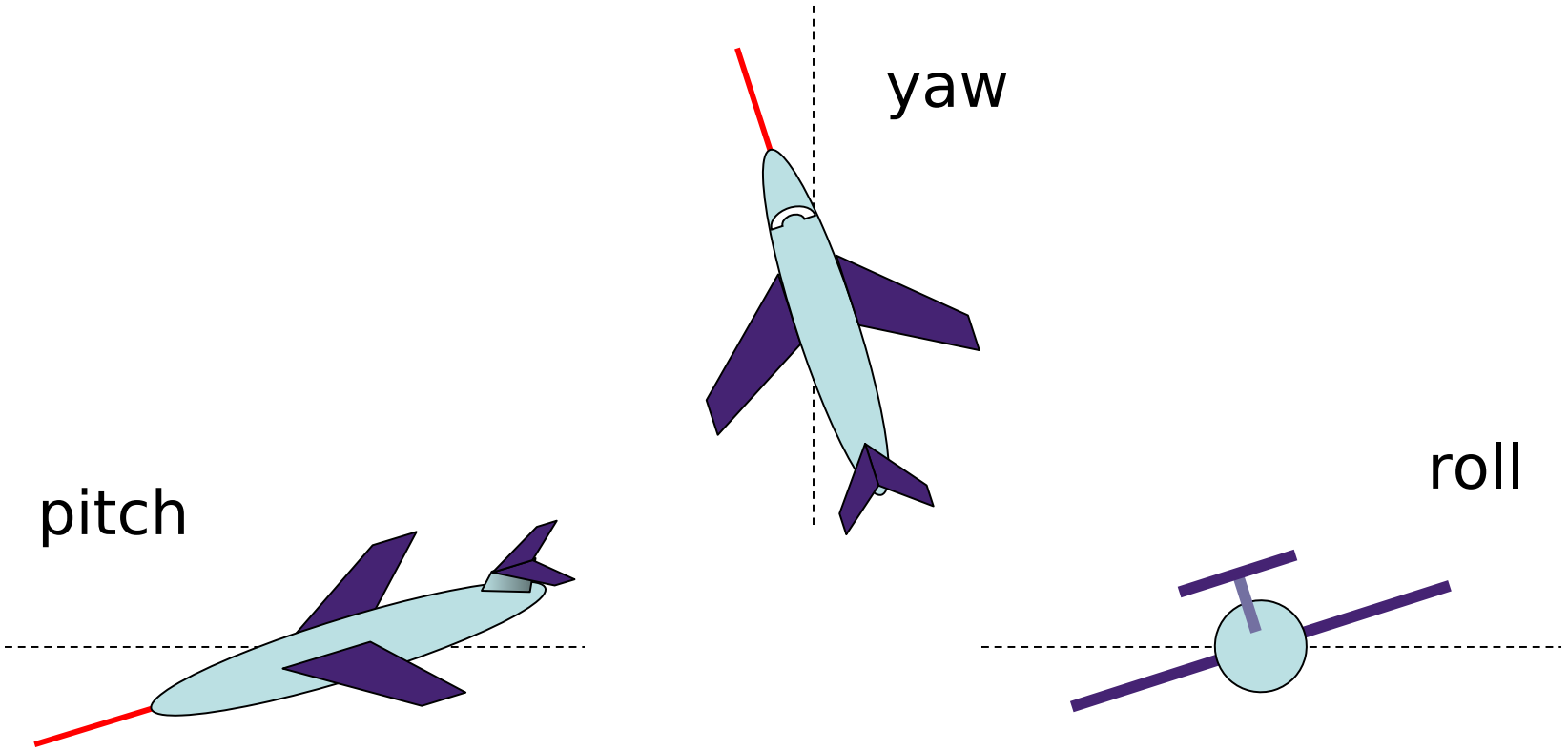
positioning in 3D space
moving and grasping
seeing 3D (helmets and caves)

positioning in 3D space

The degree of freedom (DOF) of a mechanical system is the number of independent parameters that define its configuration

- virtual controls and 3d Visualization
  - These require you to navigate and interact in a three-dimensional space
  - steering wheels, knobs and dials … just like real!
- The 3D mouse
  - six-degrees of movement: x, y, z + roll, pitch, yaw
- data glove
  - 3D input device
  - 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, yaw and roll



3D displays

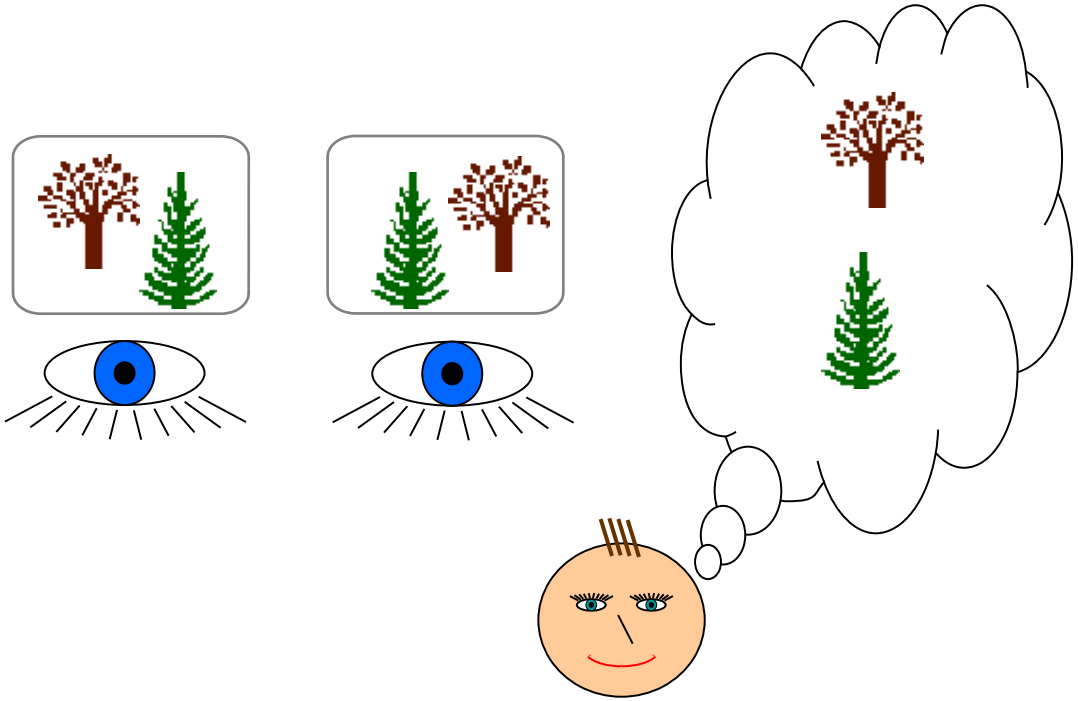
- 3D images used in VR have led to new forms of input device and require more sophisticated outputs
- Desktop VR is delivered using
  - ordinary screen, mouse or keyboard control
  - Occlusion, shadow, perspective and motion give 3D effect

Seeing in 3D

- Our eyes use many cues to perceive depth in the real world
- use stereoscopic vision
  - each eye sees only a flattened form of the world
  - Stereo vision enable us to view the world in 3d
- VR helmets

VR headsets

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



Motion Sickness

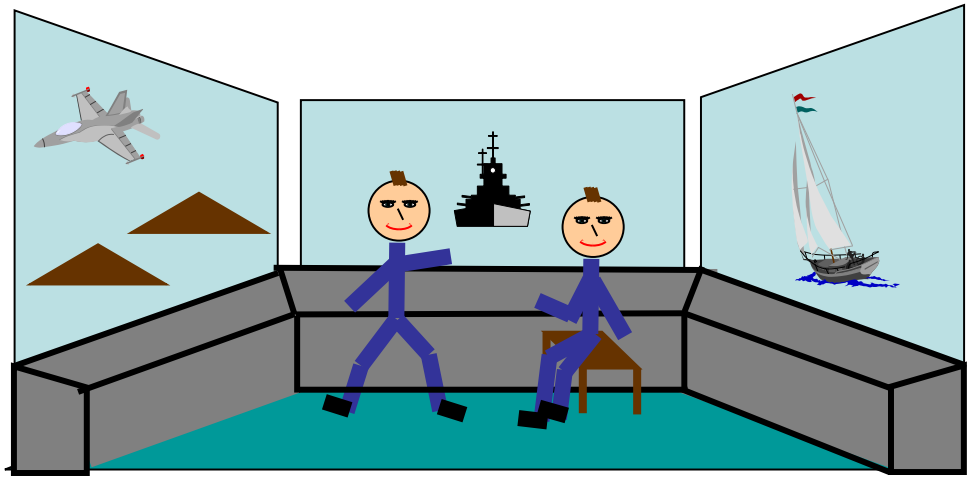
- In real life when we move our head the image our eyes see changes accordingly.
- VR systems produce the same effect by using sensors in the goggles or helmet and then using the position of the head to determine the right image to show.

VR motion sickness

- If the system is slow in producing these images a lag develops between the user moving his head and the scene changing.
- If this delay is more than a hundred milliseconds or so the feeling becomes disorienting.

Simulators and VR caves

- More general-purpose rooms called caves have large displays positioned all around the user, or several back projectors.
- In these systems the user can look all around and see the virtual world surrounding them.



Physical Controls, Sensors and Special Devices

dedicated displays

- analogue representations:
  - dials, gauges, lights, etc.

- digital displays:
  - small LCD screens
  - LED lights used on the back of a computer system to display the processor state, battery charging, On top side of mobile phones etc.
- head-up displays
  - Mostly found in aircraft cockpits
  - show most important controls
    ... depending on context

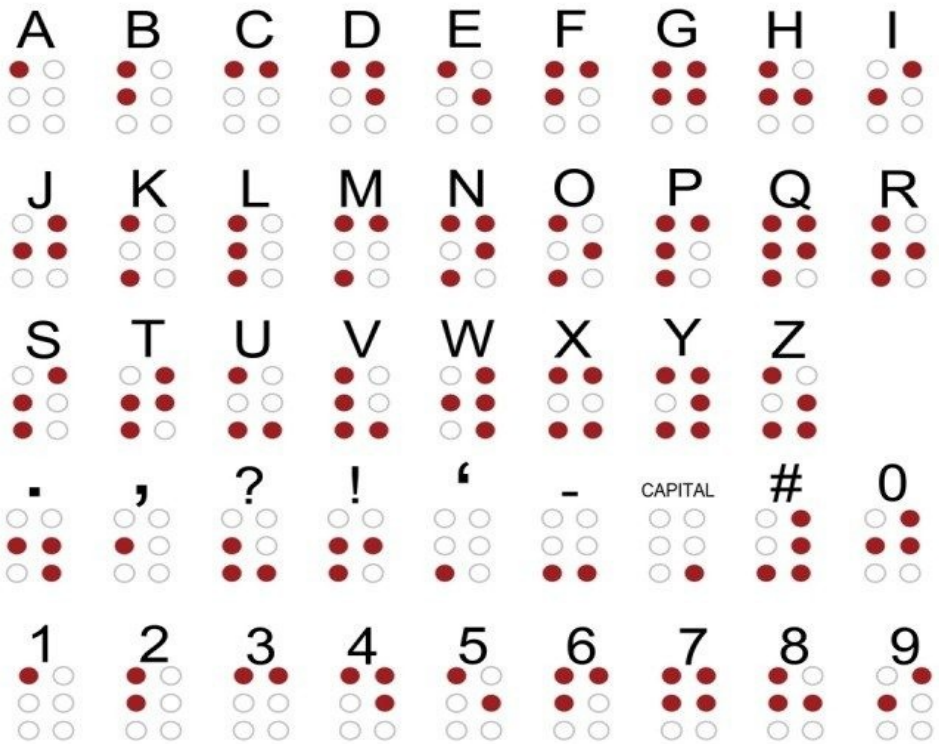
Sound output

- Sounds offer an important level of feedback in interactive systems.
  - beeps, bongs, clonks, whistles and whirrs
- used for error indications
- confirmation of actions e.g. keyclick
- The advantage of auditory feedback is evident when we consider a simple device such as a doorbell.

Touch, feel, smell

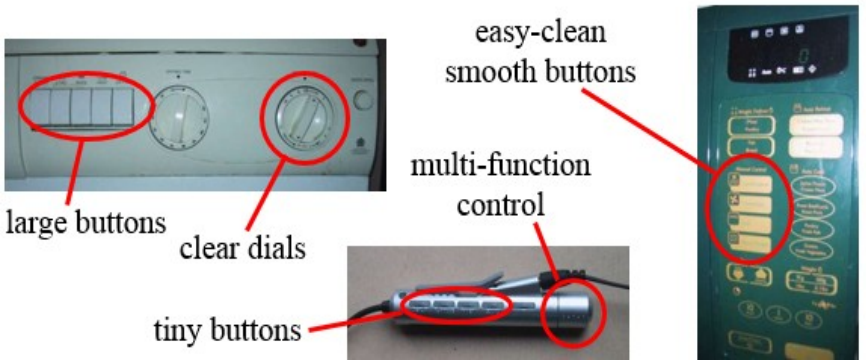
- **touch and feeling important**
  - in games … vibration
  - In medical domains to ‘practice’ surgical procedures, the feel of an instrument moving through different tissue types is very important
- **These various forms of force, resistance and texture that influence our physical senses are called *haptic* devices.**
- **Texture**
  - Electronic braille displays for visually impaired people
- **Smell, taste**
  - current technology very limited

BRAILLE Alphabet



physical controls

- The smooth controls have no gaps where food can accumulate and clog buttons, so it can easily be kept clean and hygienic.
- MiniDisc controller needs to be small and unobtrusive.
- When using the washing machine you are handling dirty clothes, which may be grubby, but not to the same extent, so the smooth easy-clean panel is less important



Environment and bio-sensing

- sensors all around us
  - car courtesy light – small switch on door
  - ultrasound detectors – security
  - washbasins controlled by infrared sensors
  - RFID security tags in shops
  - temperature, location
- Sensors can also be used to capture physiological signs
  - iris scanners, body temperature, heart rate, blink rate

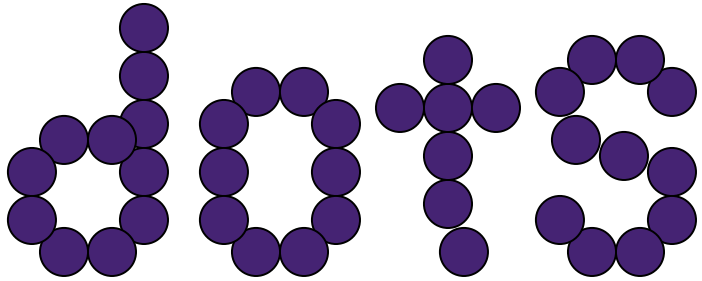
Paper: printing and scanning

print technology

fonts, page description, WYSIWYG

scanning, OCR

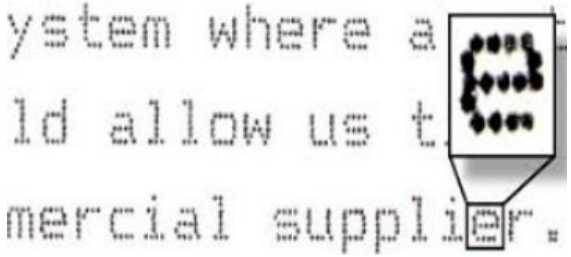
Printing



- Printing technologies, like screens, build the image on the paper as a series of dots allows any character set or graphic to be printed
- critical features:
  - resolution
    - size and spacing of the dots
    - measured in dots per inch (dpi)
  - speed
    - usually measured in pages per minute
  - cost!!

Types of dot-based printers

- dot-matrix printers
  - use inked ribbon (like a typewriter)
  - line of pins that can strike the ribbon, dotting the paper.
  - typical resolution 80-120 dpi
- ink-jet and bubble-jet printers
  - tiny blobs of ink sent from print head to paper
  - typically 300 dpi or better .
- laser printer
  - like photocopier: dots of electrostatic charge deposited on drum, which picks up toner (black powder form of ink) rolled onto paper which is then fixed with heat
  - typically 600 dpi or better.



Fonts

- Font – the particular style of text

Courier font
Helvetica font
Palatino font
Times Roman font
∀ ♣×∝≡↩ℜ€⊗↵~€ (special symbol)

- Size of a font measured in points (1 pt about 1/72”) (vaguely) related to its height

This is ten point Helvetica
This is twelve point
This is fourteen point
This is eighteen point
and this is twenty-four point

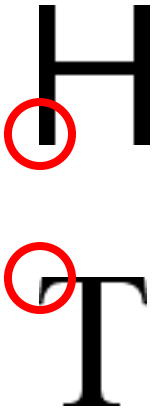
Fonts (ctd)

Pitch

- fixed-pitch – every character has the same width
  - e.g. Courier
- variable-pitched – some characters wider
  - e.g. Times Roman – compare the 'i' and the "m"

Serif or Sans-serif

- sans-serif – square-ended strokes
  - e.g. Helvetica
- serif – with splayed ends (such as)
  - e.g. Times Roman or Palatino



Readability of text

- lowercase
  - easy to read shape of words
- UPPERCASE
  - better for individual letters and non-words

    e.g. flight numbers: BA793 vs. ba793
- serif fonts
  - helps your eye on long lines of printed text
  - but sans serif often better on screen

Screen and page

- A common requirement of word processors and desktop publishing software is that what you see is what you get (WYSIWYG)
  - For example, centered text is displayed centered on the screen
- Most screens use an additive color model using red, green and blue light, whereas printers use a subtractive color model with cyan, magenta, yellow and **black** inks, so conversions have to be made

Scanners

- Take paper and convert it into a bitmap
- Two sorts of scanner
  - flat-bed: paper placed on a glass plate, whole page converted into bitmap
  - hand-held: scanner passed over paper, digitising strip typically 3-4” wide
- Shines light at paper and note intensity of reflection
  - colour or greyscale
- Typical resolutions from 600–2400 dpi

Optical character recognition

- OCR converts bitmap back into text
- more complex systems segment text, decompose it into lines and arcs, and decipher characters that way
- page format
  - columns, pictures, headers and footers

Paper-based interaction

- Paper usually regarded as *output* only
- can be *input* too – OCR, scanning, etc.
- More recently
  - papers micro printed - like watermarks
    - identify *which* sheet and *where* you are
  - special ‘pen’ can read locations
    - know where they are writing

memory

short term and long term

speed, capacity, compression

formats, access

Short-term Memory - RAM

- Random access memory (RAM)
  - on silicon chips
  - 100 nano-second access time
  - usually volatile (lose information if power turned off)
  - data transferred at around 100 Mbytes/sec
- Some *non-volatile RAM* used to store basic set-up information
- Typical desktop computers:
  64 to 256 Mbytes RAM

Long-term Memory - disks

- magnetic disks
  - floppy disks store around 1.4 Mbytes
  - hard disks typically 40 Gbytes to 100s of Gbytes access time ~10ms, transfer rate 100kbytes/s
- optical disks
  - use lasers to read and sometimes write
  - more robust that magnetic media
  - CD-ROM
    - same technology as home audio, ~ 600 Gbytes
  - DVD - for AV applications, or very large files

Blurring boundaries

- PDAs
  - often use RAM for their main memory
- Flash-Memory
  - used in PDAs, cameras etc.
  - silicon based but persistent
  - plug-in USB devices for data transfer

speed and capacity

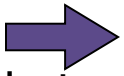
- what do the numbers mean?

- some sizes (all uncompressed) …
  - this book, text only ~ 320,000 words, 2Mb
  - the Bible ~ 4.5 Mbytes
  - scanned page ~ 128 Mbytes
    - (11x8 inches, 1200 dpi, 8bit greyscale)
  - digital photo ~ 10 Mbytes
    - (2–4 mega pixels, 24 bit colour)
  - video ~ 10 Mbytes *per second*
    - (512x512, 12 bit colour, 25 frames per sec)

virtual memory

- Problem:
  - running lots of programs + each program large
  - not enough RAM
- Solution - Virtual memory :
  - store some programs temporarily on disk
  - makes RAM appear bigger
- But ... swopping
  - program on disk needs to run again
  - copied from disk to RAM
  - s l o w s t h i n g s d o w n

Compression

- reduce amount of storage required
- lossless
  - recover exact text or image – e.g. GIF, ZIP
  - look for commonalities:
    - text: AAAAAAAAAABBBBBCCCCCCCC  10A5B8C
    - video: compare successive frames and store change
- lossy
  - recover something like original – e.g. JPEG, MP3
  - exploit perception
    - JPEG: lose rapid changes and some colour
    - MP3: reduce accuracy of drowned out notes

Storage formats - text

- ASCII - 7-bit binary code for to each letter and character
- UTF-8 - 8-bit encoding of 16 bit character set
- RTF (rich text format)
  - text plus formatting and layout information
- SGML (standardized generalised markup language)
  - documents regarded as structured objects
- XML (extended markup language)
  - simpler version of SGML for web applications

Storage formats - media

- Images:
  - many storage formats :
    (PostScript, GIFF, JPEG, TIFF, PICT, etc.)
  - plus different compression techniques
    (to reduce their storage requirements)
- Audio/Video
  - again lots of formats :
    (QuickTime, MPEG, WAV, etc.)
  - compression even more important
  - also ‘streaming’ formats for network delivery

methods of access

- large information store
  - long time to search => use index
  - what you index -> what you can access
- simple index needs exact match
- forgiving systems:
  - Xerox “do what I mean” (DWIM)
  - SOUNDEX – McCloud ~ MacCleod
- access without structure …
  - free text indexing (all the words in a document)
  - needs lots of space!!

processing and networks

finite speed (but also Moore's law)

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