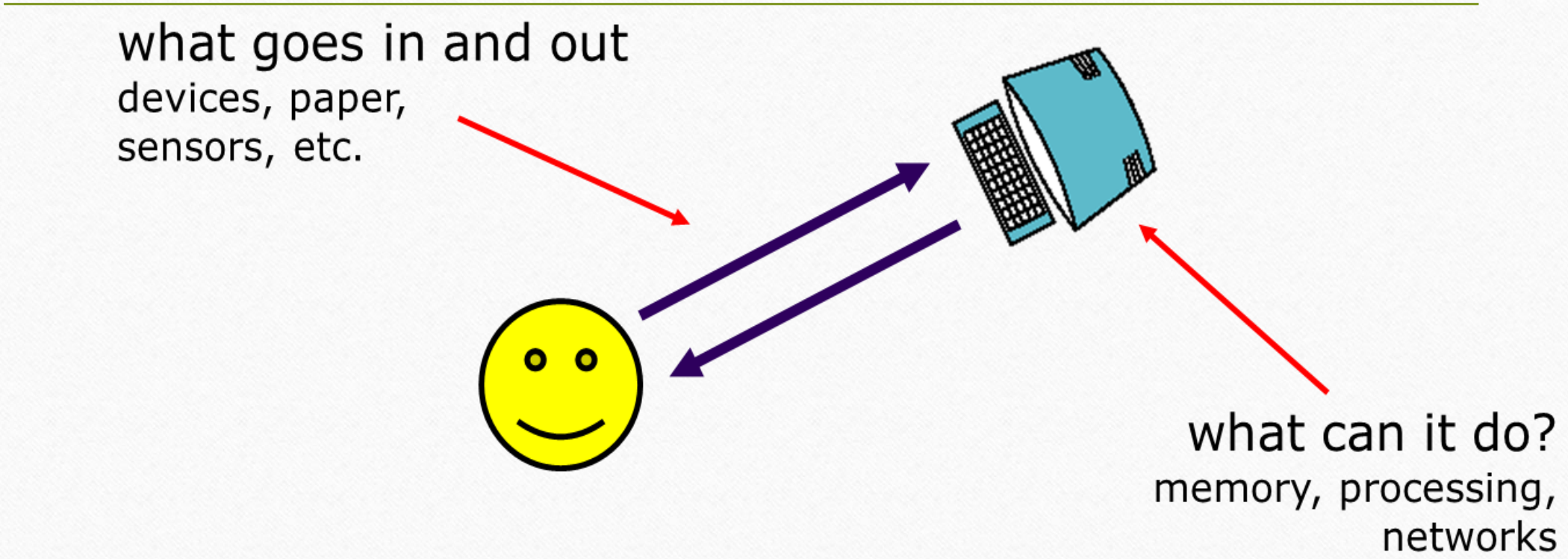
CHAPTER - THREE
Computer in HCI

❖ 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!

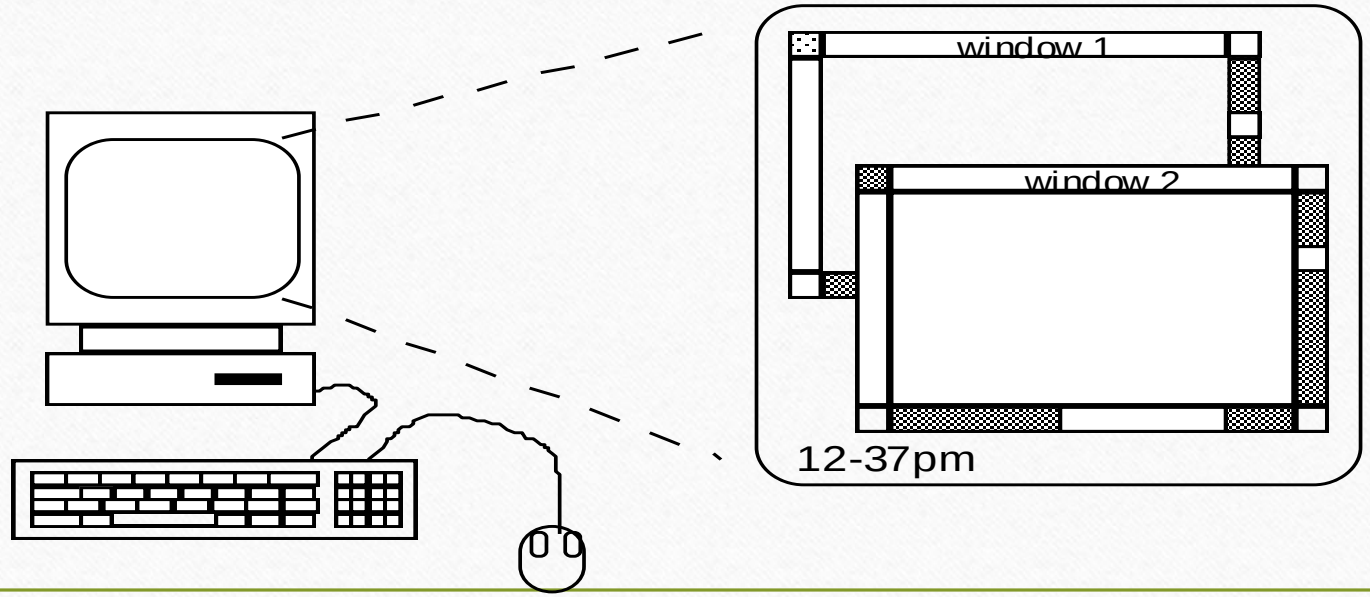


A ‘typical’ computer system

- screen, or monitor, on which there are windows, keyboard, mouse/trackpad.
- variations(**desktop**, **laptop** and **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

- computers in your house?
- computers in your pockets

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

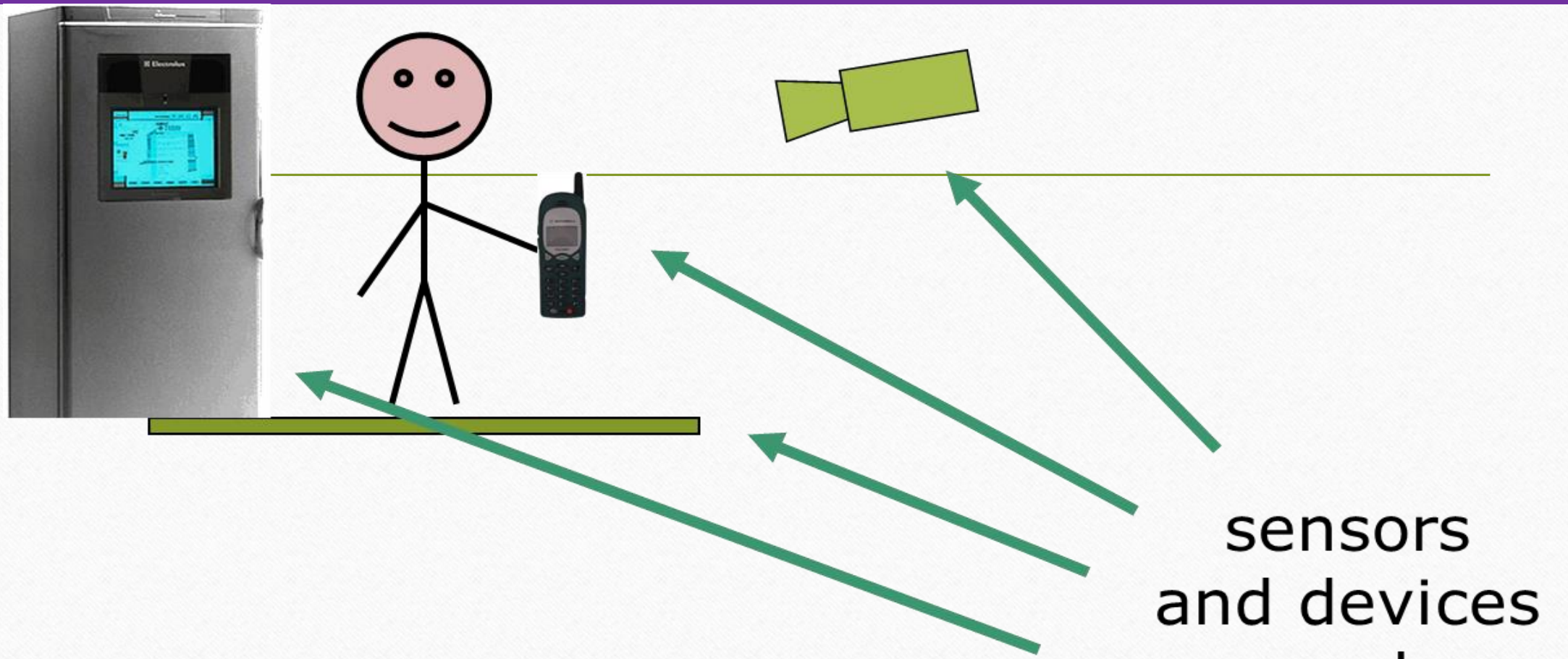
Interactivity?

- 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 …**

Richer interaction



Text Entry Devices

- **keyboards (QWERTY et al.)**
- **chord keyboards, phone pads**
- **handwriting, speech**

- **keyboards (QWERTY et al.)**

❖ Most common text input device

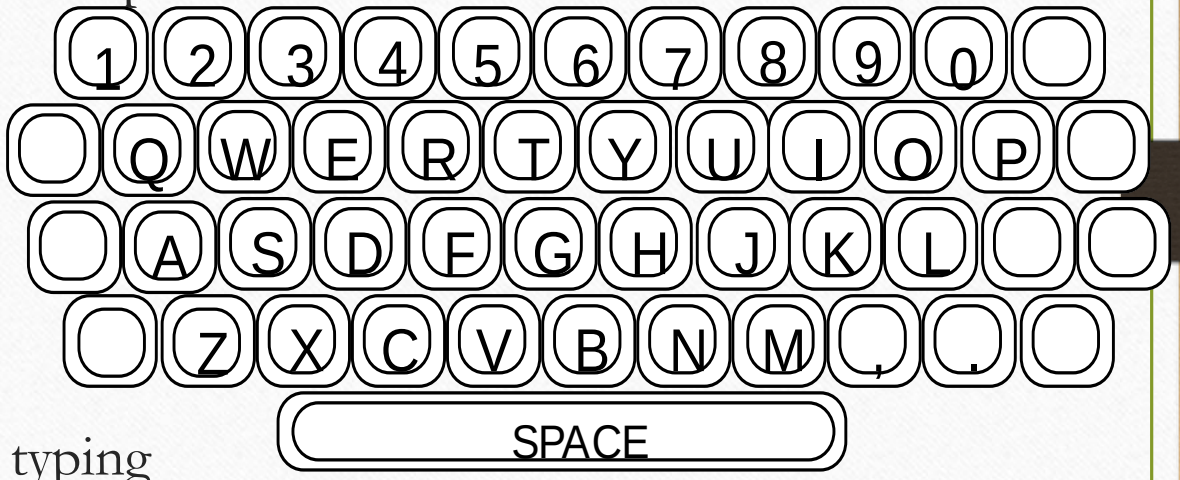
❖ Allows rapid entry of text by experienced users

❖ Keypress closes connection, causing a character code to be sent

❖ Usually connected by cable, but can be wireless

Keyboards: layout – QWERTY

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



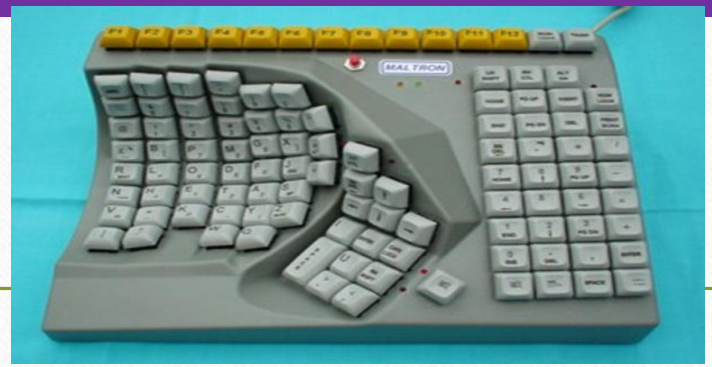
- **QWERTY** arrangement not optimal for typing
  – layout to prevent typewriters jamming!
- Alternative designs allow faster typing but large social base of QWERTY typists produces reluctance to change.

Alternative keyboard layouts

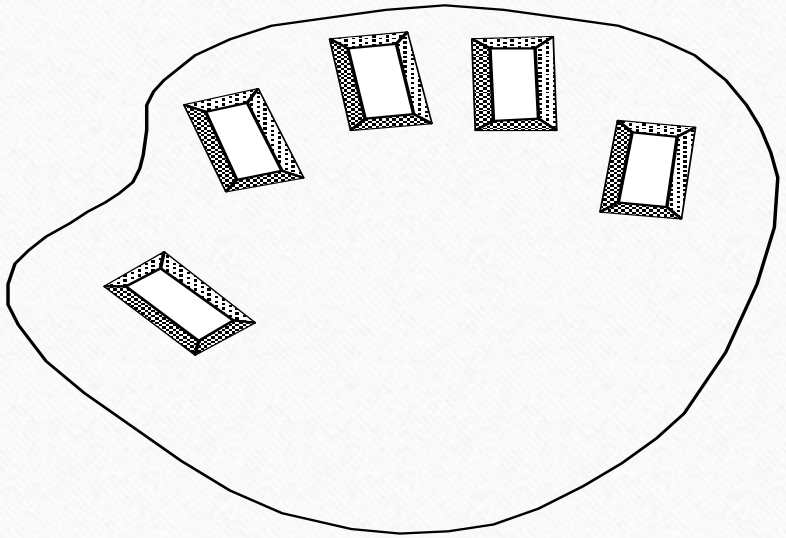
- **Alphabetic**
  - ✓keys arranged in alphabetic order
  - ✓not faster for trained typists
  - ✓not faster for beginners either!
- **Dvorak**
  - ✓common letters under dominant fingers
  - ✓biased towards right hand
  - ✓common combinations of letters alternate between hands
  - ✓10-15% improvement in speed and reduction in fatigue
  - ✓But - large social base of QWERTY typists produce market pressures not to change

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 - four or 5
- letters typed as combination of keypresses
- compact size
  - ideal for portable applications



Handwriting recognition

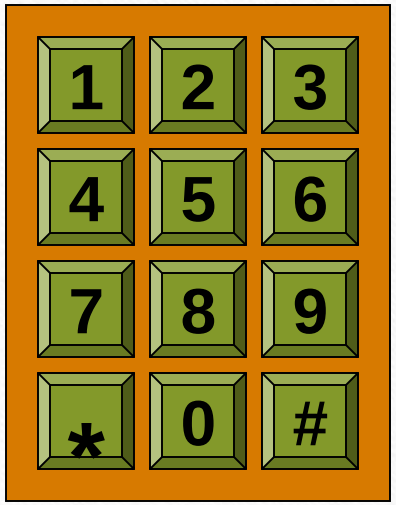
- Text can be input into the computer, using a pen and a digesting tablet
  - natural interaction
- Technical problems:
  - ✓ capturing all useful information - stroke path, pressure, etc. in a natural manner
  - ✓ segmenting joined up writing into individual letters
  - ✓ interpreting individual letters
  - ✓ coping with different styles of handwriting
- Used in PDAs, and tablet computers leave the keyboard on the desk!

Speech recognition

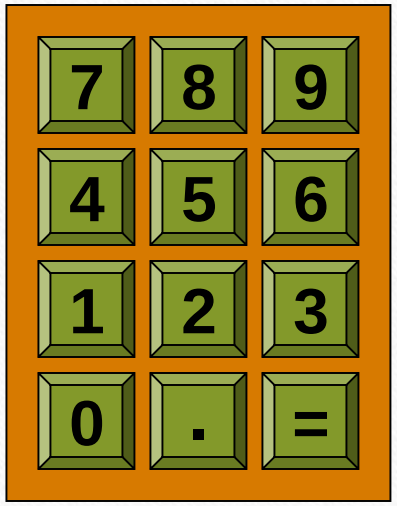
- **Improving rapidly**, Most successful when:
  - single user – initial training and learns peculiarities
  - limited vocabulary systems
- Problems with
  - external noise interfering
  - imprecision of pronunciation
  - large vocabularies
  - different speakers

Numeric keypads

- for entering numbers quickly:
  - calculator, PC keyboard
- for telephones not the same!!
- ATM like phone



telephone



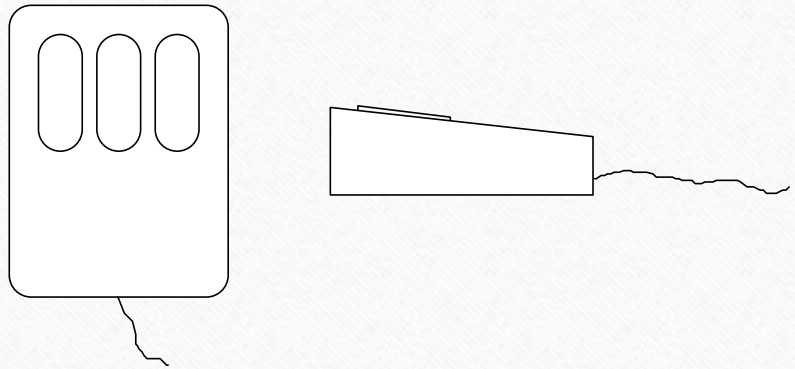
calculator

positioning, pointing and drawing

- ✓ mouse
- ✓ touchpad
- ✓ trackballs
- ✓ joysticks
- ✓ touch screens
- ✓ tablets
- ✓ eyegaze
- ✓ Cursors and etc.

The Mouse

- Handheld pointing device
  - very common
  - easy to use



- Two characteristics
  - planar movement
  - buttons

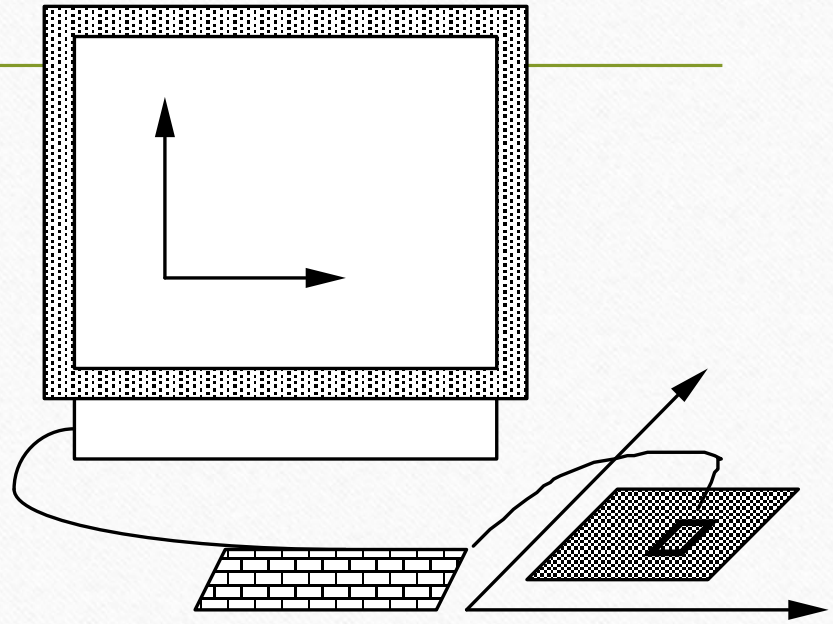
    (usually from 1 to 3 buttons on top, used for making a selection, indicating an option, or to initiate drawing etc.)

The Mouse …

- 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 *foot mouse*
  - 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 and keyboard nipple

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

Keyboard nipple

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

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 the screen
- May use touch-sensitive surface or magnetic detection
- Used in PDAs, tablets PCs, and drawing tables

Light Pen

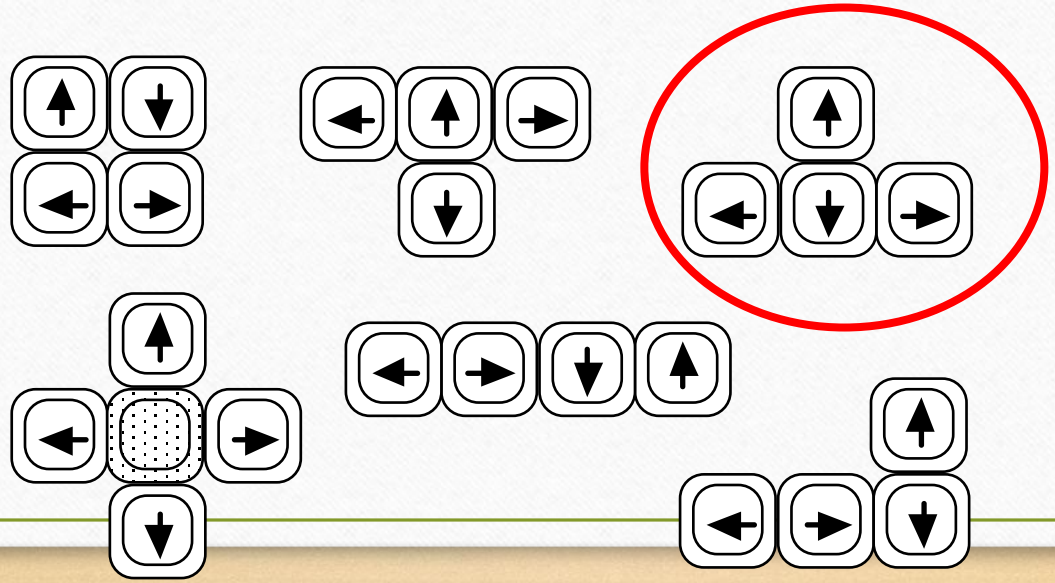
- Now rarely used
- Uses light from the screen to detect location

BOTH …

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

Cursor keys

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



Discrete positioning controls

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

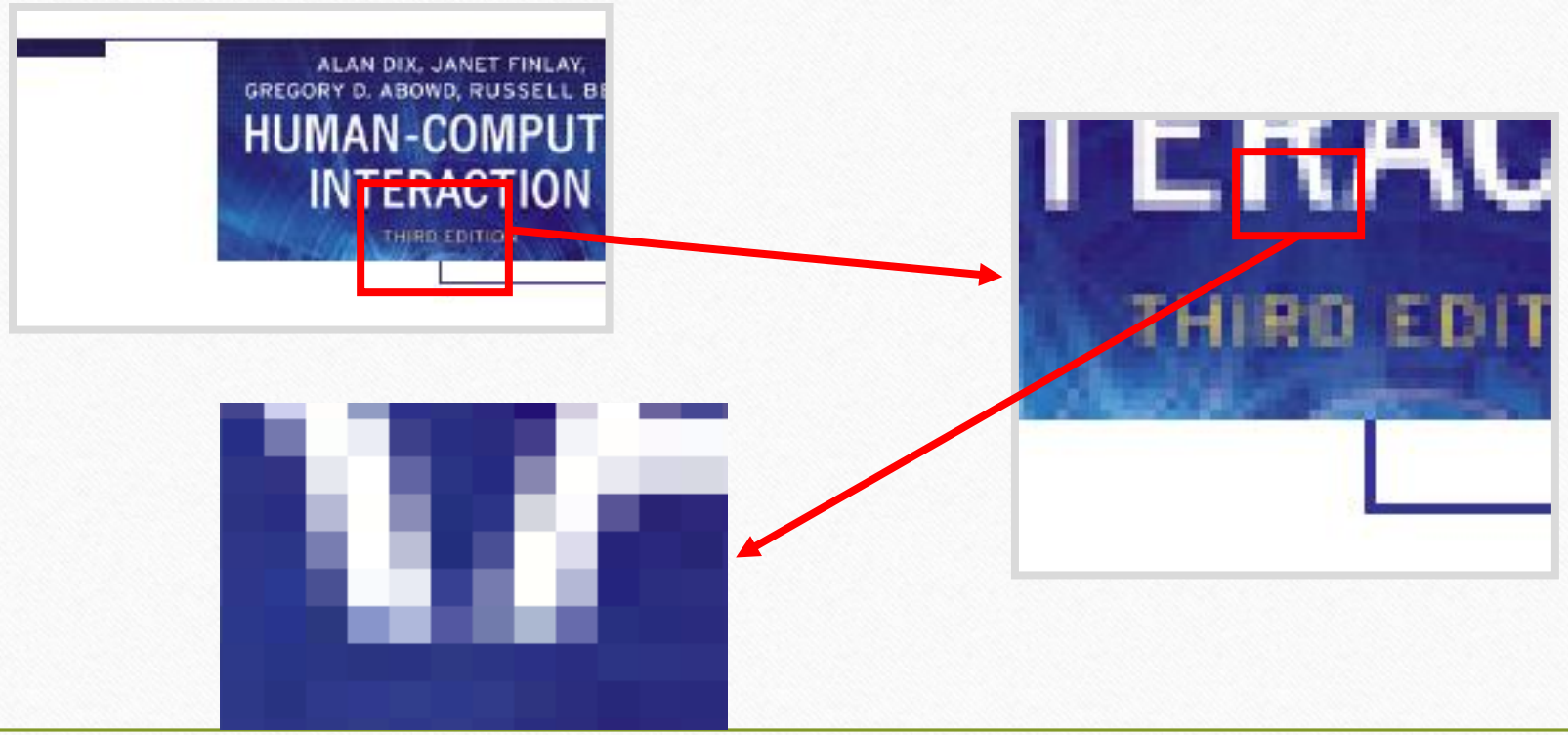
Display Devices

- **Bitmap screens (CRT & LCD)**

- **large & and situated displays digital paper**

Bitmap Displays

- screen is vast number of coloured dots

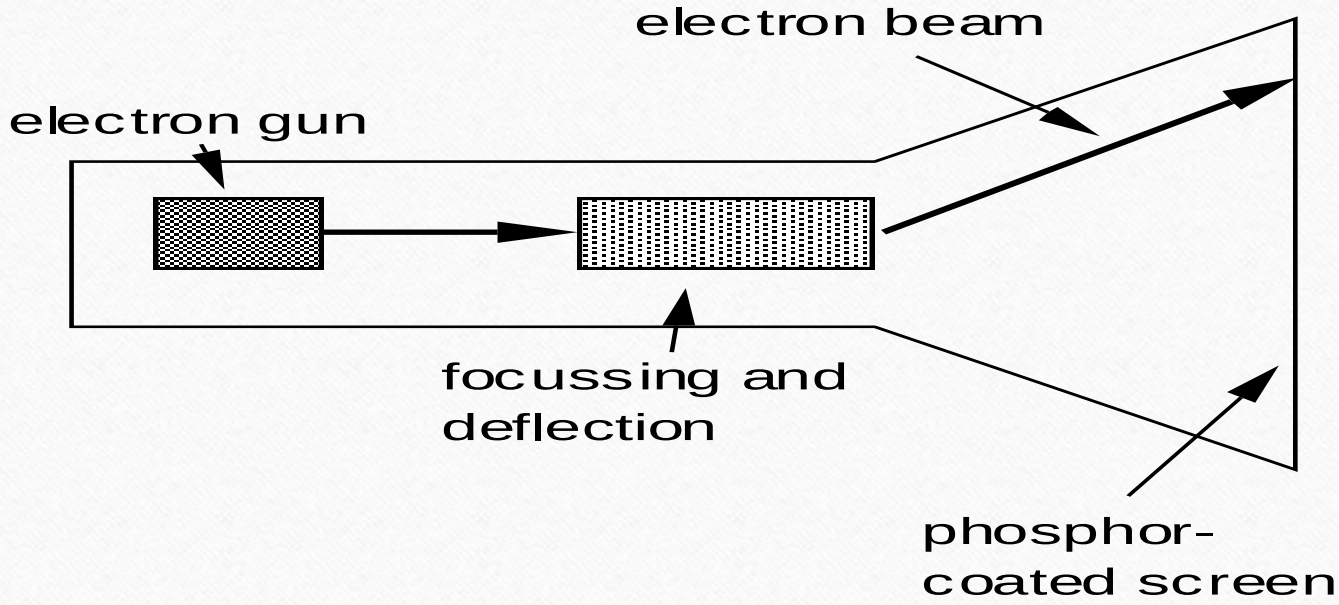


Resolution and Colour Depth

- Resolution … used (inconsistently) for
  - ✓ number of pixels on the 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
  - ✓ Ratio 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 pallet
  - ✓ 8 bits each for red/green/blue = millions of colours

Cathode Ray Tube

- Stream of electrons emitted from an 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 dedicated displays: digital watches, mobile phones, HiFi controls
- How it works …
  - Top plate transparent and polarised, bottom plate reflecting.
  - Light passes through the top plate and crystal, and reflects back to the eye.
  - Voltage applied to crystal changes polarisation and hence the color
  - 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
  - no jaggies
  - 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 widescreen
  - ✓ 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 screem 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

small displays beside office doors

handwritten notes left using stylus

office owner reads notes using web interface

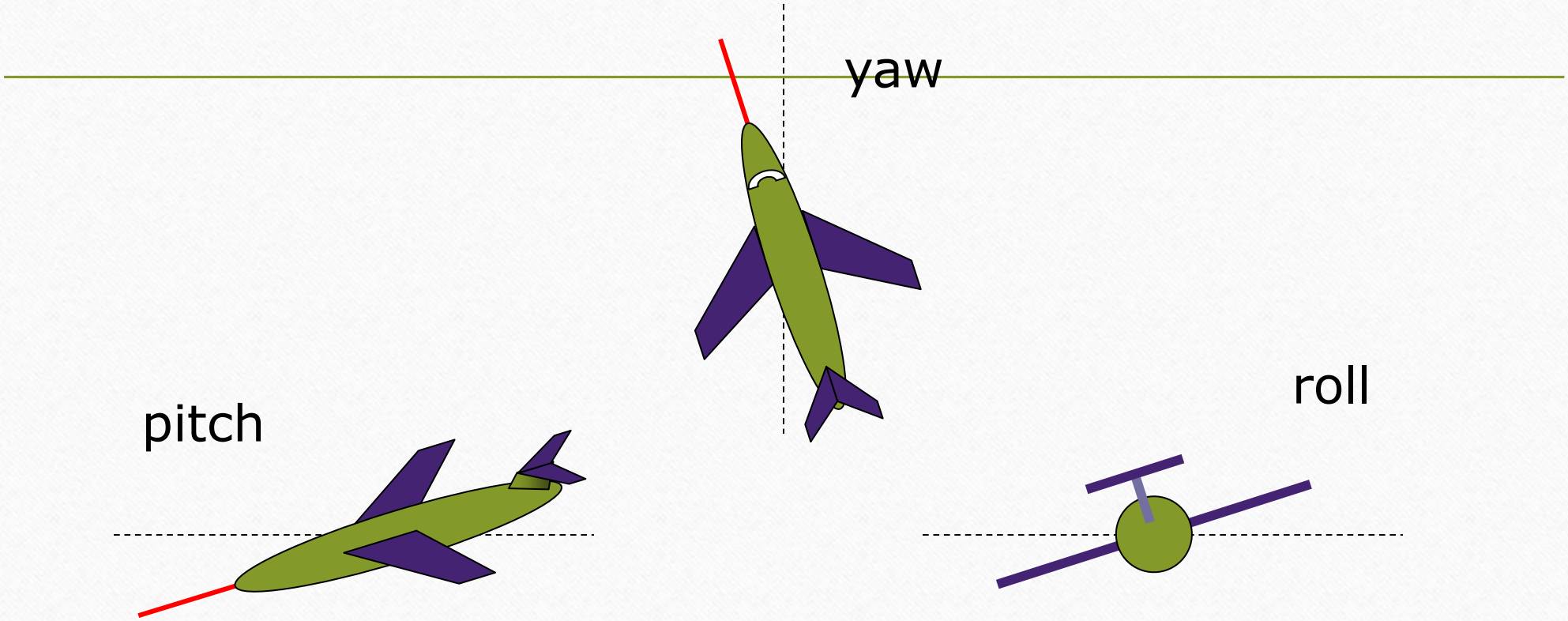
Virtual Reality and 3D Interaction

- 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, yaw and roll



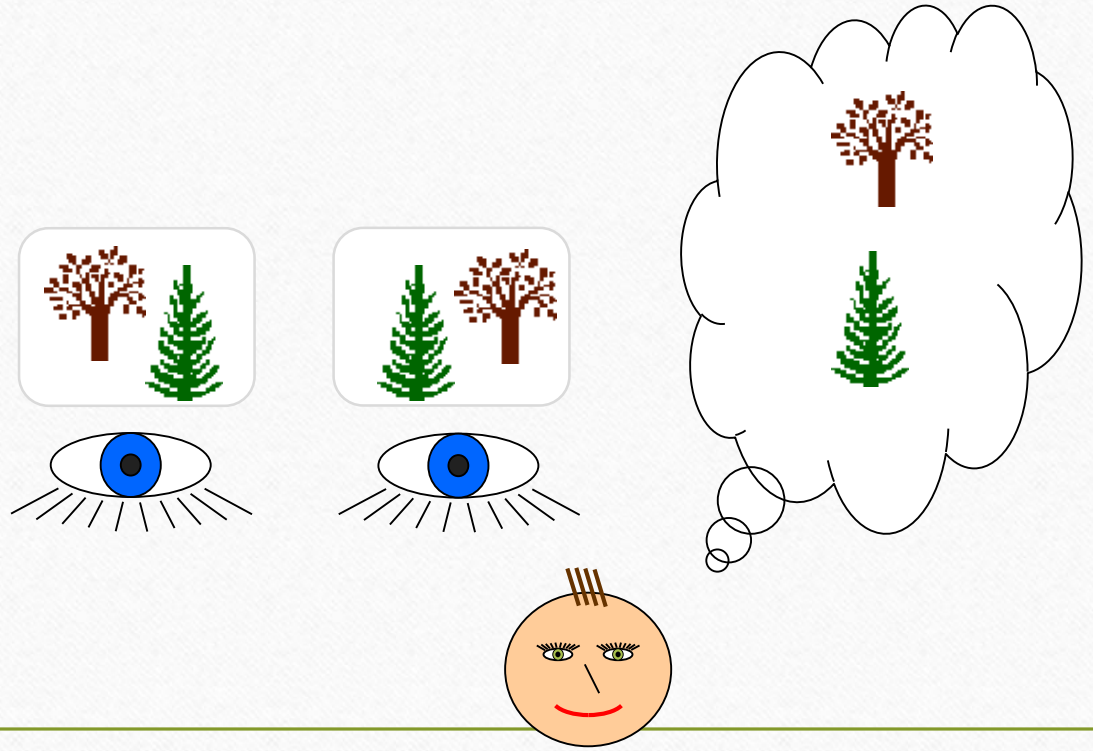
3D displays

- **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.

also see extra slides on 3D vision

VR headsets

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

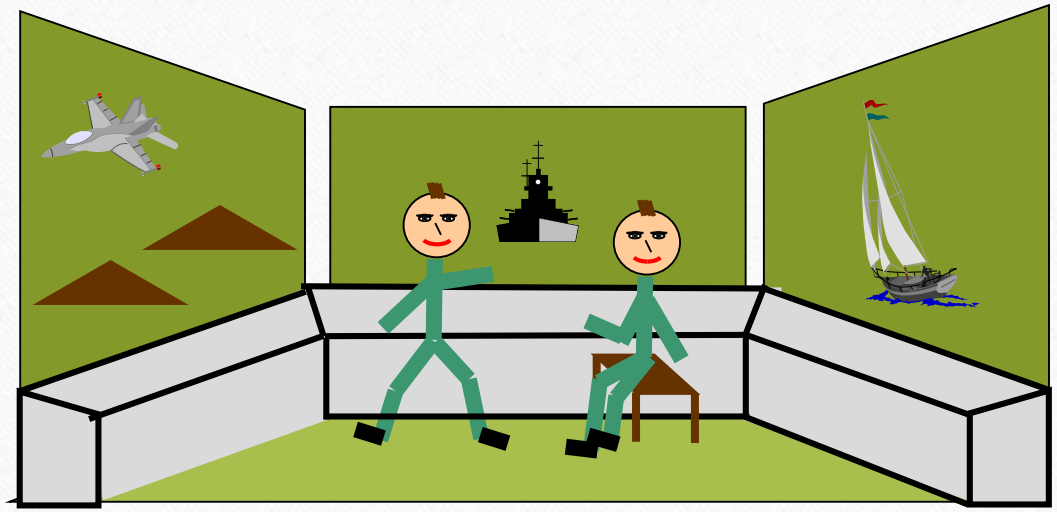


VR motion sickness

- **time delay**
  - move head … lag … display moves
  - *conflict:* head movement vs. eyes
- **depth perception**
  - headset gives different stereo distance
  - but all focused in the 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

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Environment and Bio-sensing

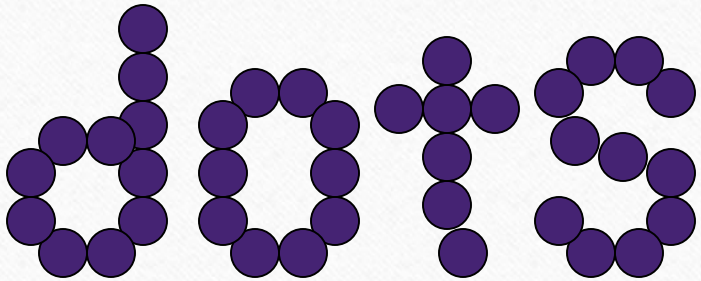
- sensors all around us:
  - ✓ car courtesy light – small switch on door
  - ✓ ultrasound detectors – security, washbasins
  - ✓ RFID security tags in shops
  - ✓ temperature, weight, location and even our own bodies …
  - ✓ iris scanners, body temperature, heart rate, galvanic skin response, blink rate

paper: printing and scanning

- print technology
- fonts, page description, WYSIWYG
- scanning, OCR

Printing

- image made from small 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.

Printing in the workplace

- shop tills
  - dot matrix
  - same print head used for several paper rolls
  - may also print cheques
- thermal printers
  - special heat-sensitive paper
  - paper heated by pins makes a dot
  - poor quality, but simple & low maintenance
  - used in some fax machines

Page Description Languages

- Pages very complex
  - different fonts, bitmaps, lines, digitised photos, etc.
- Can convert it all into a bitmap and send to the printer but often huge !
- Alternatively Use a page description language
  - sends a *description* of the page can be sent,
  - instructions for curves, lines, text in different styles, etc.
  - like a programming language for printing!
- PostScript is the most common

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

Scanners …

Used in:

- desktop publishing for incorporating photographs and other images
- document storage and retrieval systems, doing away with paper storage
+ special scanners for slides and photographic negatives

Optical Character Recognition

- OCR converts bitmap back into text
- different fonts
  - create problems for simple “template matching” algorithms
  - 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.
- Xerox PaperWorks
  - glyphs – small patterns of /\\//\\\
    - used to identify forms etc.
    - used with scanner and fax to control applications
- more recently
  - papers micro printed - like wattermarks
    - 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!

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

END OF CHAPTER – THREE !