The Computer

From Dix, Finlay, Abowd & Beale's *Human-Computer Interaction (Chapter 2)*

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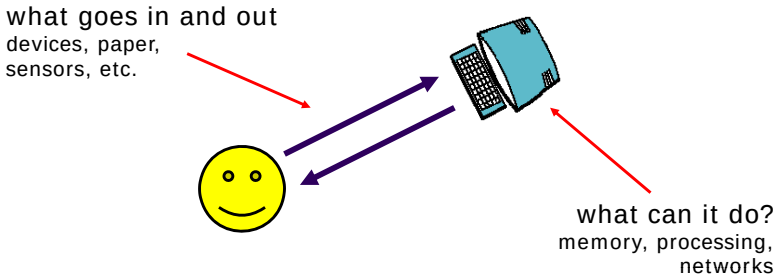
박경신

Computer

- A computer system is made up of various elements
- Input & Output
  - Input devices – text entry and pointing
  - Output devices – screen (small & large), digital paper
  - Physical interaction – e.g. sound, haptics, physiological sensing
- Memory
  - RAM & Permanent media, capacity & access
- Processing
  - Speed of processing, networks

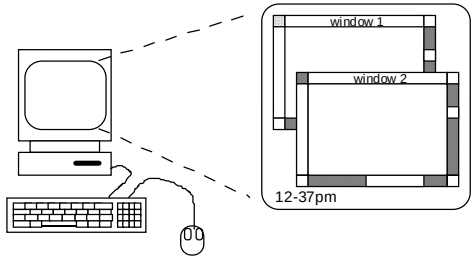
Interacting with Computers

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

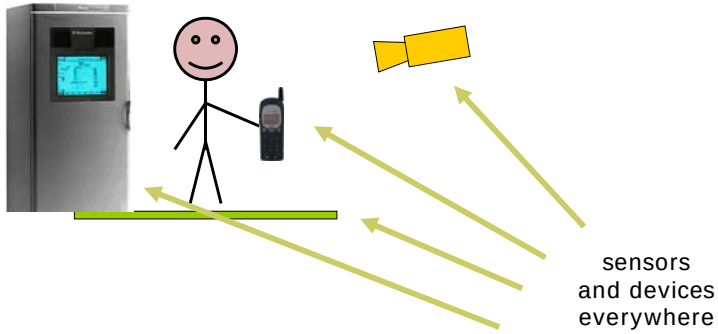
  can you think of more?
- in your pockets?
  - PDA
  - phone, camera
  - smart card, card with magnetic strip?
  - electronic car key
  - USB memory

  try your pockets and bags

Interactivity?

- No interactivity in the early age of computing
  - 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?
- Immature technologies can benefit from interactivity
  - Vision, speech recognition, ...
  - Human speech recognition is not perfect, but is usable because...
  - **human-human interaction is inherently interactive**

Richer Interaction



Text Entry Devices

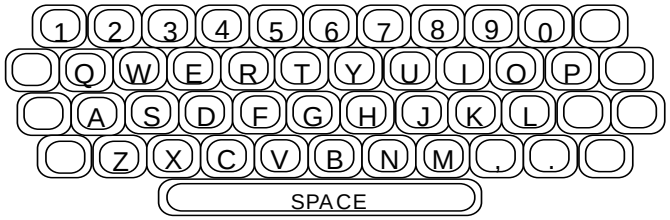
keyboards (QWERTY et al.)
chord keyboards, phone pads
handwriting, speech

Keyboards

- Most common text input device
- Allows rapid entry of text by experienced users
- Faster than writing, sometimes faster than speaking!

- Keypress closes connection, causing a character code to be sent
- Usually connected by cable, but can be wireless

QWERTY Keyboard



QWERTY Keyboard

- **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!
  - Often used in pocket electronic organizers
- **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

DVORAK Keyboard

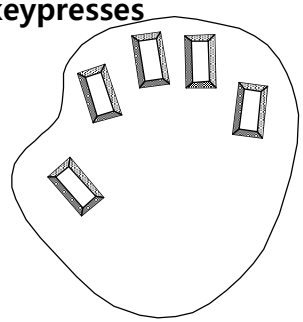
- Design objectives:
  - The majority of keystrokes should alternate between hands.
  - Place commonly used keys on the middle row.
  - Minimize keystrokes made with stretching too far.
  - Minimize keystrokes made with weak fingers.
  - 56% of keystrokes are made with the right hand
    - Probably, not an objective but a side-effect.
    - Biased towards right-handed people
- Experiments have shown a speed improvement of between 10 and 15%

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

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

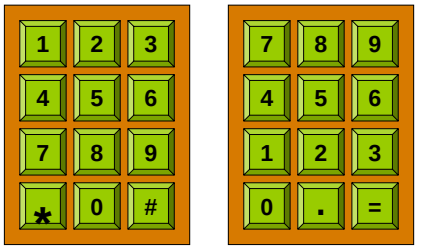
- Most successful when:
  - single user – initial training and learns peculiarities
  - limited vocabulary systems
- Problems with
  - external noise interfering
  - imprecision of pronunciation
  - large vocabularies
  - different speakers
- Recognition rate of 97% means...
  - A letter in error in every 30 letters.
  - A spelling mistake every six or so words.
- **Imagine everybody in an office is talking**
  - Noisy environment makes speech recognition even harder.
  - Unsuitable when **privacy** and **confidentiality** are important.

Numeric Keypads

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

not the same!!

ATM like phone



telephone calculator

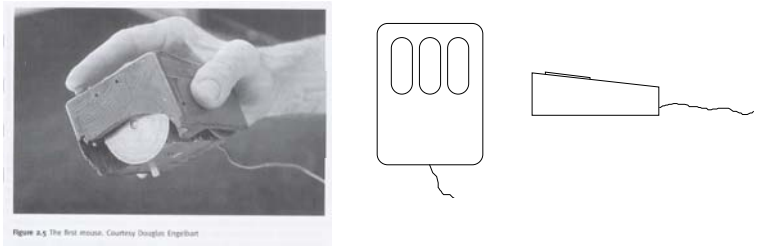
Positioning, Pointing and Drawing

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

Mouse

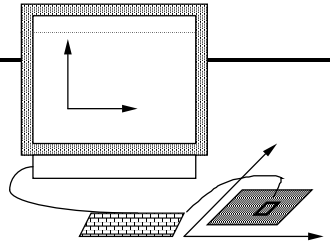
- First introduced by Douglas C. Engelbart in 1964
- **Handheld pointing device**
  - **very common**
  - **easy to use**
- Two characteristics
  - planar movement
  - buttons

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



Mouse

- Mouse located on desktop
  - requires physical space
  - no arm fatigue



- **Relative movement** only is detectable.
  - Movement of mouse (i.e., displacement, not an absolute position) moves screen cursor
  - Screen cursor oriented in (x, y) plane, mouse movement in (x, z) plane … (A mental transformation is required)
- … **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 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

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 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

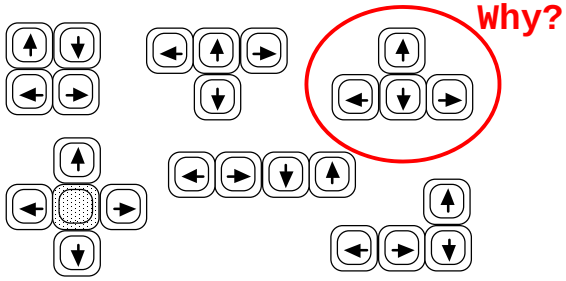
- Mouse like-device with cross hairs
- used on special surface
  - rather like stylus
- very accurate
  - used for digitizing maps

Eyegaze

- Control interface by eye gaze direction
  - e.g. look at a menu item to select it
- Many different technologies
  - Uses laser beam reflected off retina .. A very low power laser
  - OEG
  - Machine vision
- Often used for evaluation
- Potential for hands-free control
  - When do you need 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
- Many, many keys…
  - What are the advantages?
  - And disadvantages?

Display Devices

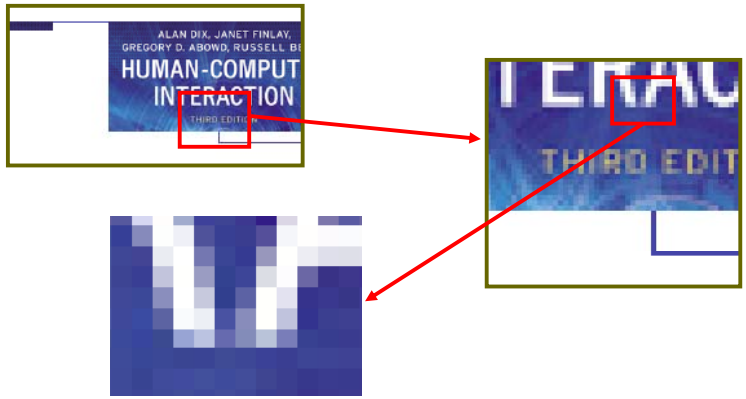
bitmap screens (CRT & LCD)

large & situated displays

digital paper

Bitmap Displays

- Screen is vast number of coloured dots

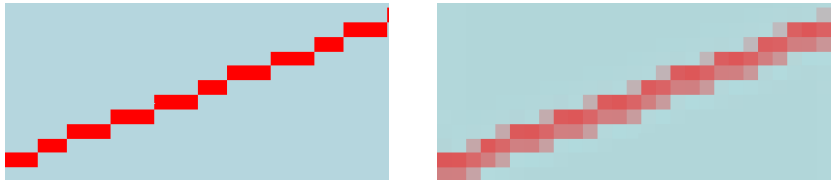


Resolution and Colour depth

- 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
  - 256 from a pallete
  - 8 bits each for red/green/blue = millions of colours

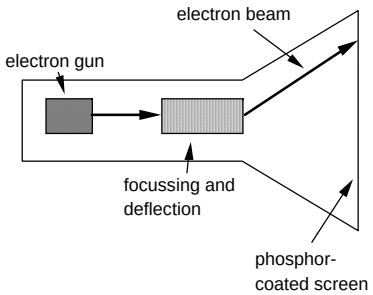
Anti-Aliasing

- 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 (CRT)

- 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

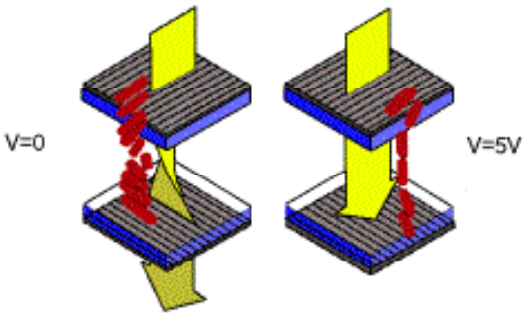
★ Take extra care if pregnant.
but also posture, ergonomics, stress

Liquid Crystal Displays (LCD)

- 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, HiFi controls
- 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

Liquid Crystal Display

- Liquid crystal
  - long polymer molecules in an orderly arrangement, but not as orderly as a crystal
  - A molecule has a polarity so that it can align to an electric field.



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

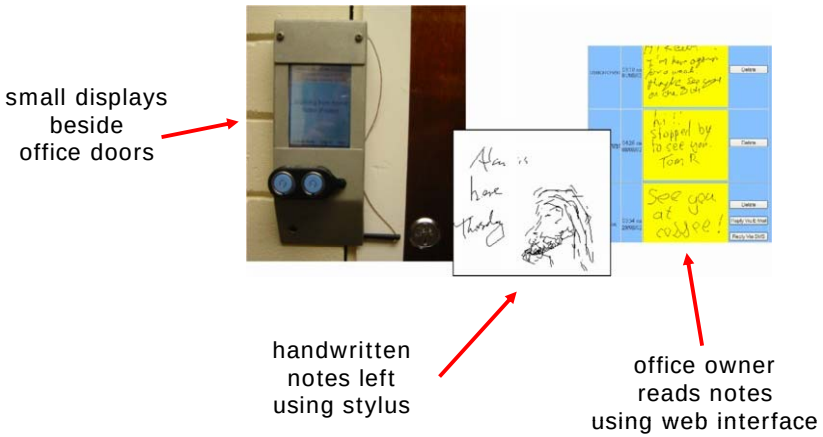
- Used for meetings, lectures, etc.
- Technology
  - Plasma – usually wide screen
  - Video walls – lots of small screens together
  - Projected– RGB lights or LCD projector
    - hand/body obscures screen
    - may be solved by 2 projectors + clever software
  - Back-projected projector
    - frosted 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
  - Display on my office door
    - If it say "available", what does this mean?
    - If it has a space for writing, what is it for?

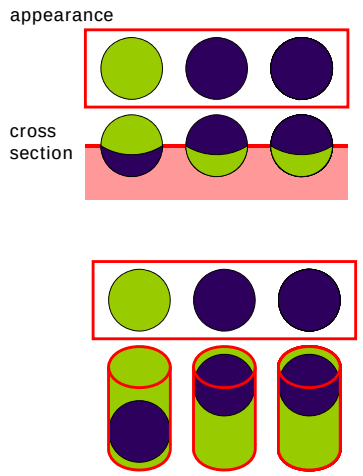
Hermes a Situated Display

- Small displays beside office doors



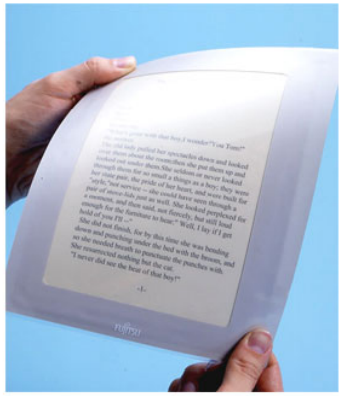
Digital Paper

- What?
  - thin flexible sheets
  - updated electronically
  - but retain display
- How?
  - small spheres turned
  - or channels with coloured liquid and contrasting spheres
  - rapidly developing area



Digital Paper from Fujitsu

Fujitsu Laboratories has succesfully made a prototype electronic paper which is comparable to regular copy paper in brightness and thickness. Fujitsu hopes to have the paper in regular production by 2006.



Several characteristics of the paper have been developed; ease of reading, ease of portability, durability and improved brightness and contrast of the paper. The new developments have made the electronic paper with a white ratio of 80 or above and a contrast ratio of 15 or above. When compared with regular photo-copy paper there is very little difference. When the power is turned on and off with colour and text being added to the paper, and then subsequently turned off, the paper still retains the material that was written on it using a built-in memory function. The power function of the electronic paper is a special energy saving device suited for this application.

The paper will be easy to use, have almost unlimited rewriting capabilities, freedom of deformation and portability. Fujitsu hopes that this invention will contribute to the paperless office and reduce the amount of paper consumption in the world.

www.mobilemag.com

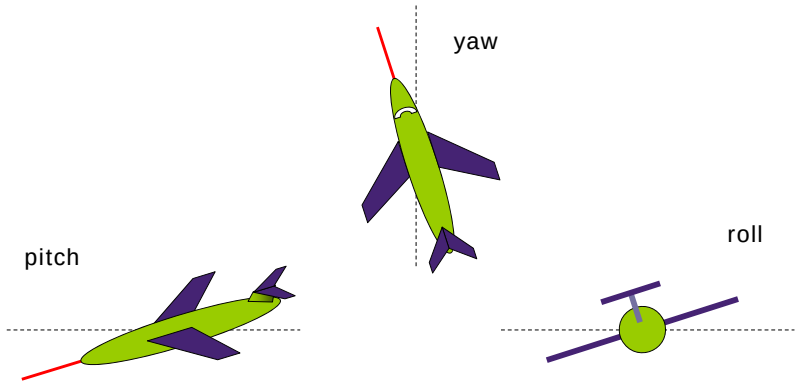
Virtual Reality and 3D Interaction

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!
- 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

Yaw, Pitch and Roll

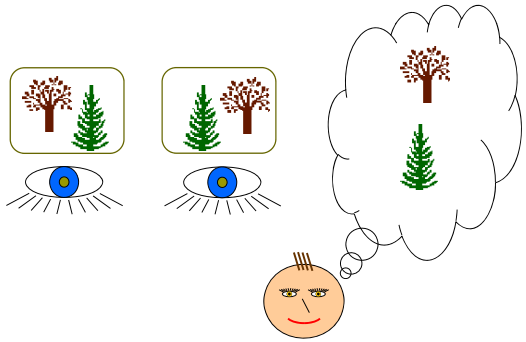


3D Displays

- 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.

VR headsets

- Small TV screen for each eye
- Slightly different angles
- 3D effect

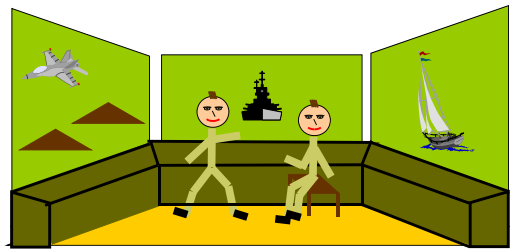


VR Motion Sickness

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

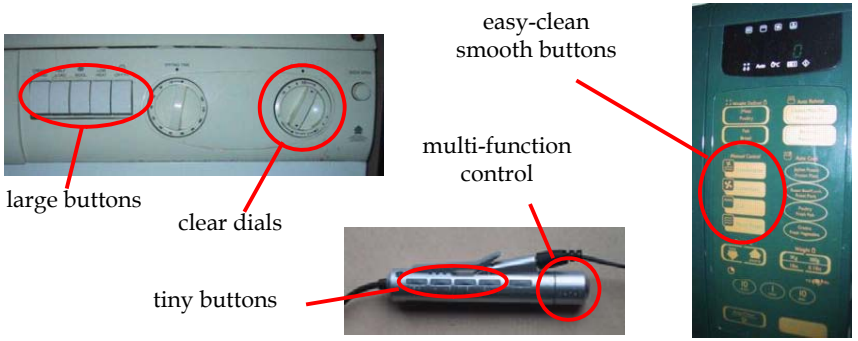
- Touch and feeling important
  - in games ... vibration, force feedback
  - in simulation ... feel of surgical instruments
  - called *haptic* devices
- Texture, smell, taste
  - current technology very limited

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.



Environment and Physiological 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

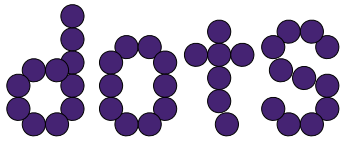
print technology

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

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

- 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

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

PostScript Example

- %!
- %% Draws a one square inch box and inch in from the bottom left
- /inch {72 mul} def % Convert inches->points (1/72 inch)
- newpath % Start a new path
- 1 inch 1 inch moveto % an inch in from the lower left
- 2 inch 1 inch lineto % bottom side
- 2 inch 2 inch lineto % right side
- 1 inch 2 inch lineto % top side
- closepath % Automatically add left side to close path
- stroke % Draw the box on the paper
- showpage % We're done... eject the page

Screen and Page

- WYSIWYG
  - what you see is what you get
  - aim of word processing, etc.
- but …
  - screen: 72 dpi, landscape image
  - print: 600+ dpi, portrait
- Can try to make them similar
  but never quite the same
- So … need different designs, graphics etc, for screen and print

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)

- 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 /WW//WWW
    - 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 ... swapping
  - 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
- Techniques
  - Run-length encoding
  - Huffman encoding
  - Predictive encoding
  - Perceptual encoding, ...
- Data is not always serial!
  - 1-D: Text, audio, ...
  - 2-D: Still image
  - 3-D: Motion picture
  - Difference methods for different dimensional data

Compression

- 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

- Character formats
  - ASCII - 7-bit binary code for to each letter and character
  - Unicode - 8-bit encoding of 16 bit character set
- Document formats
  - Rich Text Format (RTF) text plus formatting and layout information
  - Standard Generalized Markup Language (SGML) documents regarded as structured objects
  - Extended Markup Language (XML) simpler version of SGML for web applications

Storage Formats - Media

- Images
  - many storage formats :
    (PostScript, GIFF, JPEG, TIFF, PICT, BMP, RGB, 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 design

If processor is slower than is expected...

- Functional faults - Ex: Drawing a line with a mouse
  - Program detects depressing of a button, and then reads the current cursor position
  - If there is a time delay between the detection of button depression and reading of cursor position, a line will not begin at the point of button click.
  - The result does not conform to the user intention → functional faults
- Delayed feedback - Ex: Cursor tracking, icon wars, ..
  - Sometimes, a program is to busy to respond to inputs.
  - Nevertheless, the input module can receive input messages and stores them in a queue.
  - A program, now free from a busy task, starts to handle the input messages.
  - A user, without a prompt feedback, can issue the same command repeatedly, will receive an unexpected burst of delayed responses.

If processor is faster than is expected...

- Flashing feedback
  - A user need time to perceive appearing, moving, and disappearing of GUI objects
  - Ex: Game programs relying on a delay loop for timing
    - Run an old Tetris program on your PC. A shower of blocks even in level 0.
  - Ex: A new browser window of the same size and position as an existing browser window
    - It is hard to tell if the current window is showing a new page or a new browser window was created for the new page.
- One should not assume about the speed of a processor.
  - Sometimes, an intentional delay is useful in order to allow a user to be prepared and have time to perceive changes.
    - Animation is one of the most common and effective ways to provide a proper feedback to a user.

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
- All these bounds are not a serious problem for a modern PC. However, remember there are other kinds of computers, e.g., PDAs and phones.

Networked Computing

- Networks allow access to ...
  - large memory and processing
  - other people (groupware, email)
  - shared resources – esp. the web
- Networked computing means...
  - Computing resources are distributed.
  - Many users can access the same resource at the same time.
  - Channels between computing resources are not homogeneous and reliable.
  - Ideals of consistency, informative feedback and predictable response are violated.
- Issues
  - network delays – slow feedback
  - conflicts - many people update data
  - unpredictability

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

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