The Computer

A computer system is made up of various elements:

1. Input devices – text entry and pointing
2. Output devices – screen (small & large), digital paper
3. Virtual reality – special interaction and display devices
4. Physical interaction – e.g. sound, touch screen
5. Paper – as output (print) and input (scan)
6. Memory – RAM & permanent media, capacity & access
7. 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.
Interactivity?

Now most computing is interactive

- quick feedback
- the user in control (most of the time)
- doing rather than thinking ...

Is faster always better?
Richer interaction

sensors and devices everywhere
How many ...

0 computers in your house?
   0 hands up, ...
      ... none, 1, 2, 3, more!!

0 computers in your pockets?

are you thinking ...
   ... PC, laptop, PDA ??
How many computers ...

in your house?

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

in your pockets?

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

can you think of more?

try your pockets and bags
text entry devices

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

Keyboards

• Most common text input device
• Allows rapid entry of text by experienced users
• Key press 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
  - highlighted 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
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 is still high
- Used where one-handed operation is possible
Numeric keypads

- for entering numbers quickly:
  - calculator, PC keyboard
- for telephones
- not the same!! ATM like phone
Phone Pad and T9 Entry

0 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!

0 T9 predictive entry
  0 type as if single key for each letter
  0 use dictionary to ‘guess’ the right word
  0 hello = 43556 ...
  0 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
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
  0 requires physical space
  0 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.
  0 device itself doesn’t obscure screen, is accurate and fast.
  0 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 = \textit{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
- 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
Questions

- List elements of computer system?
- Example of input devices is _______
- Examples of output devices is _______
- Input devices is _______
- ____ detects the presence of finger or stylus on the screen
- Standardized layout of keyboard is ____
- ____ is a handheld pointing device
- ____ is the four keys (up, down, left, right) on keyboard
- Keyboard nipple is used in ____ (computers, laptops)
  - ____ is a small pen-like pointer to draw directly on screen
display devices

bitmap screens (CRT & LCD)
large & situated displays
digital paper
bitmap displays

The 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
Health hints ...

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

★ Take extra care if pregnant.
   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, and mobile phones
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
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.
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
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

also see chapter 10
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
- tiny buttons

- easy-clean smooth buttons
- multi-function control
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 dots

- 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

0 Font – the particular style of text

- Courier font
- Helvetica font
- Palatino font
- Times Roman font
- § ‘ ∝ ≜ ⊗ ⊔ (special symbol)

0 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
  0 fixed-pitch – every character has the same width
    e.g. Courier
  0 variable-pitched – some characters wider
    e.g. Times Roman – compare the ‘i’ and the “m”

Serif or Sans-serif
  0 sans-serif – square-ended strokes
    e.g. Helvetica
  0 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
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 (ctd)

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

0 paper usually regarded as output only
0 can be input too – OCR, scanning, etc.
0 Xerox PaperWorks
  0 glyphs – small patterns of //\//\\
  0 used to identify forms etc.
  0 used with scanner and fax to control applications
0 more recently
  0 papers micro printed - like watermarks
    0 identify which sheet and where you are
  0 special ‘pen’ can read locations
    0 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
Long-term Memory - disks

- magnetic disks
  - floppy disks store around 1.4 Mbytes

- optical disks
  - use lasers to read and sometimes write
  - more robust than magnetic media
  - CD-ROM
  - 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
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
Compression

0 reduce amount of storage required

0 lossless

0 recover exact text or image – e.g. GIF, ZIP
0 look for commonalities:
  0 text: AAAAAAAAAABBBBBBCCCCCCCC
  0 video: compare successive frames and store change

0 lossy

0 recover something like original – e.g. JPEG, MP3
0 exploit perception
  0 JPEG: lose rapid changes and some colour
  0 MP3: reduce accuracy of drowned out notes
Storage formats - text

- ASCII - 7-bit binary code for 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
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!
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

- 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
Questions

0 number of pixels on screen is called ______
0 ____ converts bitmap back to text
0 ____ takes paper and convert it into a bitmap
0 Moore’s Law
0 ____ stores some programs temporarily on disk
0 How to reduce amount of storage required?
0 Two types of compression? 1. __ 2. ___
0 the particular style of text is called _____
0 floppy disk is an example of ___ disk (magnetic, optical)
0 CD disk is an example of ___ disk (magnetic, optical)
0 Common languages for the internet?
1. ______
2. ______
3. ______