HUMAN-COMPUTER INTERACTION THIRD EDITION

chapter 1

the human

the human

- Information i/o …
  - visual, auditory, haptic, movement
- Information stored in memory
  - sensory, short-term, long-term
- Information processed and applied
  - reasoning, problem solving, skill, error
- Emotion influences human capabilities
- Each person is different

Vision

Two stages in vision

- physical reception of stimulus
- processing and interpretation of stimulus

The Eye - physical reception

- mechanism for receiving light and transforming it into electrical energy
- light reflects from objects
- images are focused upside-down on retina
- retina contains rods for low light vision and cones for colour vision
- ganglion cells (brain!) detect pattern and movement

Interpreting the signal

- Size and depth
  - visual angle indicates how much of view object occupies
    (relates to size and distance from eye)
  - visual acuity is ability to perceive detail
    (limited)
  - familiar objects perceived as constant size
    (in spite of changes in visual angle when far away)
  - cues like overlapping help perception of size and depth

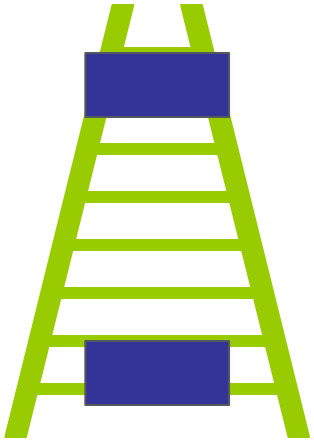
Interpreting the signal (cont)

- Brightness
  - subjective reaction to levels of light
  - affected by luminance of object
  - measured by just noticeable difference
  - visual acuity increases with luminance as does flicker
- Colour
  - made up of hue, intensity, saturation
  - cones sensitive to colour wavelengths
  - blue acuity is lowest
  - 8% males and 1% females colour blind

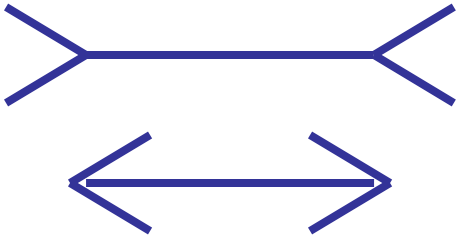
Interpreting the signal (cont)

- The visual system compensates for:
  - movement
  - changes in luminance.
- Context is used to resolve ambiguity
- Optical illusions sometimes occur due to over compensation

Optical Illusions



the Ponzo illusion



the Muller Lyer illusion

Reading

- Several stages:
  - visual pattern perceived
  - decoded using internal representation of language
  - interpreted using knowledge of syntax, semantics, pragmatics
- Reading involves saccades and fixations
- Perception occurs during fixations
- Word shape is important to recognition
- Negative contrast improves reading from computer screen

Hearing

- Provides information about environment:
  distances, directions, objects etc.
- Physical apparatus:
  - outer ear – protects inner and amplifies sound
  - middle ear – transmits sound waves as vibrations to inner ear
  - inner ear – chemical transmitters are released and cause impulses in auditory nerve
- Sound
  - pitch – sound frequency
  - loudness – amplitude
  - timbre – type or quality

Hearing (cont)

- Humans can hear frequencies from 20Hz to 15kHz
  - less accurate distinguishing high frequencies than low.
- Auditory system filters sounds
  - can attend to sounds over background noise.
  - for example, the cocktail party phenomenon.

Touch

- Provides important feedback about environment.
- May be key sense for someone who is visually impaired.
- Stimulus received via receptors in the skin:
  - thermoreceptors – heat and cold
  - nociceptors – pain
  - mechanoreceptors – pressure
    (some instant, some continuous)
- Some areas more sensitive than others e.g. fingers.
- Kinethesis - awareness of body position
  - affects comfort and performance.

Movement

- Time taken to respond to stimulus:

  reaction time + movement time

- Movement time dependent on age, fitness etc.
- Reaction time - dependent on stimulus type:
  - visual ~ 200ms
  - auditory ~ 150 ms
  - pain ~ 700ms
- Increasing reaction time decreases accuracy in the unskilled operator but not in the skilled operator.

Movement (cont)

- Fitts' Law describes the time taken to hit a screen target:

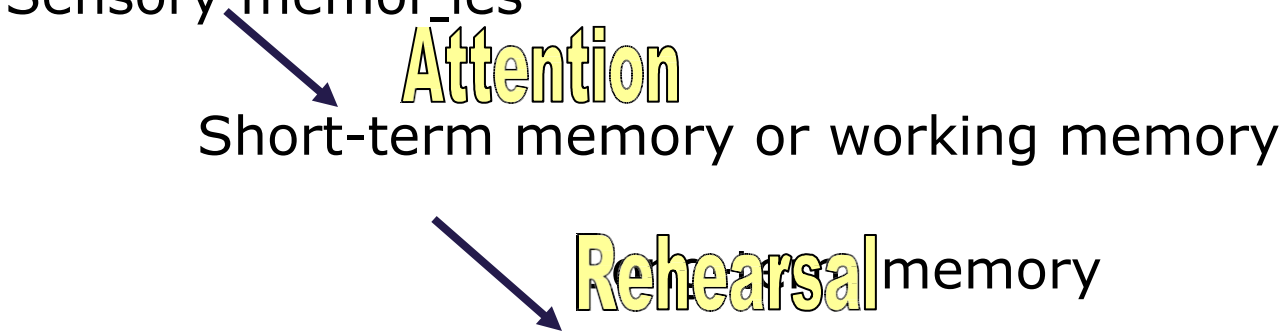
$$Mt = a + b \log_2(D/S + 1)$$

where: a and b are empirically determined constants Mt is movement time
D is Distance
S is Size of target

⇒ targets as large as possible
distances as small as possible

Memory

There are three types of memory function:



Selection of stimuli governed by level of arousal.

sensory memory

- Buffers for stimuli received through senses
  - iconic memory: visual stimuli
  - echoic memory: aural stimuli
  - haptic memory: tactile stimuli
- Examples
  - "sparkler" trail
  - stereo sound
- Continuously overwritten

Short-term memory (STM)

- Scratch-pad for temporary recall
  - rapid access ~ 70ms
  - rapid decay ~ 200ms
  - limited capacity - 7± 2 chunks

Examples

212348278493202

0121 414 2626

HEC ATR ANU PTH ETR EET

Long-term memory (LTM)

- Repository for all our knowledge
  - slow access ~ 1/10 second
  - slow decay, if any
  - huge or unlimited capacity

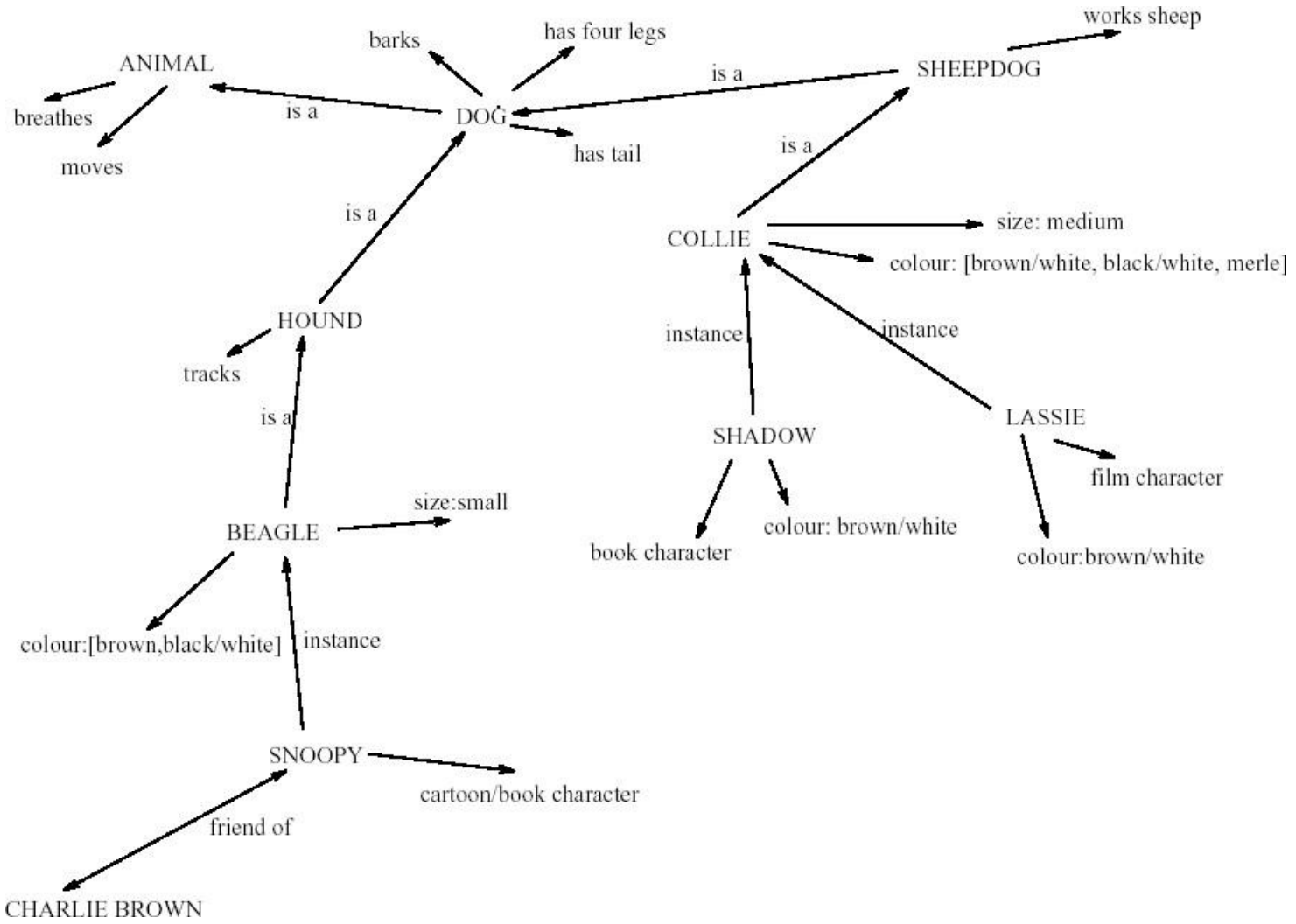
- Two types
  - episodic – serial memory of events
  - semantic – structured memory of facts,concepts, skills

  semantic LTM derived from episodic LTM

Long-term memory (cont.)

- Semantic memory structure
  - provides access to information
  - represents relationships between bits of information
  - supports inference
- Model: semantic network
  - inheritance – child nodes inherit properties of parent nodes
  - relationships between bits of information explicit
  - supports inference through inheritance

LTM - semantic network



Models of LTM - Frames

- Information organized in data structures
- Slots in structure instantiated with values for instance of data
- Type–subtype relationships

DOG

Fixed
legs: 4

Default
diet: carniverous
sound: bark

Variable
size:
colour

COLLIE

Fixed
breed of: DOG
type: sheepdog

Default
size: 65 cm

Variable
colour

Models of LTM - Scripts

Model of stereotypical information required to interpret situation

Script has elements that can be instantiated with values for context

Script for a visit to the vet

Entry conditions:	*dog ill* *vet open* *owner has money*
Result:	*dog better* *owner poorer* *vet richer*
Props:	*examination table* *medicine* *instruments*
Roles:	*vet examines* *diagnoses* *treats* *owner brings dog in* *pays* *takes dog out*
Scenes:	*arriving at reception* *waiting in room* *examination* *paying*
Tracks:	*dog needs medicine* *dog needs operation*

Models of LTM - Production rules

Representation of procedural knowledge.

Condition/action rules

if condition is matched

then use rule to determine action.

IF dog is wagging tail
THEN pat dog

IF dog is growling
THEN run away

LTM - Storage of information

- rehearsal
  - information moves from STM to LTM
- total time hypothesis
  - amount retained proportional to rehearsal time
- distribution of practice effect
  - optimized by spreading learning over time
- structure, meaning and familiarity
  - information easier to remember

LTM - Forgetting

decay

- information is lost gradually but very slowly

interference

- new information replaces old: retroactive interference
- old may interfere with new: proactive inhibition

so may not forget at all memory is selective …

… affected by emotion – can subconsciously `choose' to forget

LTM - retrieval

recall

- information reproduced from memory can be assisted by cues, e.g. categories, imagery

recognition

- information gives knowledge that it has been seen before
- less complex than recall - information is cue

Thinking

Reasoning

deduction, induction, abduction

Problem solving

Deductive Reasoning

- Deduction:
  - derive logically necessary conclusion from given premises.

    e.g. If it is Friday then she will go to work
    It is Friday
    Therefore she will go to work.

- Logical conclusion not necessarily true:

    e.g. If it is raining then the ground is dry
    It is raining
    Therefore the ground is dry

Deduction (cont.)

- When truth and logical validity clash …

  e.g. Some people are babies
  Some babies cry
  Inference - Some people cry

  Correct?

- People bring world knowledge to bear

Inductive Reasoning

- Induction:
  - generalize from cases seen to cases unseen

    e.g.all elephants we have seen have trunks
    therefore all elephants have trunks.

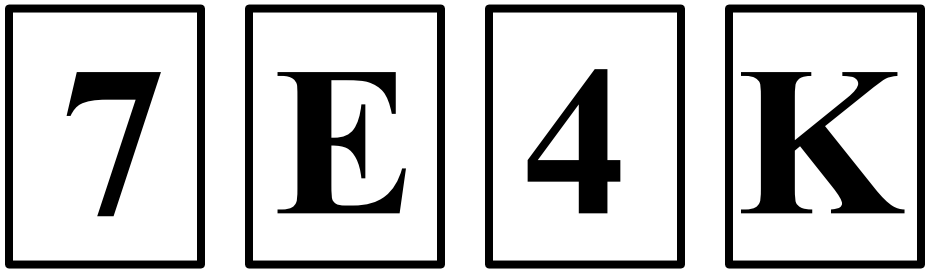
- Unreliable:
  - can only prove false not true

  … but useful!

- Humans not good at using negative evidence

  e.g. Wason's cards.

Wason's cards



If a card has a vowel on one side it has an even number on the other

Is this true?

How many cards do you need to turn over to find out?

…. and which cards?

Abductive reasoning

- reasoning from event to cause

  e.g. Sam drives fast when drunk.

  If I see Sam driving fast, assume drunk.

- Unreliable:

  – can lead to false explanations

Problem solving

- Process of finding solution to unfamiliar task using knowledge.
- Several theories.
- Gestalt
  - problem solving both productive and reproductive
  - productive draws on insight and restructuring of problem
  - attractive but not enough evidence to explain `insight' etc.
  - move away from behaviourism and led towards information processing theories

Problem solving (cont.)

Problem space theory

- problem space comprises problem states
- problem solving involves generating states using legal operators
- heuristics may be employed to select operators
  e.g. means-ends analysis
- operates within human information processing system
  e.g. STM limits etc.
- largely applied to problem solving in well-defined areas
  e.g. puzzles rather than knowledge intensive areas

Problem solving (cont.)

- Analogy
  - analogical mapping:
    - novel problems in new domain?
    - use knowledge of similar problem from similar domain
  - analogical mapping difficult if domains are semantically different
- Skill acquisition
  - skilled activity characterized by chunking
    - lot of information is chunked to optimize STM
  - conceptual rather than superficial grouping of problems
  - information is structured more effectively

Errors and mental models

Types of error

- slips
  - right intention, but failed to do it right
  - causes: poor physical skill,inattention etc.
  - change to aspect of skilled behaviour can cause slip
- mistakes
  - wrong intention
  - cause: incorrect understanding

    humans create mental models to explain behaviour.

    if wrong (different from actual system) errors can occur

Emotion

- Various theories of how emotion works
  - James-Lange: emotion is our interpretation of a physiological response to a stimuli
  - Cannon: emotion is a psychological response to a stimuli
  - Schacter-Singer: emotion is the result of our evaluation of our physiological responses, in the light of the whole situation we are in
- Emotion clearly involves both cognitive and physical responses to stimuli

Emotion (cont.)

- The biological response to physical stimuli is called *affect*

- Affect influences how we respond to situations
  - positive → creative problem solving
  - negative → narrow thinking

"Negative affect can make it harder to do even easy tasks; positive affect can make it easier to do difficult tasks"

(Donald Norman)

Emotion (cont.)

- Implications for interface design
  - stress will increase the difficulty of problem solving
  - relaxed users will be more forgiving of shortcomings in design
  - aesthetically pleasing and rewarding interfaces will increase positive affect

Individual differences

- long term
  - sex, physical and intellectual abilities
- short term
  - effect of stress or fatigue
- changing
  - age

Ask yourself:
will design decision exclude section of user population?

Psychology and the Design of Interactive System

- Some direct applications
  - e.g. blue acuity is poor

    ⇒ blue should not be used for important detail

- However, correct application generally requires understanding of context in psychology, and an understanding of particular experimental conditions

- A lot of knowledge has been distilled in
  - guidelines (chap 7)
  - cognitive models (chap 12)
  - experimental and analytic evaluation techniques (chap 9)

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chapter 2

the computer

The Computer

a computer system is made up of various elements

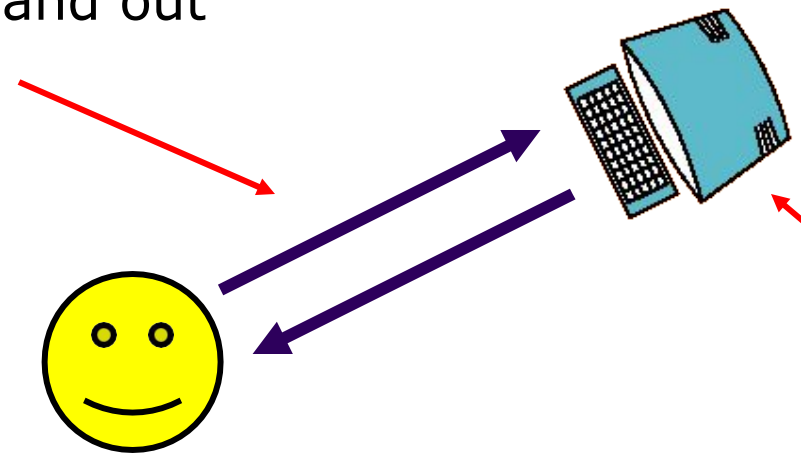
each of these elements affects the interaction

- 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.



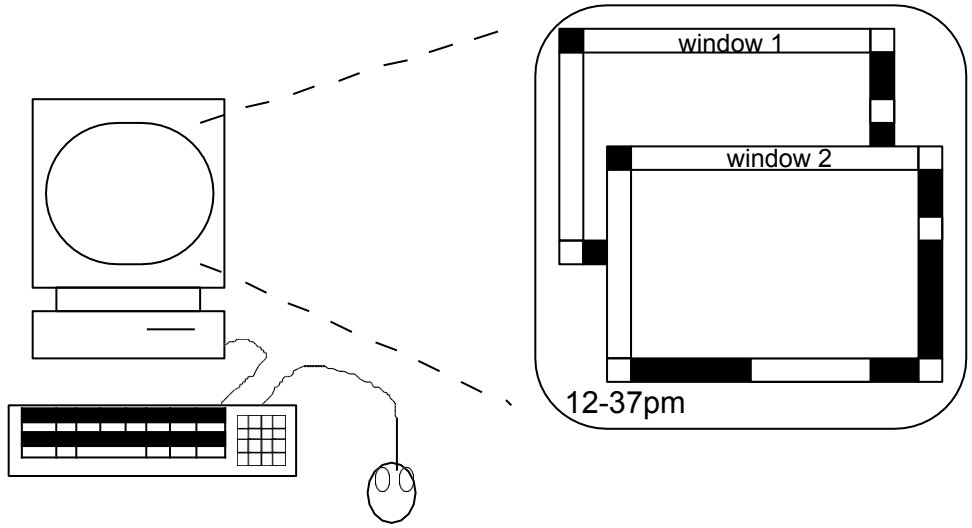
what can it do?
memory, processing,
networks

A 'typical' computer system

?

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

- variations
  - desktop
  - laptop
  - 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?

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

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

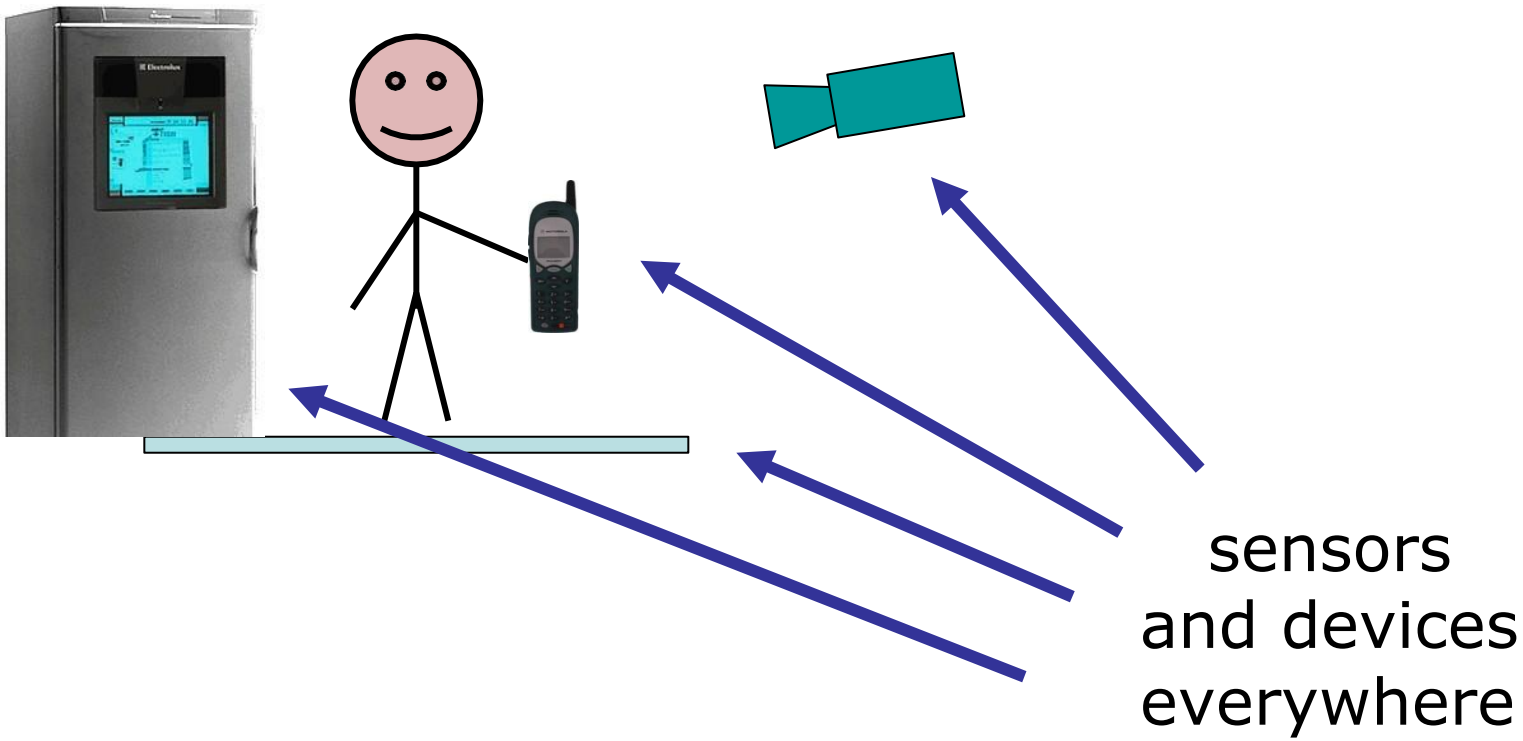
    … and if it is not right …

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

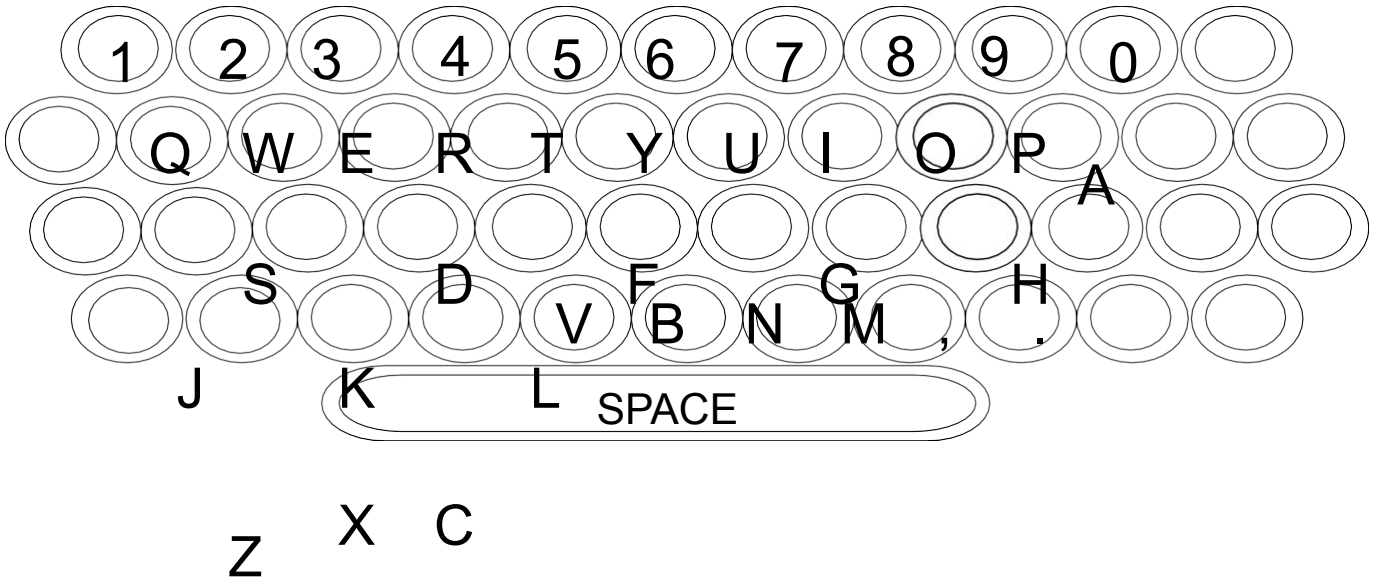
- Keypress closes connection, causing a character code to be sent
- Usually connected by cable, but can be wireless

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
- 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

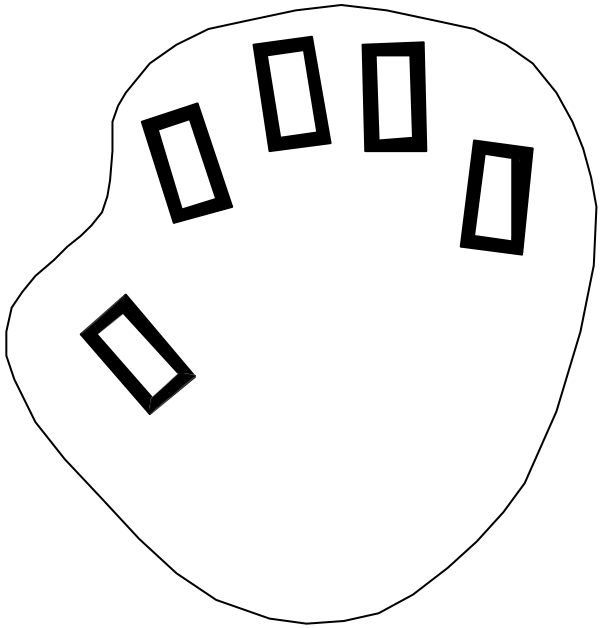
- ideal for portable applications

  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

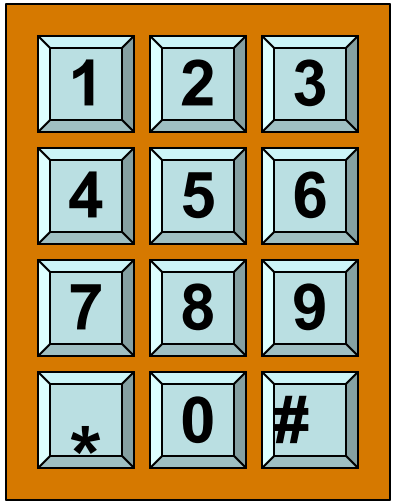
- Improving rapidly
- Most successful when:
  - single user – initial training and learns peculiarities
  - limited vocabulary systems
- Problems with
  - external noise interfering
  - imprecision of pronunciation
  - large vocabularies
  - different speakers

Numeric keypads

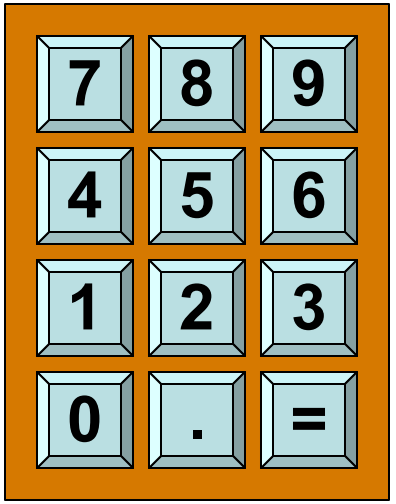
- for entering numbers quickly:
  - calculator, PC keyboard
- for telephones

not the same!!

ATM like phone



telephone



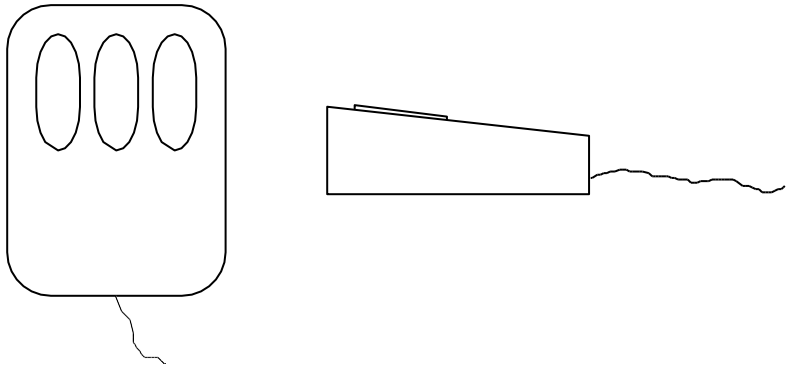
calculator

positioning, pointing and drawing

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

the Mouse

- Handheld pointing device
  - very common
  - easy to use

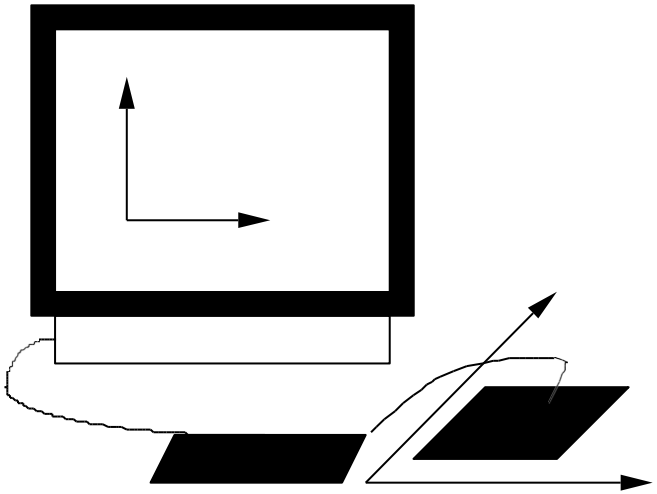


- Two characteristics
  - planar movement
  - buttons

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

the mouse (ctd)

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



Relative movement only is detectable.
Movement of mouse moves screen cursor
Screen cursor oriented in (x, y) plane,
mouse movement in (x, z) plane …

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

How does it work?

Two methods for detecting motion

- Mechanical
  - Ball on underside of mouse turns as mouse is moved
  - Rotates orthogonal potentiometers
  - Can be used on almost any flat surface
- Optical
  - light emitting diode on underside of mouse
  - may use special grid-like pad or just on desk
  - less susceptible to dust and dirt
  - detects fluctuating alterations in reflected light intensity to calculate relative motion in (x, z) plane

Even by foot …

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

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

Touchpad

- small touch sensitive tablets
- 'stroke' to move mouse pointer
- used mainly in laptop computers

- good 'acceleration' settings important
  - fast stroke
    - lots of pixels per inch moved
    - initial movement to the target
  - slow stroke
    - less pixels per inch
    - for accurate positioning

Trackball and thumbwheels

Trackball

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

Thumbwheels …

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

Joystick 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

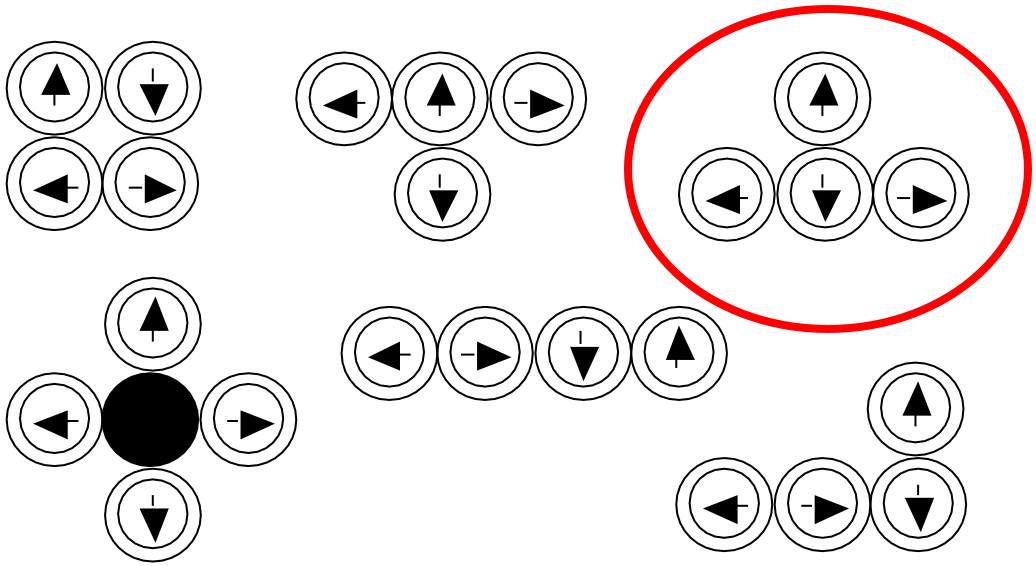
- Mouse like-device with cross hairs
- used on special surface
  - rather like stylus
- very accurate
  - used for digitizing maps

Eyegaze

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

Cursor keys

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



Discrete positioning controls

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

display devices

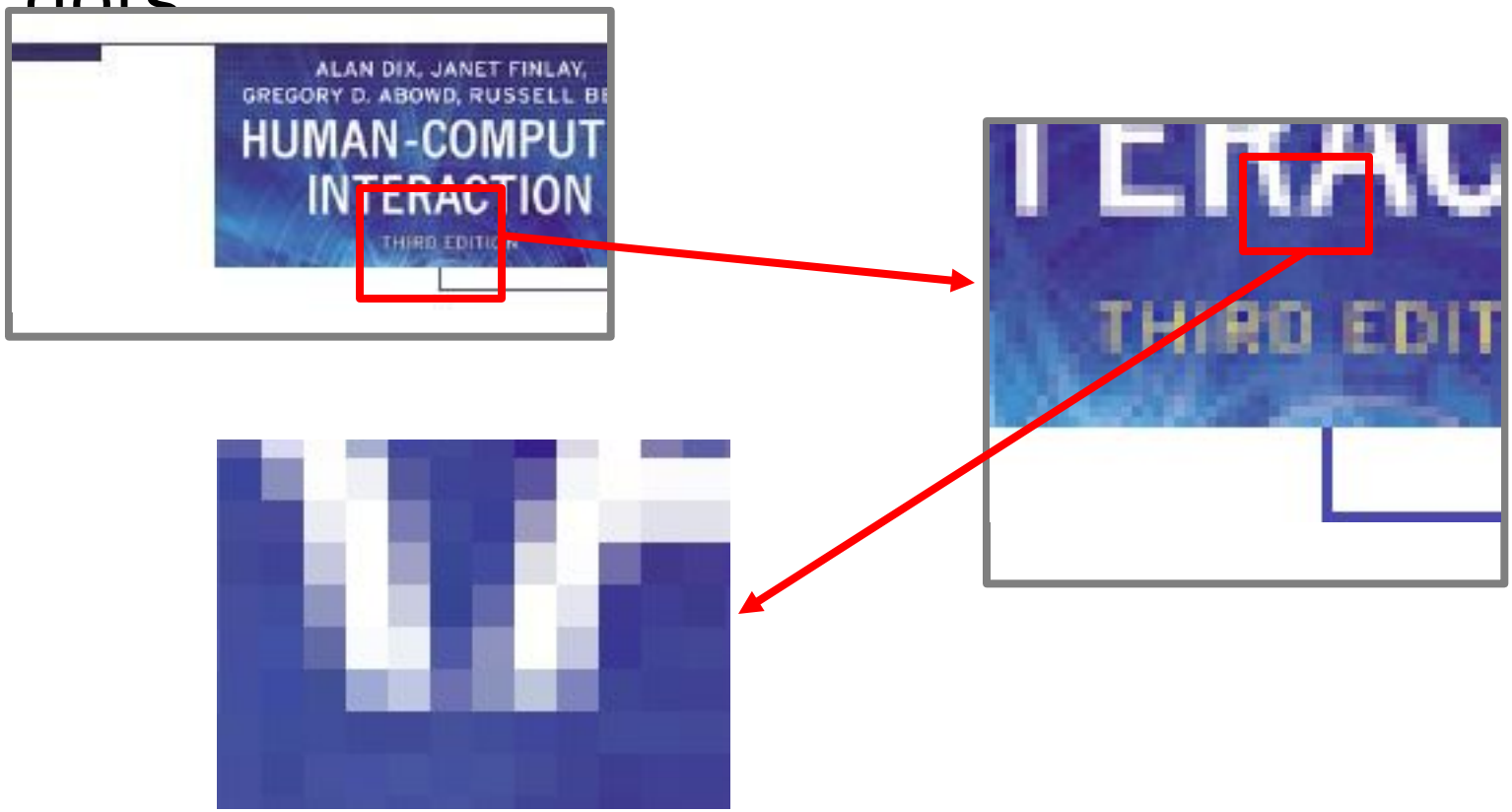
bitmap screens (CRT & LCD)

large & situated displays

digital paper

bitmap displays

- screen is vast number of coloured dots



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

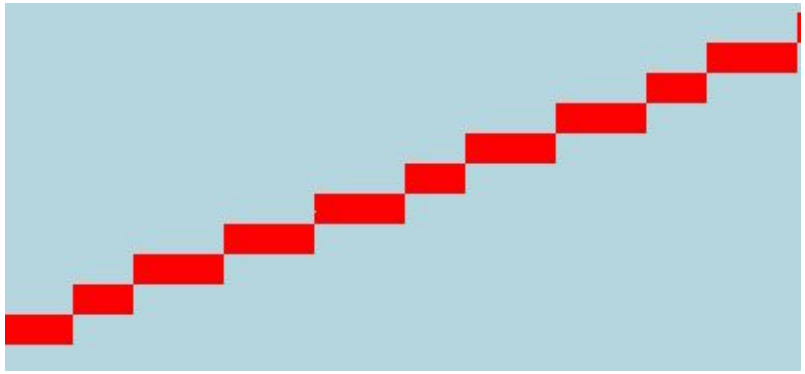
anti-aliasing

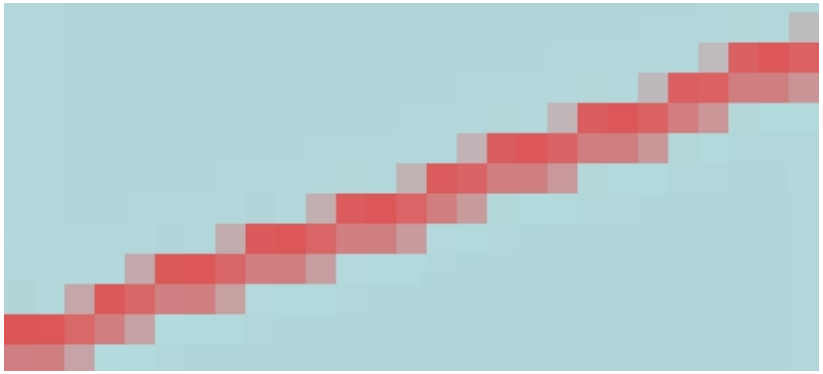
Jaggies

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

Anti-aliasing

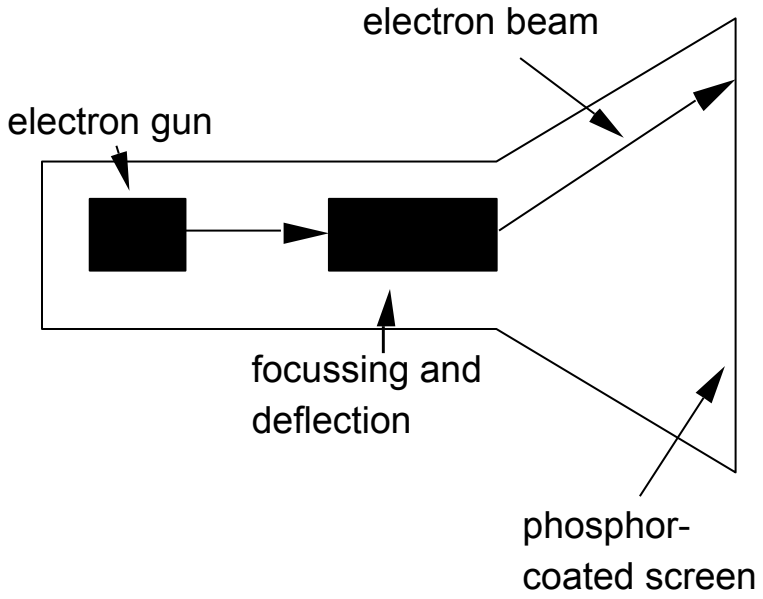
- softens edges by using shades of line colour
- also used for text





Cathode ray tube

- 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

- 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

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

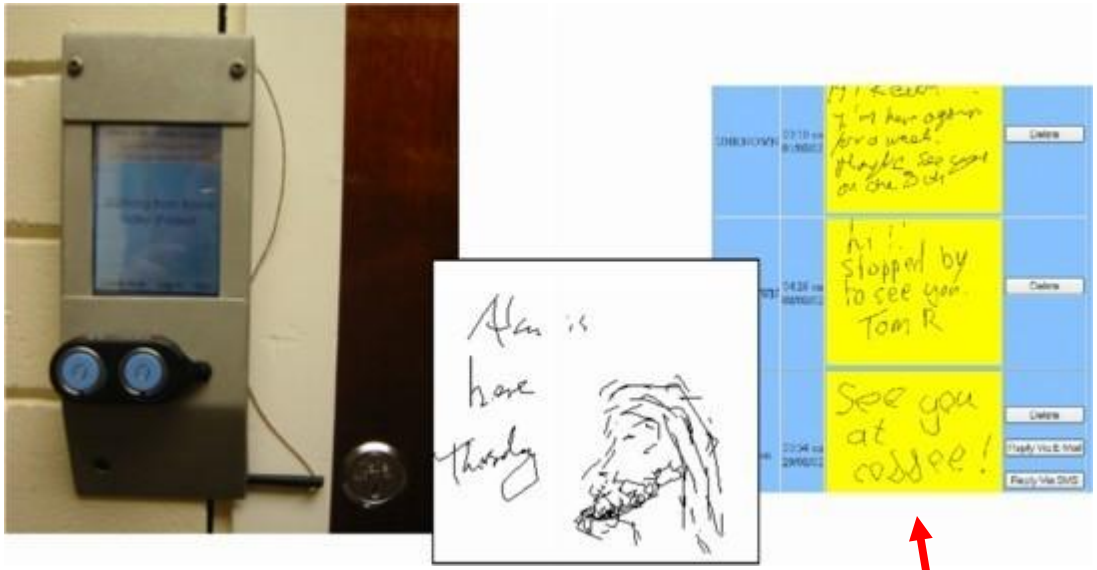
- used for meetings, lectures, etc.
- technology
  - plasma – usually wide screen
  - video walls – lots of small screens together
  - projected – RGB lights or LCD projector
    - hand/body obscures screen
    - may be solved by 2 projectors + clever software
  - back-projected
    - frosted glass +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

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 st 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

HUMAN-COMPUTER INTERACTION THIRD EDITION

chapter 3

the interaction

The Interaction

- interaction models
  - translations between user and system
- ergonomics
  - physical characteristics of interaction
- interaction styles
  - the nature of user/system dialog
- context
  - social, organizational, motivational

What is interaction?

communication

user ⟺ system

but is that all … ?

– see "language and action" in chapter 4

…

models of interaction

terms of interaction
Norman model
interaction framework

Some terms of interaction

domain – the area of work under study
e.g. graphic design

goal – what you want to achieve
e.g. create a solid red triangle

task – how you go about doing it
– ultimately in terms of operations or actions
e.g. … select fill tool, click over triangle

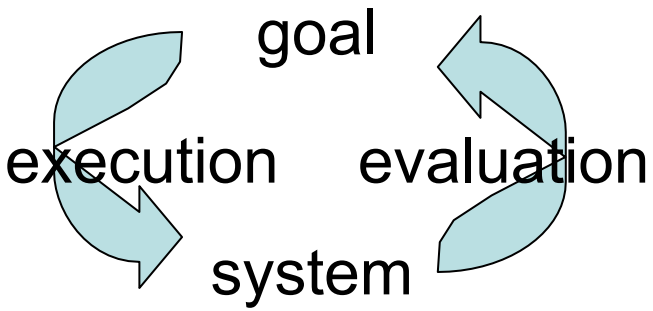
Note …
- traditional interaction …
- use of terms differs a lot especially task/goal !!!

Donald Norman's model

- Seven stages
  - user establishes the goal
  - formulates intention
  - specifies actions at interface
  - executes action
  - perceives system state
  - interprets system state
  - evaluates system state with respect to goal

- Norman's model concentrates on user's view of the interface

execution/evaluation loop



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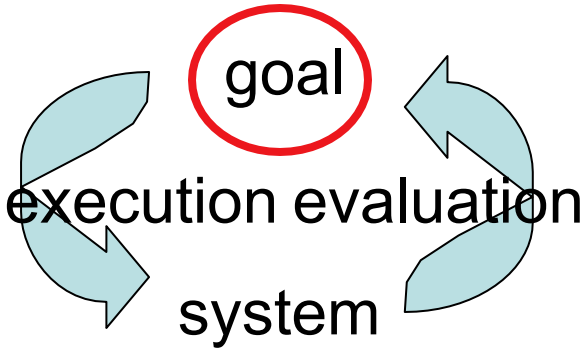

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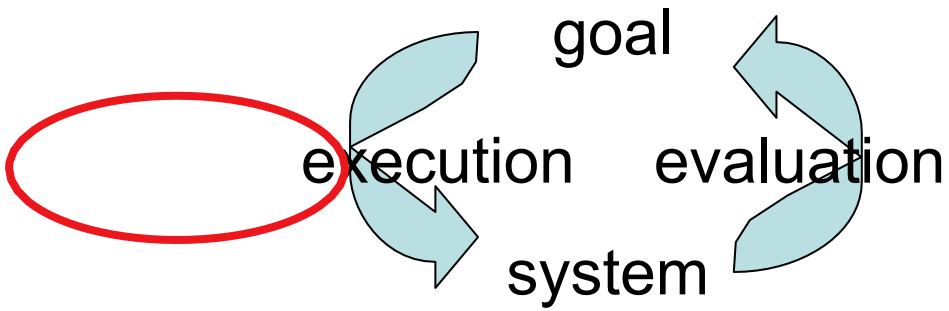

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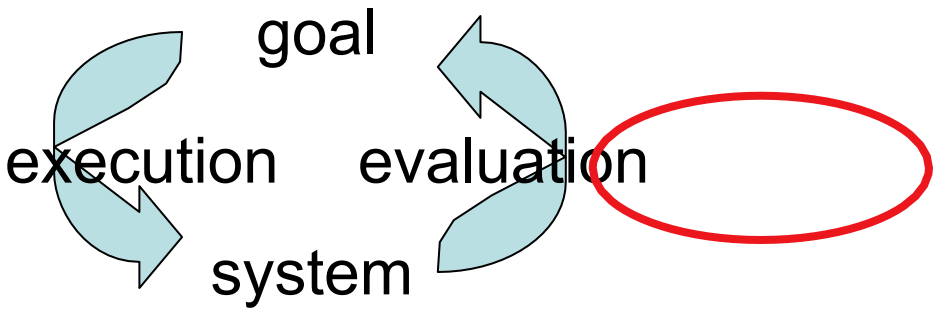

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Using Norman's model

Some systems are harder to use than others

Gulf of Execution

user's formulation of actions

≠ actions allowed by the system

Gulf of Evaluation

user's expectation of changed system state

≠ actual presentation of this state

Human error - slips and mistakes

slip

- understand system and
- goal correct formulation of
- action incorrect action

mistake

- may not even have right goal!

Fixing things?

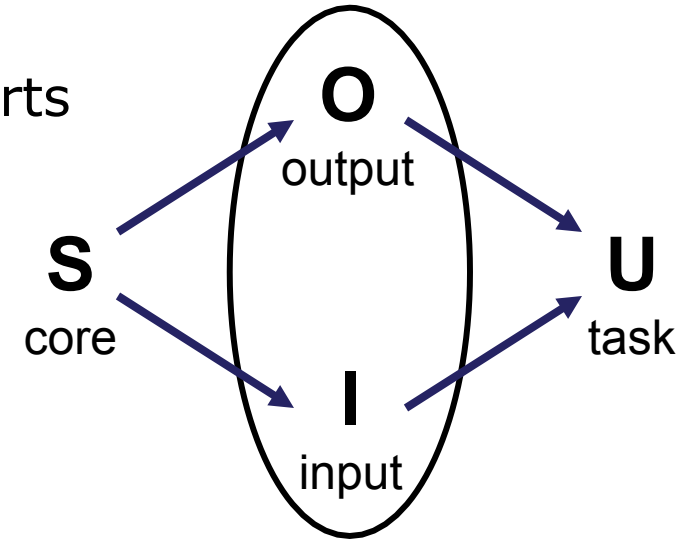
slip – better interface design

mistake – better understanding of system

Abowd and Beale framework

extension of Norman…
their interaction framework has 4 parts

- user
- input
- system
- output



each has its own unique language

interaction ⇒ translation between languages

problems in interaction = problems in translation

Using Abowd & Beale's model

user intentions

→ translated into actions at the interface

→ translated into alterations of system state

→ reflected in the output display

→ interpreted by the user

general framework for understanding interaction

- not restricted to electronic computer systems
- identifies all major components involved in interaction
- allows comparative assessment of systems
- an abstraction

ergonomics

physical aspects of

interfaces industrial

interfaces

Ergonomics

- Study of the physical characteristics of interaction
- Also known as human factors – but this can also be used to mean much of HCI!
- Ergonomics good at defining standards and guidelines for constraining the way we design certain aspects of systems

Ergonomics - examples

- arrangement of controls and displays
  - e.g. controls grouped according to function or frequency of use, or sequentially
- surrounding environment
  - e.g. seating arrangements adaptable to cope with all sizes of user
- health issues
  - e.g. physical position, environmental conditions (temperature, humidity), lighting, noise,
- use of colour
  - e.g. use of red for warning, green for okay, awareness of colour-blindness etc.

Industrial interfaces

Office interface vs. industrial interface?

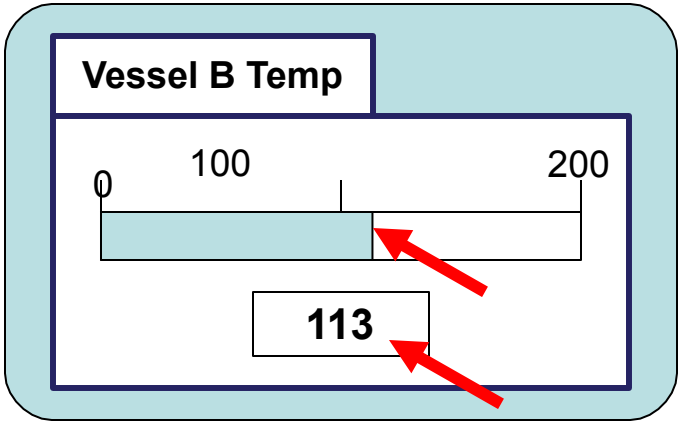
Context matters!

	office	industrial
type of data	textual	numeric
rate of change	slow	fast
environment	clean	dirty

… the oil soaked mouse!

Glass interfaces ?

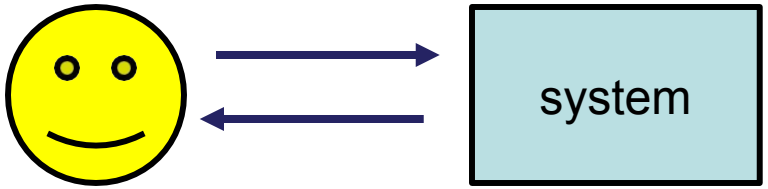
- industrial interface:
  - traditional … dials and knobs
  - now … screens and keypads
- glass interface
  - \+ cheaper, more flexible, multiple representations, precise values
  - – not physically located, loss of context, complex interfaces
- may need both

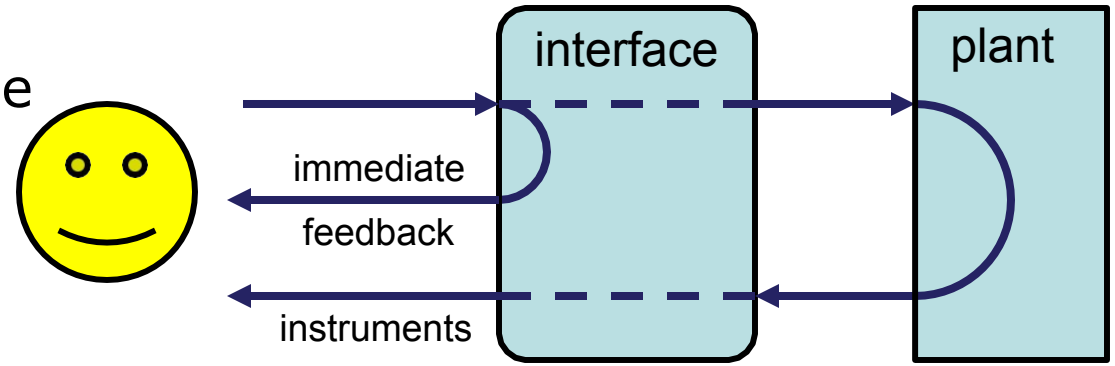


multiple representations of same information

Indirect manipulation

- office– direct manipulation
  - user interacts with artificial world
- industrial – indirect manipulation
  - user interacts *with* real world *through* interface
- issues ...
  - feedback
  - delays





interaction styles

dialogue … computer and user

distinct styles of interaction

Common interaction styles

- command line interface
- menus
- natural language
- question/answer and query dialogue
- form-fills and spreadsheets
- WIMP
- point and click
- three–dimensional interfaces

Command line interface

- Way of expressing instructions to the computer directly
  - function keys, single characters, short abbreviations, whole words, or a combination
- suitable for repetitive tasks
- better for expert users than novices
- offers direct access to system functionality
- command names/abbreviations should be meaningful!

Typical example: the Unix system

Menus

- Set of options displayed on the screen
- Options visible
  - less recall - easier to use
  - rely on recognition so names should be meaningful
- Selection by:
  - numbers, letters, arrow keys, mouse
  - combination (e.g. mouse plus accelerators)
- Often options hierarchically grouped
  - sensible grouping is needed
- Restricted form of full WIMP system

Natural language

- Familiar to user
- speech recognition or typed natural language
- Problems
  - vague
  - ambiguous
  - hard to do well!
- Solutions
  - try to understand a subset
  - pick on key words

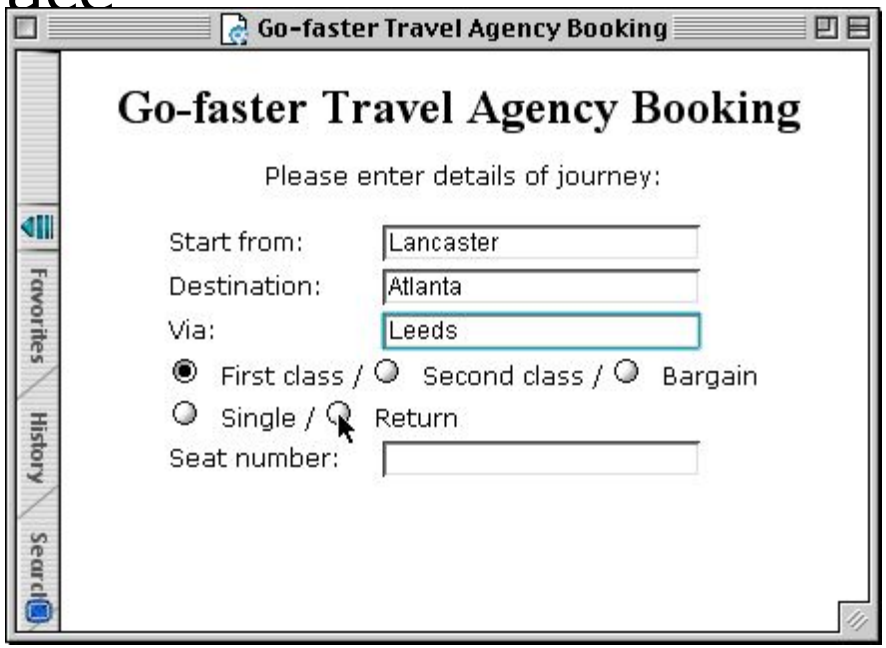
Query interfaces

- Question/answer interfaces
  - user led through interaction via series of questions
  - suitable for novice users but restricted functionality
  - often used in information systems

- Query languages (e.g. SQL)
  - used to retrieve information from database
  - requires understanding of database structure and language syntax, hence requires some expertise

Form-fills

- Primarily for data entry or data retrieval
- Screen like paper form.
- Data put in relevant place
- Requires
  - good design
  - obvious correction facilities



Spreadsheets

- first spreadsheet VISICALC, followed by Lotus 1-2-3
  MS Excel most common today
- sophisticated variation of form-filling.
  - grid of cells contain a value or a formula
  - formula can involve values of other cells
    e.g. sum of all cells in this column
  - user can enter and alter data
    spreadsheet maintains consistency

WIMP Interface

Windows

Icons

Menus

Pointers

… or windows, icons, mice, and pull-down menus!

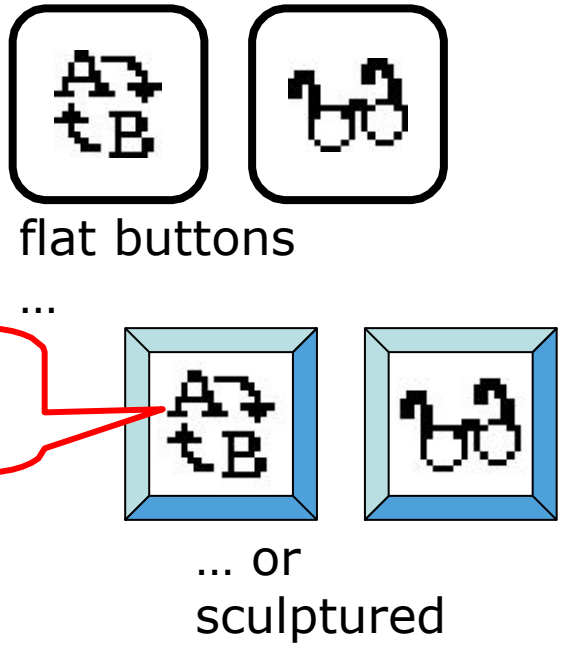
- default style for majority of interactive computer systems, especially PCs and desktop machines

Point and click interfaces

- used in ..
  - multimedia
  - web browsers
  - hypertext
- just click something!
  - icons, text links or location on map
- minimal typing

Three dimensional interfaces

- virtual reality
- 'ordinary' window systems
  - highlighting
  - visual affordance
  - indiscriminate use
- 3D workspaces
  - use for extra virtual space
  - light and occlusion give depth
  - distance effects



just confusing!

elements of the wimp interface

windows, icons, menus, pointers

+++

buttons, toolbars,
palettes, dialog boxes

also see supplementary material
on choosing wimp elements

Windows

- Areas of the screen that behave as if they were independent
  - can contain text or graphics
  - can be moved or resized
  - can overlap and obscure each other, or can be laid out next to one another (tiled)

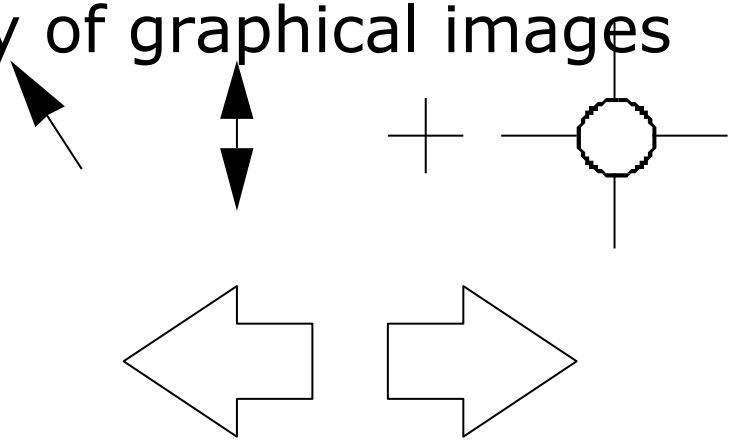
- scrollbars
  - allow the user to move the contents of the window up and down or from side to side
- title bars
  - describe the name of the window

Icons

- small picture or image
- represents some object in the interface
  - often a window or action
- windows can be closed down (iconised)
  - small representation fi many accessible windows
- icons can be many and various
  - highly stylized
  - realistic representations.

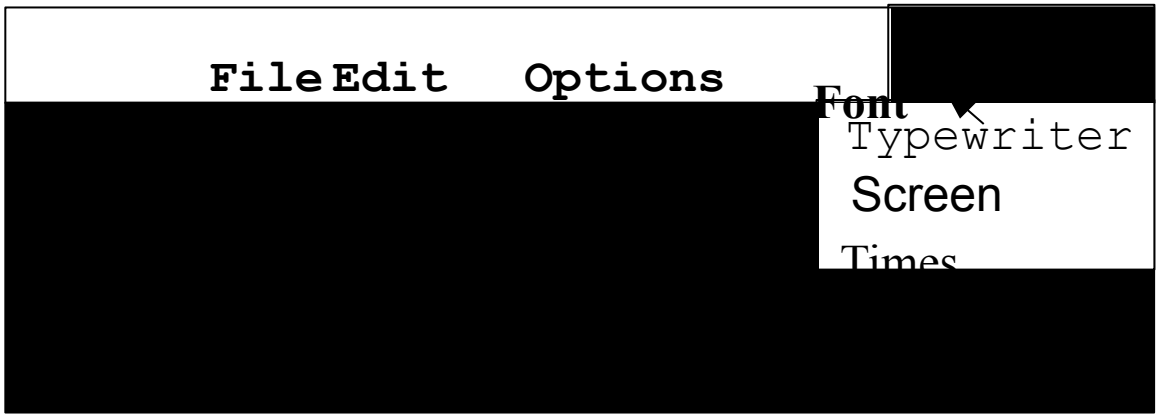
Pointers

- important component
  - WIMP style relies on pointing and selecting things
- uses mouse, trackpad, joystick, trackball, cursor keys or keyboard shortcuts
- wide variety of graphical images



Menus

- Choice of operations or services offered on the screen
- Required option selected with pointer



problem – take a lot of screen space

solution – pop-up: menu appears when needed

Kinds of Menus

- Menu Bar at top of screen (normally), menu drags down
  - pull-down menu - mouse hold and drag down menu
  - drop-down menu - mouse click reveals menu
  - fall-down menus - mouse just moves over bar!
- Contextual menu appears where you are
  - pop-up menus - actions for selected object
  - pie menus - arranged in a circle
    - easier to select item (larger target area)
    - quicker (same distance to any option)

    …but not widely used!

Menus extras

- Cascading menus
  - hierarchical menu structure
  - menu selection opens new menu
  - and so in ad infinitum
- Keyboard accelerators
  - key combinations - same effect as menu item
  - two kinds
    - active when menu open – usually first letter
    - active when menu closed – usually Ctrl + letter

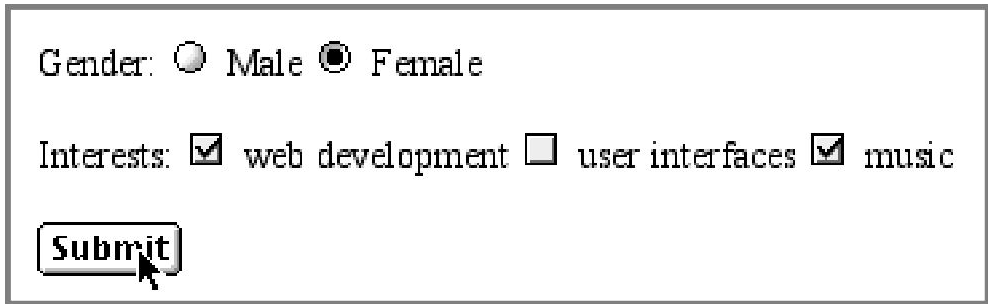
    usually different !!!

Menus design issues

- which kind to use
- what to include in menus at all
- words to use (action or description)
- how to group items
- choice of keyboard accelerators

Buttons

- individual and isolated regions within a display that can be selected to invoke an action



- Special kinds
  - radio buttons
    - set of mutually exclusive choices
  - check boxes
    - set of non-exclusive choices

Toolbars

- long lines of icons …
  … but what do they do?
- fast access to common actions
- often customizable:
  - choose *which* toolbars to see
  - choose *what* options are on it

Palettes and tear-off menus

- Problem
  menu not there when you want it

- Solution
  palettes – little windows of actions
  - shown/hidden via menu option
    e.g. available shapes in drawing package

  tear-off and pin-up menus
  - menu 'tears off' to become palette

Dialogue boxes

- information windows that pop up to inform of an important event or request information.

e.g: when saving a file, a dialogue box is displayed to allow the user to specify the filename and location. Once the file is saved, the box disappears.

interactivity

easy to focus on look

what about feel?

Speech-driven interfaces

- rapidly improving …
  … but still inaccurate
- how to have robust dialogue?
  … interaction of course!

e.g. airline reservation:
reliable "yes" and
"no"
+ system reflects back its understanding
"you want a ticket from New York to Boston?"

Look and … feel

- WIMP systems have the same elements:

  windows, icons., menus, pointers, buttons, etc.

- but different window systems

  … *behave* differently

  e.g. MacOS vs Windows menus

appearance + behaviour= look and feel

Initiative

- who has the initiative?
  - old question–answer – computer
  - WIMP interface – user
- WIMP exceptions …
  - *pre-emptive* parts of the interface
- modal dialog boxes
  - come and won't go away!
  - good for errors, essential steps
  - but use with care

Error and repair

can't always avoid errors …
… but we can put them right

make it easy to *detect* errors
… then the user can *repair* them

hello, this is the Go Faster booking system
what would you like?
(user) *I want to fly from New York to London*
you want a ticket from New York to Boston
(user) *no*
sorry, please confirm one at a time
do you want to fly from New York
(user) yes
… … …

Context

Interaction affected by social and organizational context

- other people
  - desire to impress, competition, fear of failure
- motivation
  - fear, allegiance, ambition, self-satisfaction
- inadequate systems
  - cause frustration and lack of motivation

General lesson …

if you want someone to do something …

- make it easy for them!
- understand their values