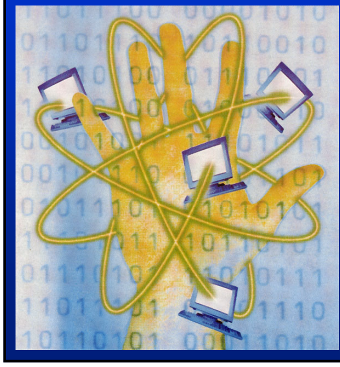
HUMAN-COMPUTER INTERFACE DESIGN

University of Essex



Course EE212 / CE653

Part 1, Section 1

Background and Human Capabilities

Computing & Electronic Systems

Autumn 2008

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and Edward Tsang

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HUMAN-COMPUTER INTERFACE DESIGN - is GUI design still important ?

- Surely GUI design is a mature subject, with little left to do ?
  - GUI has been used in computer operating systems for over 20 years
- But complexity of GUI-using products has increased
  - adding many new features and functions to control
- And number of GUI-using products has *greatly* increased
  - few new electronic products rely on switches, buttons and knobs
  - … most use some kind of graphical display
  - products with buttons are moving towards complex GUI - eg. iPhone
- For obile phones …
  - GUI design has *major* role in keeping their mobile phones competitive

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Human – Task – Machine

Machines were expensive
Labour was cheap
Human worked harder

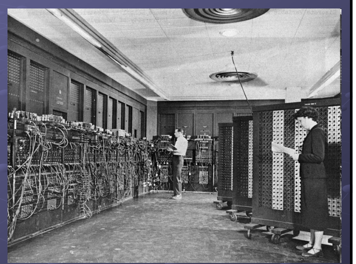
→

Machines are cheap
Labour is expensive
Machines work harder

- Evolution of HCI
  - From labour-intensive to processors-intensive
  - New hardware needs new HCI designs

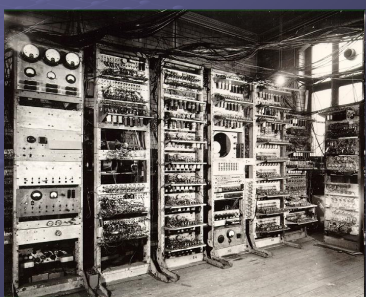
HCI History

- ENIAC (Electronic Numerical Integrator and Computer)
- About 80 bytes
- 1943-45 USA
- 30 tons



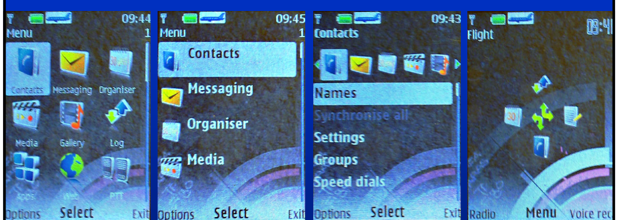
Manchester Mark 1

- 1949 UK
- Von Neumann machine



NOKIA-5300 MOBILE TELEPHONE GUI - some subtle aspects …

- Mobile phones now have customisable interfaces
  - you can interact with how you want to interact with the phone …



square grid of named icons | vertical list of icon-prefixed names | horizontal list of scrolling icons with vertical list of names | square grid of nominated icons, activated by one 5-way button

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iPhone

PDAs

Principles of HCI

- Useful
  - Do what is required
- Usable
  - Do it easily, naturally, minimize error
- Used
  - Attractive, engaging, fun to use

HCI for Error Prevention

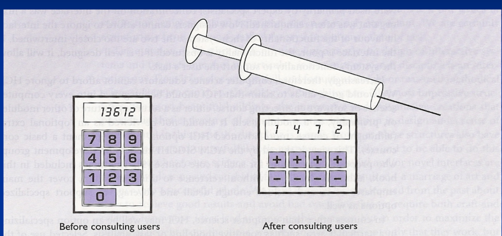

Figure 0.1 Automatic syringe: setting the dose to 1372. The effect of one key slip before and after user involvement

- Source: A. Dix et al, Human Computer Interaction, 3rd Edition, Pearson Education Ltd. 2004, p.8

HCI – Science or Craft?

- No unified or general theory
- Many practices could be discussed
- Lessons can be learned from case studies
- Tsang's view: more craft than science
- New hardware demands new HCI design
  - E.g. mobile phones, wearable hardware

HUMAN-COMPUTER INTERFACE DESIGN - academic fields

- Human-computer interface (HCI) design is a surprisingly large and multi-disciplinary subject :
  - electronic engineering
  - computer science
  - psychology - understanding human capabilities and needs
  - sociology - how human-computer systems affect structure of society
  - ergonomics - physical aspects of matching people to machines
  - graphic design and typography - artistic aspects and visual appeal
  - linguistics - the study of language, including text as well as speech
  - anthropology - science of humankind : team work, gender, birthplace

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HUMAN-COMPUTER INTERFACE DESIGN - nature of the field

- An ‘open’ kind of field of study - can seem paradoxical
  - focus on mechanistic details, within small parts of an entire system
  - field is far from complete - new knowledge is still being added
  - new technology - can change design decisions unexpectedly (SMS)
- For practical applications this means :
  - one person is unlikely to know, or to do, it all
  - need for multi-person, multi-discipline teams, with good cooperation
- Specialist team members
  - but each team member needs to be aware of the whole field of study

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HUMAN-COMPUTER INTERFACE DESIGN - level of knowledge

- ‘Awareness’ kind of knowledge
  - ‘awareness’ is required for all engineers and computer scientists
  - this is what course EE212 / CE653 is meant to provide -
    - get sufficient knowledge for simple kinds of design work
    - know the contributions that experts in other fields can make
    - be aware of pointers to where to get more detailed knowledge
- Study, in more detail, one important part of a large field
  - by practical experience of graphical user interface (GUI) design -
    - using ‘Python’ software in PC-based environment

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COURSE EE212 / CE653 - objectives

- Identify and define
  - physiological and psychological capabilities and limitations of humans
    - when operating *interactive* computer systems
- Study
  - examples of design and their suitability for various types of user,
    - based on different *styles* of interactive dialogue
- Understand
  - ‘Python’ scripting language, as a rapid prototyping environment
  - the methods for evaluating the performance of an interface design,
    - using sound experimental and statistical methods
- Analyse
  - working examples of graphical user interfaces,
    - using the ‘Python’ scripting language

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COURSE EE212 / CE653 - outline contents

- Processes in engineering design
- Human capabilities and limitations
- Dialogue styles and design guidelines, in GUI applications
- Ways of evaluating interface performance
- Features of the ‘Python’ prototyping language
- Some GUI software examples
- Assignment, based on working GUI implementation

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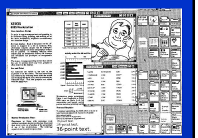
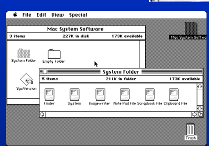
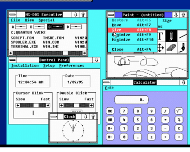
GRAPHICAL USER INTERFACING - some history



- Early development
  - Xerox Research at Palo Alto
    - ‘Star’ desktop in 1981
  - complex and powerful for its era



- Macintosh
  - Mac 128 in 1984 : System 1
  - simple but succesful



- Microsoft Windows
  - Windows 2.0 in 1987
  - colourful but crude

http://en.wikipedia.org/wiki/History_of_the_graphical_user_interface

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GRAPHICAL USER INTERFACES - what has changed in 20 years ?

- More features and functions
  - especially for networking and audio-visual display
- Pre-emptive multi-tasking and multi-threading
  - for seemingly simultaneous tasks
- Eye candy
  - colour, shadow and soft edges
- Little *fundamental* change
  - to basic mechanisms of interaction
- But there is more to come …
  - wearable displays, 3-D interaction

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ENGINEERING DESIGN IN HCI - assumptions

- Most computer engineering systems are *tools*
  - so the design aim is to optimise the performance of entire system,
    - human and machine, including how different parts interact
  - optimising the machine-part alone likely to work only for simple systems
- How to evaluate performance ?
  - by long-term feedback from the users …
    - this is impractical in many systems, due to short product lifetimes
  - therefore must revise the design method to include user test input
- 'onion-skin' structure in commonly-used design approach
  - at least three layers -
    - awareness level, based on basic design guidelines
    - practitioner level, based on detailed design strategies
    - specialist level, based on expertise in specific, narrow fields

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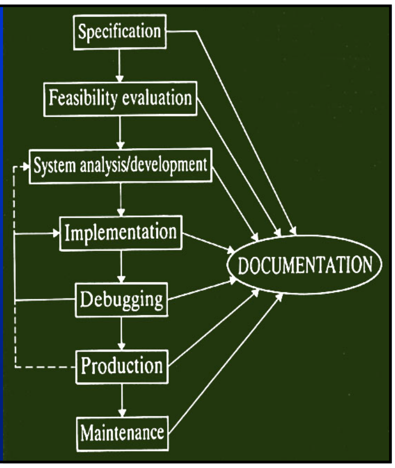
ENGINEERING DESIGN - the sequence of processes common to most kinds of engineering



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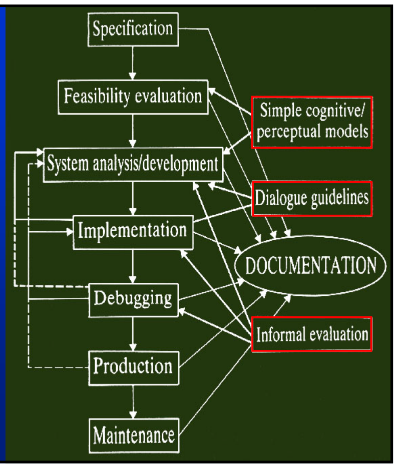
ENGINEERING DESIGN - a sequence of processes with some added awareness of HCI issues



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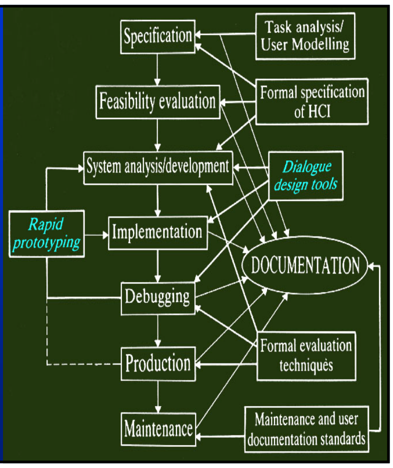
ENGINEERING DESIGN - a sequence of processes with added HCI practitioners and specialists



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HCI IN ENGINEERING DESIGN - attitudes and preconceptions

- The common view ? (in the UK but *not* the USA)
  - 'HCI is too hard, intangible and too poorly understood'
  - 'computer software is easier, tangible and well understood'
  - risks the danger of designing poor or unpopular products and services
- The 'sequence of processes' diagrams
  - probably look complicated now …
  - try returning to them in the middle and near the end of this course -
  - map your changing activity with 'Python' into the matching process boxes
- The right view
  - "stop bending people around technology and start bending technology around people" - Peter Cochrane, BT Research Labs

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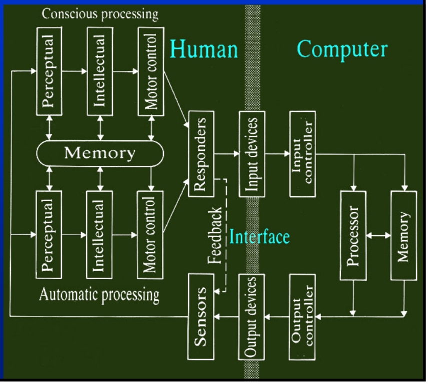
HCI DESIGN
- the entire system is engineering *plus* human

- Commonly, the design focus is on the engineering
- But human senses and cognition (thought processes) matter just as much



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USING HCI IN ENGINEERING DESIGN
- summary of stages

- Understand human characteristics
  sensory, perceptual, cognitive and motor skills
- Use design guidelines
  simple and based on previous best practice of others
- Informal evaluations and rapid prototyping
  to test and assess performance, early in the design cycle
- User modelling and (maybe) task analysis
  more complex and formal, needs specialist knowledge
- Formal evaluation and statistical methods
  ensuring that it works well and to capture user feedback
- Documentation
  if the user doesn't need a manual, then maintenance will …

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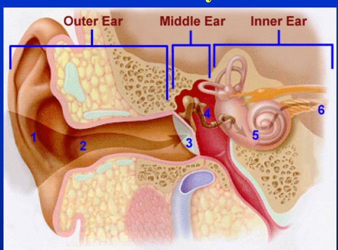
HUMAN HEARING
- delicate anatomy of the ear



1 pinna - involved with the perception of sound direction
2 ear canal - gives protection from impact
3 eardrum - converts sound to mechanical vibrations
4 ossicles - three tiny bones, smallest in the body
5 cochlea - fluid filled, converts mechanical vibrations to nerve signals
6 nerve fibres - signal connection to the brain

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HUMAN HEARING
- characteristics

- Hear sounds from 20Hz to 20,000 Hz when young
  upper limit decreases with age and with exposure to loud sounds
- Human hearing is non-linear, in ear and brain processing
  ('non-linear' means an effect is not proportional to its stimulus)
  sensitivity decreases in a noisy room and recovers in a quiet room
  you recognise your name in a noisy room better than other words
- The human sensation of the loudness of a sound is :
  NOT proportional to sound power
  NOT constant at different frequencies with the same power
- The ear-brain combination :
  is NOT a biological kind of microphone
  It IS designed to detect certain kinds of features, and ignore others

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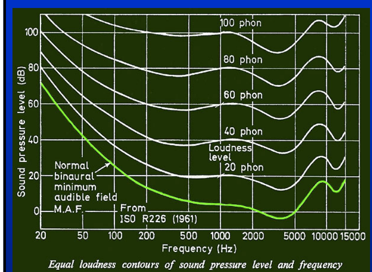
HUMAN HEARING
- Fletcher-Munson equal-loudness contours



- Sound Pressure Level
  dB re 2 x10^{-5} Pa
  0 dB SPL = 1x10^{-12} W/m^2
  power intercepted by ear = 0.1 femtowatt at the minimum audible 2 kHz tone
- 120 dB SPL
  is approx. threshold of short-term hearing damage
- Dynamic range
  of sound power in hearing is ≈ 10^{12} (1 million million)
- Loudness perception is approximately logarithmic
  +10 dB roughly doubles loudness, which means ten times the power
  $2^{(120/10)}$ ≈ 4,000:1 is subjective range

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HUMAN HEARING
- example of impact on HCI design

- A system might use audio alerts for alarms -
  suppose that two kinds of alarm are needed
  the second alarm is specified as twice as loud, to the user, as the first
- What design decision should be made ?
  a) the alarm signal power should be doubled (+3dB)
  b) the alarm signal amplitude should be doubled (+6dB)
  c) the alarm signal frequency should be doubled
- +10 dB change in power is needed
  ten times the sound power
- That 's why acoustic musicians don't like playing loudly
  it's hard work producing all that extra power …

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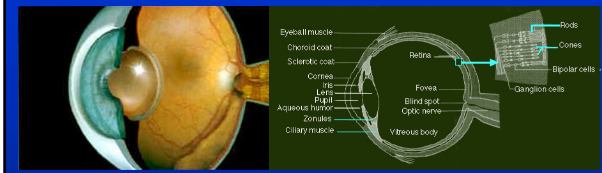
HUMAN VISION
- not what it seems ?



- Delicately complex structure, and a non-linear sensor
  - retina built backwards, photoreceptors under blood vessels and nerves
  - 100 million rods (achromatic), over 3 million cones (colour-sensitive)
  - best resolution approx. 0.3 mm at I metre, or 60 seconds of arc
  - vision information bandwidth approx. 800 Mbit/s at the photoreceptors
  - brain constructs the subjective equivalent of a 68 Megapixel picture
  - angle of attention ‘cognitively variable’ from > 160 to < 1.5 degrees

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HUMAN VISION
- characteristics

- Resolution of the eye :
  - at its best only over a very small area around the ‘look direction’
  - decreases dramatically away from this axis, as does colour sensitivity
- Sensitivity of the eye :
  - varies dramatically with average light level, using three mechanisms -
    - by contraction or expansion of iris (fast-action but limited range)
    - by light-dependent chemical changes in the retina (slow-acting)
    - by brain feedback to the rod and cone cells
- Stereoscopic (depth-sensing) vision :
  - only possible within a cone about 15˚ wide, around straight-ahead
- Colour vision :
  - about 8% of males and 1% of females have a defect in seeing colours

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HUMAN VISION
- example of impact on HCI design

- A system might use a video display for human interaction -
  - suppose that a great amount of information has to be presented
  - but only a few small items are important at any one time …
- Good design decisions will ensure that :
  - minimum object size is 15 minutes of arc (4.3mm at 1 metre distance)
  - in dim light, minimum size should be greater - about 21 minutes of arc
  - important information should be placed within 15˚ of straight-ahead
- The use of colour :
  - should allow for the effects of common defects in colour vision

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HUMAN SENSES
- visual processing

- Processing in the brain -
  - seem optimised for the recognition of three-dimensional objects
    - this is why two-dimensional photographs can appear realistic
  - edges are much more significant to our brains than are surfaces
  - relatively little is known about the detailed brain mechanisms involved
- Cinema & TV
  - exploit the characteristics and limitations of the human visual system
- Visual effects and optical illusions :
  - all rely on the non-linear characteristics of the eye-brain combination,
    - exploiting both physical and cognitive (brain-based) effects
- The eye is NOT a biological kind of camera

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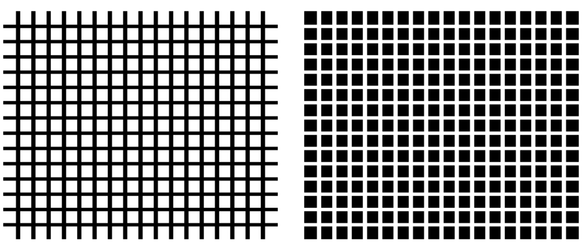
VISUAL ILLUSIONS
- Hermann grids



- Stare fixedly at any intersection of black, or white, lines
- Are there ‘ghostly’ grey areas at the other intersections ?

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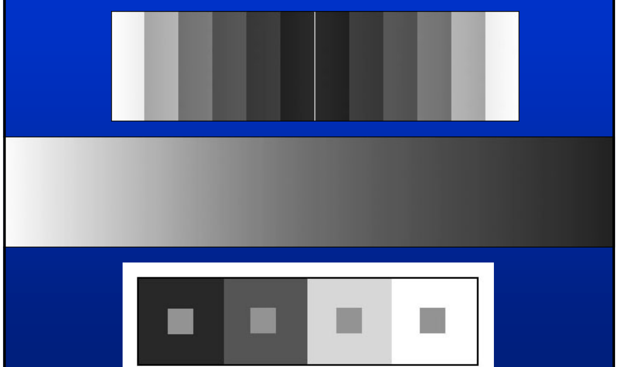
VISUAL ILLUSIONS
- Mach bands



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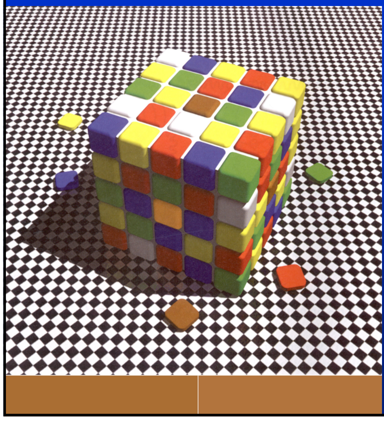
COLOUR PERCEPTION



- There's a brown square top-centre, and a yellow square at the face-centre
- Do they look the same ?

due to Purves & Lotto

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REFERENCES

No single book covers the course, but recommended are :

"Human-computer interaction" by Dix, Finlay, Abowd & Beale, Prentice Hall 1998 2nd ed. (Essex library QA76.1.A1)
the best overall coverage and a good reference source, but no 'Python'

"Designing the user interface" by Ben Shneiderman and Catherine Plaisant, Pearson Education, Inc. 2005 (Essex library QA76.1.A1S5)
a good overview of the field

plus references for Python to be introduced by John Foster

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TO FOLLOW …

- Next two lectures
  modelling how human capabilities influence interaction
  dialogue styles for graphical user interfaces
  - their advantages and disadvantages

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Grateful thanks go to Prof. Andy Downton, Dr. Adrian Clark and Mr Alwyn Lewis for permission to use material they presented in earlier years

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