E3.15
ISE3.1

IMPERIAL COLLEGE LONDON

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EXAMINATIONS 2004

EEE/ISE PART III/IV: MEng, BEng and ACGI

HUMAN-COMPUTER INTERACTION

Tuesday, 11 May 10:00 am

Time allowed: 3:00 hours

There are SIX questions on this paper.

Corrected Copy

Answer FOUR questions.

All questions carry equal marks

Any special instructions for invigilators and information for candidates are on page 1.

Examiners responsible First Marker(s) : J.V. Pitt
Second Marker(s) : Y.K. Demiris

1. (a) Consider the menu illustrated in Figure 1. Identify one way in which the menu supports novice users and one way in which it supports expert users.

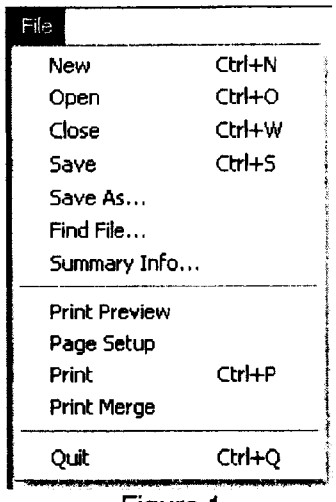


Figure 1

[2]

(b) Briefly discuss the issues and trade-offs involved in having a broad vs. a deep menu structure.

[4]

(c) Yuold Design Corporation have been hired to design a menu based interface for the meeting room booking system of a large open plan office. This system is not online for free access: instead rooms are booked by request through central administrators. One interview with a potential user of the system revealed the following comment:

"Well none of us really knows how to use a computer and we're all a bit scared of them... But we've all been doing this for a few years now... we tend to have busy periods when we book all the rooms for the next year. We spend every minute of every day making bookings, then it all goes quiet for a few months..."

Identify some of the key issues which should be considered in the design of the interface, based on this comment.

[4]

(d) Sketch a potential screen layout (interface design) for the new system. The design should show the options available to users in at least two menus. The system should enable the user to select a meeting room, select a date, select a view (e.g. by day, by month), and add or delete bookings. Indicate any additional menus added to improve usability.

[10]

2. (a) Define *Norman's Stages of Action*, and use this definition to explain the *Gulf of Execution* and the *Gulf of Evaluation*.

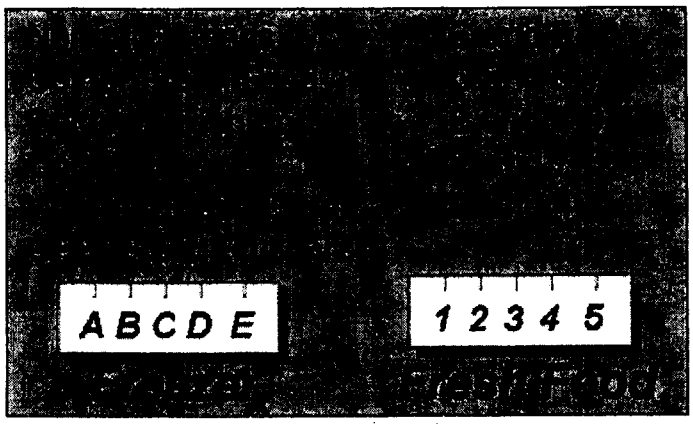
[4]

(b) Specify, with examples, six principles for placement of controls and displays with respect to other controls and displays.

[6]

(c) Norman's refrigerator contains two controls organized as illustrated in Figure 2(a). It turns out that Control A controls a thermostat and Control B controls a valve which determines how much cold air is directed to the freezer unit and how much to the fresh food compartment (see Figure 2(b)).

(a)



(b)

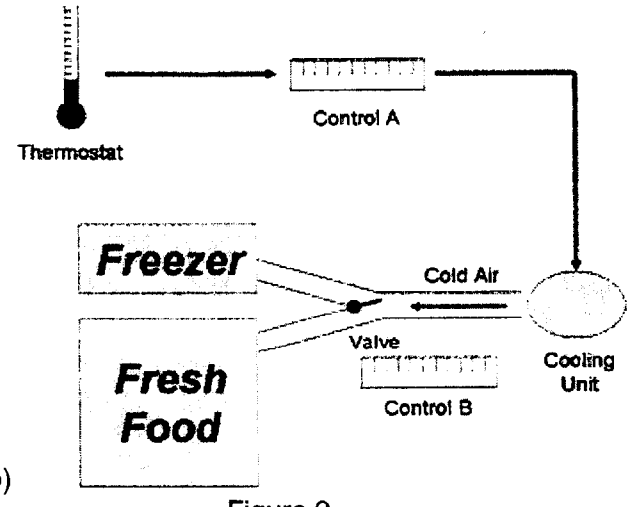


Figure 2

Using a sketch, propose an alternative control panel (interface) that conveys the correct mental model to the user, as the user changes the settings. Indicate how the mental model is being conveyed, for example how the interface overcomes the gulf of execution and gulf of evaluation, and which control/display placement principles have been used.

[10]

3. A hospital wants to provide each nursing assistant with a handheld device to be used to record and remind him (or her) of when medicine must be administered to a patient under his or her care. The device must be small, lightweight, and support the following functionality, so that the nurse can:

   - Enter and display each patient's name, medical number, age, and comments (e.g. allergies, etc.);
   - Enter and display a list of medicines that need to be administered to each patient, with dosage and times;
   - Enter when medicine has been administered to a patient, as well as any unusual or adverse reactions to treatment;
   - Delete patient records at the end of a successful course of treatment;
   - Synchronize the device with a central database for backup and download of patients and treatments (as an alternative to direct data entry).

   The device should also:

   - Beep 5 minutes before the medicine is due to be administered, and should continue to beep at 5 minute intervals until the patient has been treated (and the data entry has been made, as above).

   (a) Draw a Dialogue Network Diagram (DND) for the device interface. Justify any design decisions you make.

   [8]

   (b) Sketch a set of screens, one for each state in the DND of part (a), and use Action-Condition-Effect rules to define the interaction.

   [8]

   (c) Considering that a considerable amount of data entry is required, briefly discuss alternative input devices for data entry.

   [4]

4. (a) Briefly describe the dialogue style *Direct Manipulation*. List some of the 'virtues' of Direct Manipulation as a dialogue style for human-computer interaction.

[4]

(b) *MicroMP3* is a simple MP3 audio player. The interface is intended to allow users to create and delete playlists, to add or delete songs from those playlists, and to play either entire playlists or just individual songs.

Sketch an interface for *MicroMP3* that uses Direct Manipulation to achieve these five tasks. Briefly point out the main interface elements and explain how each task is performed.

[8]

(c) Briefly describe the *Keystroke Level Model* (KLM) and explain its application in the evaluation of human-computer interfaces.

[4]

(d) Apply the Keystroke Level Model to *one* of the tasks supported by the interface designed in part (b). State clearly any assumptions that are made.

[4]

5. (a) *Extreme Interfaces* is a term used to describe those areas of Human-Computer Interaction which could be considered unconventional or off-centre.

(i) Briefly describe *four* application case studies which effectively illustrate the role of an extreme interface. For each case study, indicate the application domain being served, the device developed for the application, and the sensing process employed in the operation of the device.

[6]

(ii) Briefly discuss how the design of an extreme interface impacts on the HCI design framework that considers the users, tasks, system and environment in interface design.

[4]

(b) (i) Define *Affective Computing* and explain how it relates to particular problems in Human-Computer Interaction.

[3]

(ii) Explain how an *AffectiveWare* system operates, using a diagram or diagrams where appropriate. Include a detailed description of the working of at least one affective sensor.

[5]

(iii) Compare the advantages and disadvantages of two affective sensors, one that provides a continuous reading, and another that provides a reading only at the time of an interaction.

[2]

6. In addition to many other responsibilities a manager has to overview 60 projects, and must become aware of any project that may be in trouble. The projects are roughly equally spread between five geographical categories (UK, EU, USA, Middle East and Far East) and each project is principally characterised by two attributes concerned with how well the project is performing with respect to time and cost. Each attribute can take on one of five values indicating how well or badly the project is progressing. The two worst values of each attribute should attract the attention of the manager who is then obliged, at the very least, to become familiar with details before taking any action. The detail comprises up to three key personnel (who the manager may know), the geographic location of the project and a brief (<20 words) statement of the time and/or cost problem(s). It should be possible, however, for the manager to look at the details of any project at any time, as well as obtain an overall idea of how all the projects are progressing.

   As an interaction designer and expert on information visualization, you have been asked to propose a first trial design for a suitable visualization tool for use by the manager. The manager is not a computer expert and does not want to use a keyboard unless necessary.

   (a) Identify the issues that will influence your design.

   [4]

   (b) Describe a design for a suitable visualization tool, illustrating it where appropriate with annotated sketches. Specify in detail how you intend that the manager should interact with the visualization tool. Indicate how the issues identified in part (a) have been addressed in the design.

   [16]

master - 27/4/04

E3.15 Human-Computer Interaction **MODEL ANSWERS** **Dr J V Pitt**

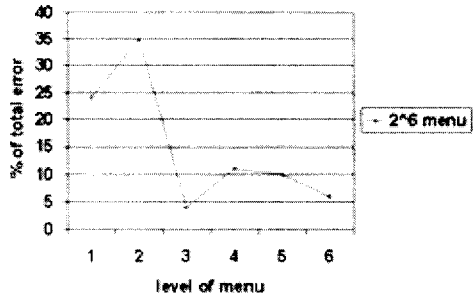
1.
(a) application
(b) lecture material
(c) application
(d) application

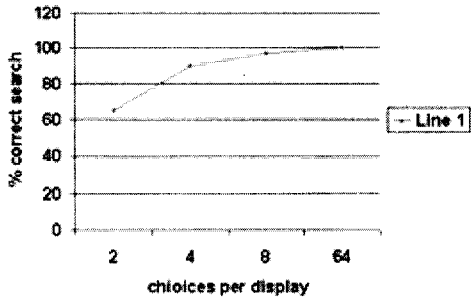
(a)
Use of categorization to help novices
Provision of shortcuts to help experts

(b)
Suppose you have 64 items to arrange in menus.
Which is best structure: 2^6 (menus of item so six choice to get to to leaf), 4^3, 8^2, or 64^1?

Can do experiments. Measure errors made and time taken to find target meneme.

With respect to errors





Kink in 2^6 graph due to weak association between category heading and target meneme.

On 64^1 100% success rate.

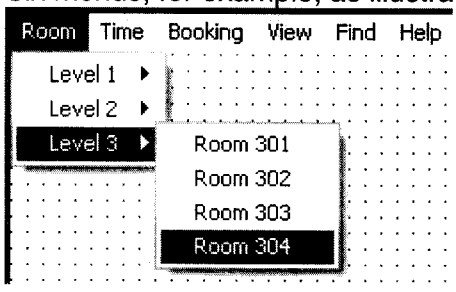
Time is fastest on 64^1 menu too.

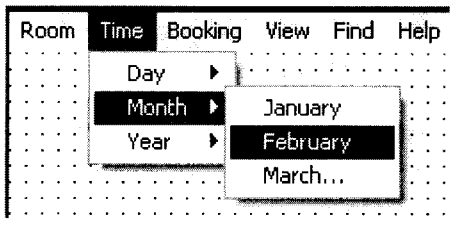
Such results may question why we need menus at all!

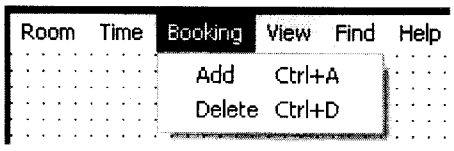
More to it than just this: other cognitive factors, trade offs, etc,

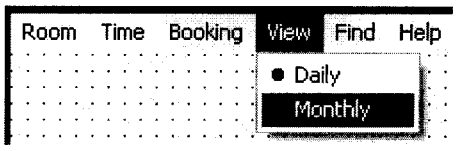
(c)
Key element is to make observation with respect to users, system, tasks and environment. Sort of thing that should be mentioned is:
Users are novices with computers, but experts in task domain
Therefore interface should appeal to existing mental model of task
Must also have high support for recall, if it can be months between uses
Repetition of task means frequently accessed functionality should be easily accessible

(d)
Six menus, for example, as illustrated below.









Deep menus for room selection, by level and then by room number
Deep menu for date selection.

Idea is that interface shows last selected room and date, updates as user selects new menemes from menu.

Can view by month or by day in view menu, and switch here. Note daily selected here. Can then block-select days (on month view) or hours (on day view) and select command to add. Selecting such a booking can be deleted by delete meneme.

Find menu to enable user to ask queries

Help menu is obvious...

Could offer quit

Use of lean cuisine notation would be a bonus.

2.
(a) Bookwork
(b) Bookwork and application
(c) Application

(a)
Norman's Stages

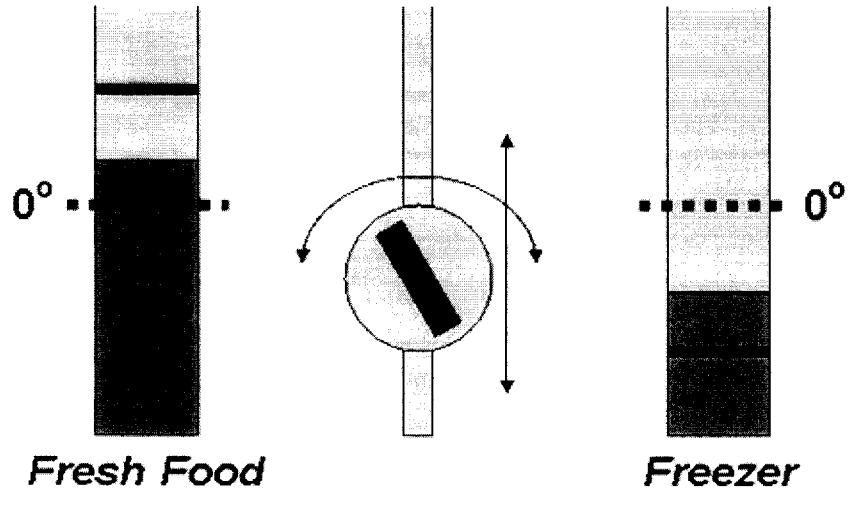
Stage	What	Use Kiosk
1	formulate goal	buy wine for dinner party
2	formulate intention	use kiosk
3	form an action plan	use card, ask for recommendation, etc
4	perform actions	insert card
5	perceive change	interface change
6	interpret perception	sound, light
7	evaluate state	welcome etc

Gulf of Execution: matching what a user wants to achieve (in psychological terms) with what a system is capable of doing (in physical terms), what it is right to do, and doing it
Gulf of Evaluation: matching what actually happens (in physical terms) with what was desired or expected (in psychological terms)

(b)
Controls vs controls:
Temporal: sequence of use
Functional: functionally related grouped together e.g menus
Frequency: Dvorak keyboard layout

Controls vs displays:
Spatial: video-conference studios cameras buttons
Movement: knob rotation and slider
Cognitive compatibility: alignment of input/output e.g NL with speech

(c)
Possible arrangement (not only, not necessarily the best)



Both controls contained in one:
Control A is now a slider that moves in vertical direction
Control B is now a knob that rotates around central axis with central bar pointing to fridge or freezer

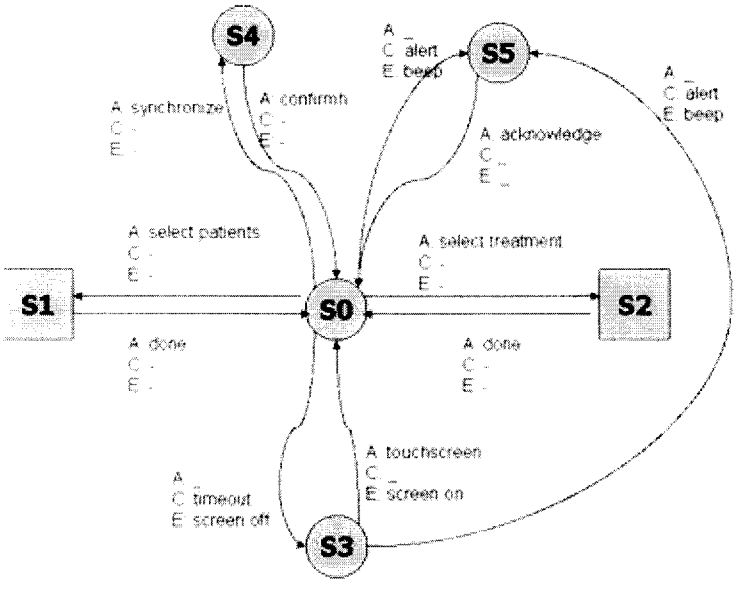
Appeal to movement compatibility
Vertical movement up to make hotter, down to make colder
Rotation left opening valve towards fridge, right towards freezer

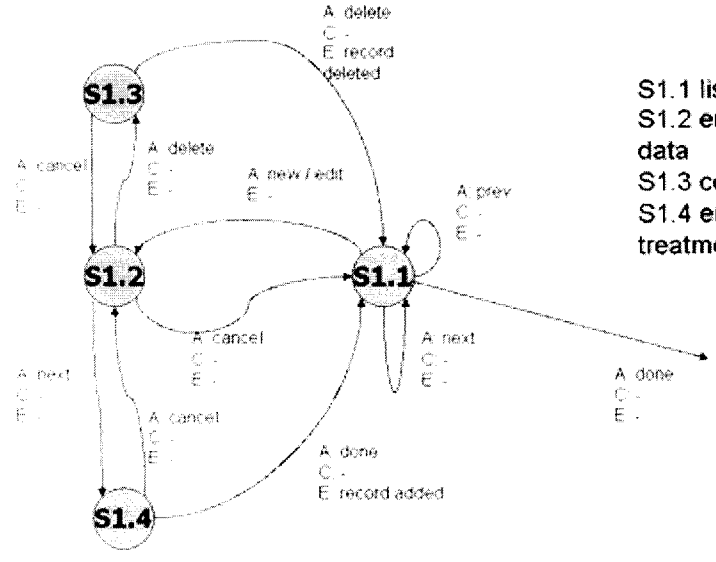
Temperature gauges (displays linked to controls) rather than ambiguous instructions helps to overcome gulf of execution

Use black lines to indicate where temperature will settle. Overcomes gulf of evaluation (the original required user to wait 24 hours to test results) as both black lines [in,de]decrease as slider moves [up,down] and [con,di]verge as the knob is rotated [right,left]

3.
(a) application
(b) application
(c) application

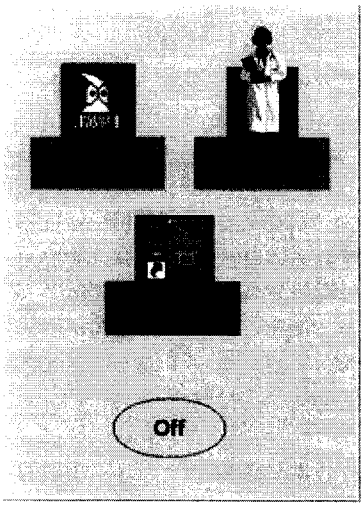
(a)
Possible diagram shown below.
First two tasks are done in subdialogue S1, states 1.2 and 1.4 after select new or edit old record.
Third task is done in sub-dialogue S2 (not shown)
Fourth task is alert dialogue. Assumption here is just to show alert and acknowledge. Not going to bother about the timings simplification is justified on the grounds that DND are not intended to show such detailed reference to internal clocks
Fifth task is also done in sub-dialogue 1 state 1.3
Sixth task is shown on main picture





S1.1 list patients
S1.2 enter patient data
S1.3 confirm?
S1.4 enter patient treatment

(b)
Many possible designs, looking for something like



A Tap on Patients icon
C: none
E: brings up patient dialogue S1.1

A Tap on Treatments icon
C: none
E: brings up patient dialogue in S2

Etc.

In patient dialogue see scrollable list of patients, tap on patient name to see record, tap on new to get new record etc
Treatments screen has list of treatments for current day, and times, with checkbox to tap when treatment has been given.
Sychnronize and alert screens are simple

(c)
Want some imagination as well as bog standard.
Bog standard could be docking station or speech processor.
More imaginative could be virtual keyboard projection or lightpen with special pad.

(4)
(a) 4 marks, Bookwork
(b) 8 marks, Application
(c) 4 marks, Bookwork
(d) 4 marks, Application

(a)
Direct Manipulation is an interaction style which seeks to bridging the gulf of execution and the gulf of evaluation through display and user manipulation of a common conceptual model. It relies on

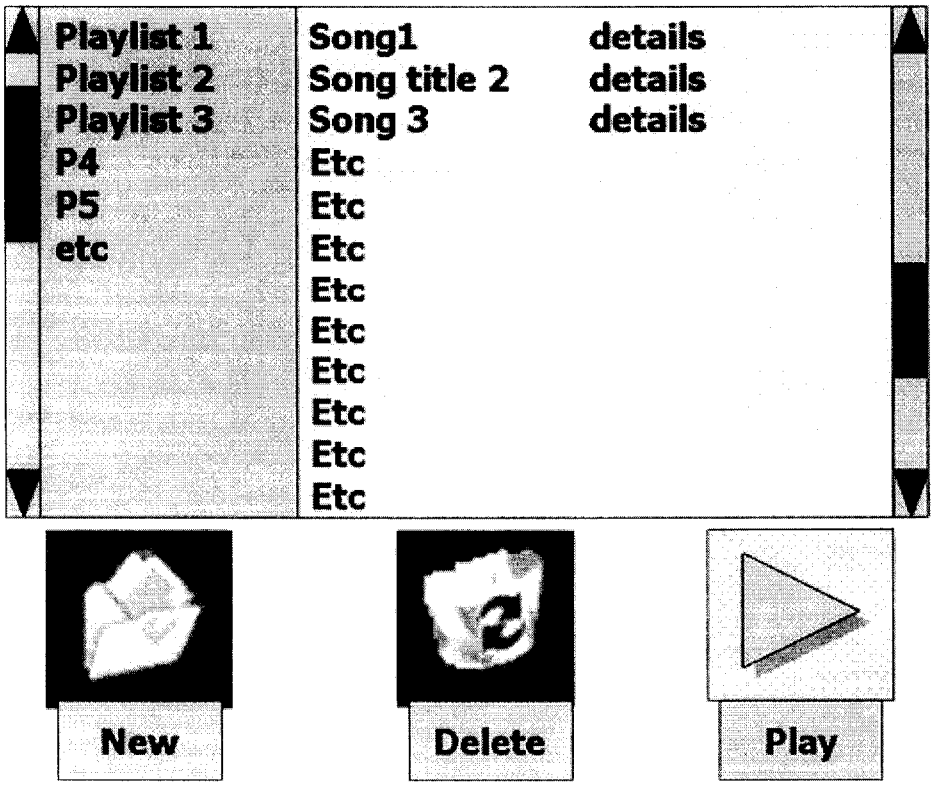
- continuous representation of the objects and tasks of interest
- physical actions like button presses, drag and drop
- rapid feedback and reversible operations

In particular, *information displayed is part of the manipulative interface itself*

Shneiderman, suggests the following virtues:

1. Novices learn basic functionality quickly, often by demonstration
2. Experts can work rapidly on a wide range of tasks
3. Knowledgeable intermittent users can retain operational concepts
4. Error messages are rarely needed
5. Users can see immediately if their actions are furthering their goals, and if not simply change the direction of activity
6. Users have reduced anxiety because the system is comprehensible and because actions are easily reversible

(b)



Drag playlist from playlist area to song area to show songs
Add song: Drag song from song area to other playlist
Add playlist: Drag new icon onto playlist area to make new playlist
Delete song or playlist: Drag song or playlist onto delete to er, delete..

Should also have title areas, indicate selected playlist, etc.

Drag and drop playlists onto play to play entire playlist, song to play just one song

Could have buttons for pause, back 1 song, forward 1 song, but this is not DM.

(c)

- **Purpose**
  - approximate prediction of time to perform tasks
  - allows comparison between alternative design options
  - applicable in principle to any interactive system
- **Assumptions**
  - expert, error-free performance to do routine tasks
  - assumes knowledge of tasks/sub-tasks, method used to do task, and some information about the system
- **Content of the model**
  - description of task + simple model of user + simple model of computer
- **Tasks**
  - Tx = Tk + Tb + Tp + Th + Td + Tm + Tr, where:

Tk = keystroke time
Tb = mouse button press
Tp = pointing time
Th = homing time
Td = drawing time
Tm = mental time (preparing for action)
Tr = system response time

Some otherevaluation methods considered so far need a realisation of some or all of the system

- powerful and (potentially) accurate, BUT
- tend to need resources and tend to occur later on in development

- **analytic techniques use *reasoning* on the basis of *knowledge* about the system**
  - are applicable early in development (e.g. to specifications)
  - can (in principle) be applied cheaply to get rough answers to design problems
- **analytic techniques generally intend to *predict* system performance**
  - informal analysis: implicit representation of system and users
  - formal analysis: explicit representation of system (e.g. specified in some notation)

KLM is an analytic technique

(d)
Any sensible application of KLM is acceptable.

5.
(a) 6 marks, Bookwork, 4 marks application
(b) 3 marks Bookwork, 5 marks understanding, 2 marks application

(a)
(i)
There are many possible answers, but here are 6 discussed in the lectures.

1. Application Domain: Creative Arts (Dance)
Device: Pressure Sensing Pads
Piezoelectric pressure sensing pads are combined with other sensing devices to track the dynamics of human foot movements (e.g in the "Expressive Shoe" project).

Application Case Study: Expressive Ballet Shoe
The data from pressure sensing pads (combined with other sensing devices) embedded in the shoe are reported continuously by wireless transmission in real time to a synthetic orchestra which acts as a continuous accompaniment to the performance of the ballet dancer. See "Expressive Footwear" reference in the notes.

2. Application Domain: Music
Device: Vibro-tactile transducers sewn into fabric.
Arrays of transducers woven into in a full-body suit transmitting continuous vibro-tactile data from an attached computer system to the human subject wearing the suit.

Application case Study: The Haptic Suit
A computer wearable interface, which exploits the delicate sensory channel of human touch to augment the audio appreciation of music. Embedded transducers in the suit act as vibro-tactile sensors complementing the musical experience conveyed through the head phones. (see ref: to the Haptic Suit in the "Extreme Interface" article in the attached notes)

3. Application Domain: Entertainment, Games
Device: Bio-feedback Sensors
Sensors attached to an operators' skin and having the capacity to report ongoing variable changes in the emotional state of the operators/players, e.g in interactive Affective Mind Games.
Application Case Study: Affective Mind Games
In Mind Games, the speed of animated racing dragons is controlled via bio-feedback sensors attached to the players' fingers. The player achieving the highest level of relaxation communicates this to the game system and thereby elicits a winning performance from his/her dragon. See "Extreme Interface" article (featuring Mind Games) in the notes.

4. Application Domains: Recording Dance Movement & Scripting Animation
Device: Tracked LEDs:
Arrays of light emitting diodes being continuously sensed in the presence of photo diodes is an effective movement tracking technique in HCI.

Application Case Study: The Sensed Data Glove:
One application of this tracking technique is the sensed data glove, in which the movement and gestures of the hand act as input to a real time computer animation system. In the case study reported in the attached notes "Gestural Input", the Data Glove idea has been expanded to become a full-body Data Suit acting as a real time animation input medium.

5. Application Domain: Community Information Systems
Device: Touch-sensitive Screens with Interactive Agents
Touch-sensitive screens reporting operator's finger contact and movement as input to multimedia information systems coupled with interactive software agents.

Application Case Study: The Electronic Coffee Table in a Community Setting :
An innovative application for the screen is the Electronic Coffee Table case study in an interactive touch sensitive screen acts as an interface to an agent-based multimedia system for a local neighbourhood community. See paper "The Electronic Coffee Table" in the notes.

6. Application Domain: Music Performance
Device: Precision Strain Gauges
As HCI devices, sensitive force-sensing gauges can report variable forces being applied to the surfaces of musical instruments by an operator/virtuoso .

Application Case Study: Hyperviolin
Hyperviolins are members of a stringed family "Hyperinstruments" in which precision force-sensing strain gauges and other monitoring devices report the actions of a virtuoso to a linked synthetic electronic orchestra, thereby extending and augmenting the performance of the soloist. See refs. to "Hyperstrings" & "Extreme Interfaces" in the attached notes.

(ii)
Extreme Interfaces
These are interfaces that may be found at the extreme ends of the spectrum of applications in the domain of HCI (Human Computer Interaction). The primary characteristics of extreme interfaces, apart from being innovative and/or the outcome of research, in terms of the design framework:

tasks: as opposed to office automation often from such domain as creative arts, entertainment, or social communications

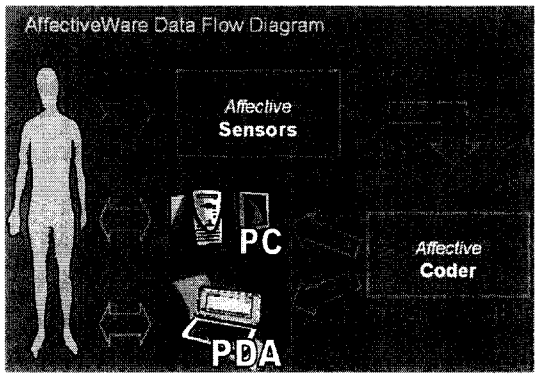
users: concerned with the gauging of a user's affective emotion state, or the recording of the full body movement of the operator, or the combining of a user's gestural actions with her personal software agent embedded in an interactive system.

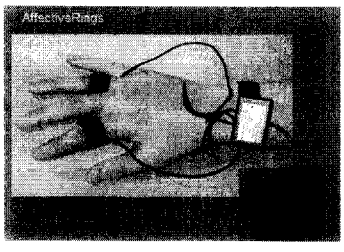
Environment: ubiquitous computing, territory-as-interface, etc.

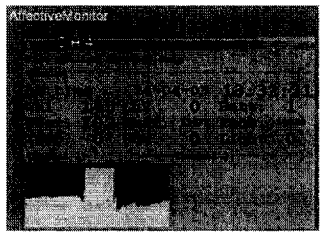
system: often (invariably) include the employment of unconventional interface technology; of course this is the constraint that is being loosened completely (snapped)

(b)
(i)
Affective computing is an area of research in which a computer measures the user's emotional valence whilst continuing with its usual functions (Picard, 1997). Broader definition of affective computing is a human-computer interaction in which a device has the ability to detect and appropriately respond to its user's emotions and other stimuli. A computing device with this capacity could gather cues to user emotion from a variety of sources - facial expressions, posture, gestures, speech, the force or rhythm of key strokes and the temperature changes of the hand and so on.(1 mark) The main psychological problem in HCI is when participants think that computers are annoying or stupid, and therefore think of themselves as dummies. This projection may lead them to stop using the particular system efficiently or at all. (1 mark) To overcome the problem of communication between users and computers is it highly desirable to develop a mathematical model of emotion, hence the development of Affective computing. (1 mark)

(ii)
An AffectiveWare data flow diagram should be drawn (1 mark)
The explanation should emphasise the AffectiveLoop created between the human, the sensors, the coder and the computer. (1 mark) There are two sensors which can be described, the AffectiveRings and the AffectiveMouse. The AffectiveMouse looks like an ordinary mouse. Actually it is covered with electro-conductive layer. Skin conductance is measured between a button and the body of the mouse. (1 mark, see pictures).







The descr iption should include an explanation of the principle of skin conductance (1 mark) and the AffectiveMonitor (1 mark) in operation in this instance.

(iii)
The AffectiveRings provides a constant reading, the AffectiveMouse an intermittent reading. Possible answers include the following, although students may come up with others: The advantage of the AffectiveRings is that data is not missed during any observation period. The disadvantage is that they are always on the hand of the user which may make them inconvenient and the user conscious of their presence. (1 mark) The advantage of the AffectiveMouse is that the user is less aware of the monitoring. The disadvantage is that important readings may be missed when the subject's hand is not in contact with the mouse. (1 mark)

6
(a) and (b) Application

(a) ISSUES:

1. It cannot be assumed that the manager will be watching a display continuously, so his/her attention must be attracted by other than visual means wherever the manager is located and whatever task the manager is currently carrying out.
2. The time and cost performance of all projects must be visible at all times so that the manager can rapidly become aware of the status of all projects.
3. Examination of the details of a project should not involve a change in the display to a completely new presentation of information.
4. The five categories of time and cost performance should be capable of rapid interpretation.

(b) DESIGN

Issue (a) points to the need for drawing attention to a significant detail in a sea of information, while the manager may not be monitoring as s/he is paying attention to other duties. This has to be tempered by the speed at which the data changes are likely to happen: if it as a result of overnight updates or if there is some requirement to respond immediately. An audible warning when the time and/or cost performance of a project becomes of concern is a possibility even if the updates are overnight. The audible tone should start as soon as the manager interacts with the tool the first time after the problem has occurred. Its reinstatement might be set, after experiment, to occur if no interaction has taken place for (say) one minute, and even then initially at a much lower volume.

Issue (b) requires a method of presentation that allows all 60 projects to be represented simultaneously to facilitate an overview, but allow some sort of zooming to facitate the detailed examination of a project. One possible presentation mechanism that would allow this to be achieved is the Perspective Wall/Bifocal Display. Here, all projects can be visible all of the time.

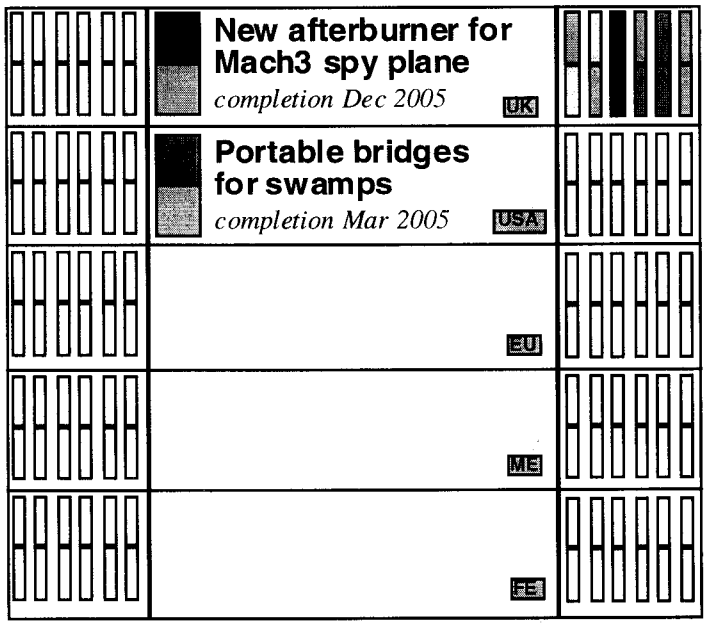
With 60 items on the display, each characterised by two attributes, the use of numerical scores is inappropriate for two reasons. First, the initial examination is qualitative. Second, it is very difficult to obtain an overview of 60 projects from sight of 120 numbers. For a rapid appraisal, colour encoding would be better, with two shades of red to denote unacceptable performance, grey to indicate performance on target, and two shades of green to indicate better than expected performance.

Since all projects must be visible at the attribute level it would be appropriate to locate, on each of five rows of the Wall, a rectangle (see sketch) whose top half encodes time performance and whose lower half encodes cost performance. This upper/lower split is suited to the thin vertically oriented rectangle associated with each project, whereas a right/left split would not. Encoding of this type (as with smartmoney.com) will facilitate an overall appreciation of project success (or otherwise) to be gained and any project of especial note to be easily identified (see sketch A where detail of the first row one of five geographical regions is shown in sufficient detail).

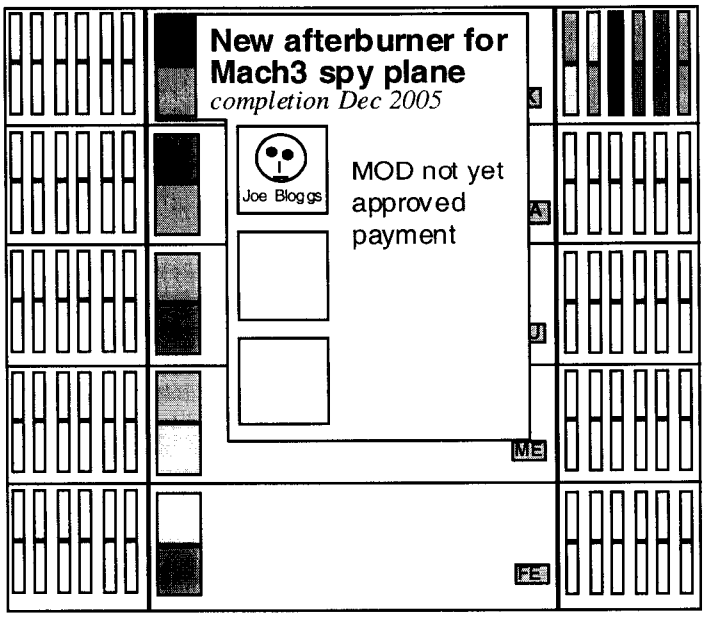
For any project residing outside the central region, examination of detail will first be achieved by moving/scrolling the Wall so that the project representation expands into the central region, as shown in the sketch. Note that the time and cost representation are unchanged from their appearance outside the central region so that this vital information is still clearly visible. The interaction required of the user, made possible by a touch screen, is a simple scrolling action with a finger. We choose this interaction mechanism rather than the Xerox PARC method of precisely identifying the (small) area of the project of interest, whereupon it is automatically moved to the

central region, for two reasons: (1) it would require a mouse or other accurate pointing mechanism, and (2) the project representation would have to be identified with precision.

In the central region there may still be insufficient room within the expanded project representation to include sufficient detail in which case a touch on the project representation will cause 'vertical' expansion as shown in the sketch (but still leave room to show context): a subsequent touch or a scrolling action will cause contraction to the representation shown in sketch A.



Sketch A



Sketch B