11.42am

Paper Number(s): **E3.15**
ISE3.1

IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE
UNIVERSITY OF LONDON

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EXAMINATIONS 2002

EEE/ISE PART III/IV: M.Eng., B.Eng. and ACGI

HUMAN-COMPUTER INTERACTION

Monday, 29 April 10:00 am

There are SIX questions on this paper.

Answer FOUR questions.

Corrected Copy

Time allowed: 3:00 hours

Examiners responsible:

First Marker(s): Pitt,J.V.

Second Marker(s): Demiris,Y.K.

Special Information for Invigilators:

None.

Information for Candidates:

None.

1 (a) Consider the following input devices for a Web browsing interface on a palmtop computer: keypad, microphone, trackball, touchscreen.
For each input device, firstly give a reason why the input device should be used with this interface, and secondly give a reason why it should not be used as the input device for this interface, with respect to the users, system, tasks or environment.

[8]

(b) Describe the Keystroke Level Model (KLM) for human-computer interface evaluation. Explain how it could be used for deciding which of these input devices is best suited to the Web browsing interface for the palmtop computer. Give an example for a simple search task for *one* device, clearly stating any assumptions you make.

[12]

2 (a) Describe the activities involved in *both* of the two widely used approaches to system design that involve users.
Briefly outline the potential benefits and the possible drawbacks of the two approaches you have described.

[12]

(b) Explain what a user model is, and how it differs from the user's model of the system. Explain how a user model can be created in terms of the user's goals, operations, methods and selections (GOMS), and briefly discuss the advantages and disadvantages of such a user model.

[8]

3 (a) Briefly describe three techniques for information visualisation, explaining how the technique makes important information perceptually prominent.

[9]

(b) What is Design Space Analysis? Briefly describe a technique for Design Space Analysis.

[6]

(c) In the design of a bar-code system for a supermarket chain, you have to decide where to locate the bar code reader. Draw a QOC (Questions-Options-Criteria) analysis diagram for an appropriate choice of options and criteria.

[5]

4 In the context of Human-Computer Interaction, define each of the following terms, and explain its role in the specification, design, implementation and/or use of an interface to a computer system:

(a) Positioning Principles (in workspace design).

(b) Ergonomics.

(c) Norman's Stages of Action.

(d) Prototyping.

(e) Event Loop.

[20]

[*Each part carries equal marks.*]

5 A supermarket chain intends to provide customers with a hand-held device, incorporating a bar-code reader, with which they can record their selection of goods. The motivation for so doing is to eliminate the need for the customer to queue at a check-out: instead a sales-person will accept the device, read off the total amount recorded, and request payment. The device would also be equipped with a smart card reader and small LCD screen, to support user-defined shopping lists and loyalty points; and also allow browsing of product ranges, recipes and in-store promotions.

(a) Identify the questions that may occur to the user while shopping, and hence the queries and modes that the device should be capable of answering.

[5]

(b) Sketch a suitable device design, and describe and justify the interactions it supports.

[5]

(c) Sketch a suitable interface design, employing appropriate presentation and representation techniques. Justify all your design decisions.

[5]

(d) Identify which Personal Interface Agents might be useful in the overall context of shopping using this device. Describe each of their individual roles and/or functions, indicate by whom the agents might be owned, and give an appropriate representation.

[5]

6 The time to find, and subsequent presentation of, the results of a search of the Web using a search engine often leave much to be desired. Furthermore, a lot of people use search engines in lieu of bookmarks. You have been asked by the director of Giggle, Inc., a search engine company, to come up with ideas about an anytime query, improved presentation and support for personalized bookmarking services.

(a) List the tasks that a user should be able to perform.

[4]

(b) Construct a simple Jackson Structure Diagram (JSD) for a customer using the search engine
Explain the notation used in the JSD.
Identify any particular difficulties in the design, and explain the limitations of JSD that cause it.

[8]

(c) Construct a Dialogue Network Diagram (DND) for the interactions described in the JSD of part ~~(a)~~. (6)
Explain the notation used in the DNDs.
What is shown in the DND that is not shown by the JSD in part ~~(a)~~? (6)
Briefly explain two limitations of DNDs for dialogue design.

[8]

E3.15 Human-Computer Interaction

Examiners	**Dr J. V. Pitt**
First Marker	**Dr J. V. Pitt**
Second Marker	**Dr O. de Bruijn**

There are SIX Questions. Answer FOUR Questions.

MODEL ANSWERS

ANSWER 1

MARKING SCHEME
(a) 8 marks: 1 for each
(b) 12 marks: 3 for KLM, 3 for how used, 6 for example

(a)
keyboard
should - users: commonplace; tasks: new task, allowing users to create messages for bulletin board pages, etc.
should not - users: not all users can type; tasks: tasks currently supported only need number pad

microphone
should - users: universal (nearly); tasks: speaker independent voice recognition possible given limited vocabulary required for specified tasks
should not - users: possible commands may not be apparent; environment: may be noisy

trackball
should - tasks: spatial displacement appropriate for slecting links
should not - tasks: needs to be small, risk of RSI; tasks: no support for URL entry

touchscreen
should - tasks, with lightpen: granularity of input and direct spatial data onto screen appropriate for given tasks; system: robust;
should not - system, using finger: takes up large amount of screen space so restricting data presentation, dirty screen impairs viewing

(b)
Definition:
KLM is a technique for analytic evaluation of a system, based on design specifications rather than implementations.
Its purpose is to give an approximate prediction of the time to perform tasks. This allows the comparison between different design options. It is applicable in principle to any interactive system.
It assumes expert, error-free performance to do routine tasks, and knowledge of the tasks and its sub-tasks, method used to do task, and some information about the system.

How Used:
The content of the model is based on a description of the task, a simple model of the user, and a simple model of the computer.
Then times are calculated by what actions are required to complete the task, and given sample times for doing keystrokes, mouse button press, pointing, homing, drawing, mental, and system response times, summing them to give a time to do the task.
We could do this for the same task with each device, and see which is best.

An Example:
Task involves search.

Device chosen: touchscreen with stylus

Task breakdowns into 3 steps:
1 enter URL of preferred search engine
2 enter search terms
3 click on hyperlink for best result

Assumptions:
split screen: conventional browser interface on top, area for character entry at bottom
user holding stylus, therefore Th (homing time) is zero
time to press is same as that for mouse button click Tb
pointing time Tp with stylus and palmtop has been determined according to Fitt's Law
system response time Tr includes network and server response time over flakey wireless connection
typing time Tk for forming character with stylus same as key press of unskilled typist

Then
1 enter URL Tm + Th + Tp + Tb + Tk * 15 (??? www.google.com<return>???) + Tr
2 enter search terms Tm + Tp + Tb + Tk * XXX (however many) + Tr
3 click on result Tm + Tp + Tb

Key point is assumptions, actually working out a figure is not so important.

ANSWER 2

MARKING SCHEME
(a) 12 marks: 8 for the steps, 4 for advantages/drawbacks
(b) 8 marks:

(a) [Bookwork, Understanding]
Approach 1:

User centred design: The key to user-centred design is to involve the user in all stages of the design process: Specifying context of use, specifying user and organisational requirements, and evaluation of prototypes

- **Benefits**
  - Start from user/task characteristics
  - Capitalise on user's knowledge and background (intuitive)
  - Emphasis on user's needs and wishes (usefulness)
  - Develop a coherent model to guide design/training
  - Mix creative and scientific elements
  - Not limited to design of computer systems
  - Avoiding user confusion and errors
- **Potential drawbacks**
  - Limited to homogeneous/accessible user groups
  - The focus on *current* users/task can limit innovation
  - There is little guidance on construction/evaluation of a conceptual model
  - High cost

Approach 2:

User participatory design: The key to user-participatory design is empowerment of the user through envisionment of the system. Envisionment is achieved through active involvement of the users who help to produce scenarios of use, prototypes and simulations.

- **Benefits**
  - improved communication between designers and users
  - resulting system based in work environment
  - changes in work procedures and training requirements are accommodated as part of the design process
  - users become "owners" of the design
  - ensures both utility and usability
- **Potential Drawbacks**
  - designers lose control of the design process
  - time and cost of project may escalate
  - selecting and motivating right user group
  - risk of 'groupthink'
  - designers not trained to communicate with users (and vice versa...)

(b)

A user model is a description of the characteristics of a typical user of a system that may have a bearing on the ability of such a user to interact effectively and efficiently with that system.

GOMS example:

```
GOAL: PHOTOCOPY_PAPER
.           GOAL: LOCATE_ARTICLE
.[select    GOAL: USE_MANUAL_METHOD
.           .     GOAL: PHOTOCOPY_PAGE repeat until no more pages
.           .     .     OPEN_COVER
.           .     .     SELECT_PAGE
.           .     .     POSITION_PAGE
.           .     .     CLOSE_COVER
.           .     .     PRESS_START_BUTTON
.           GOAL: USE_FEED_METHOD
.           .     GOAL: REMOVE_STAPLE
.           .     .     < Operators >
.           .     LOAD_FEEDER
.           .     PRESS_START_BUTTON
.end select]
.           GOAL: COLLECT_COPY
.           .     LOCATE_OUT_TRAY
.           .     REMOVE_COPY
.           GOAL: RETRIEVE_JOURNAL
.[select if manual method was used
            .     OPEN_COVER
.           .     REMOVE_JOURNAL
.           .     CLOSE_COVER
. If feed method was used  REMOVE_JOURNAL_FROM_FEEDER_OUTLET
. End select]
```

Advantages

- Analysis of the GOMS structure can yield measures of performance
  - The stacking depth provides an indication towards short-term memory load
- Can be used to predict user error
  - Forgetting to retrieve the original paper in the photocopy example, or forgetting to retrieve your bankcard after getting money from an ATM
- Can be used as a basis for more in depth construction of a user model
  - Goal structures can be used in Generalised Similarity Analysis to obtain a measure of the adequacy of the user's mental model

Disadvantages

- Largely post-hoc: risks being defined by the dialogue structure rather than by the user
- Restricted to predicting expert use
- Establishing the right level of *granularity* may be difficult

ANSWER 3

MARKING SCHEME
(a) 9 marks:
(b) 6 marks:
(c) 5 marks:

(a) [Bookwork]
Lots of possibilities:
Attribute Explorer
Rapid Serial Visual Presentation (RSVP)
Bi-focal display
etc.

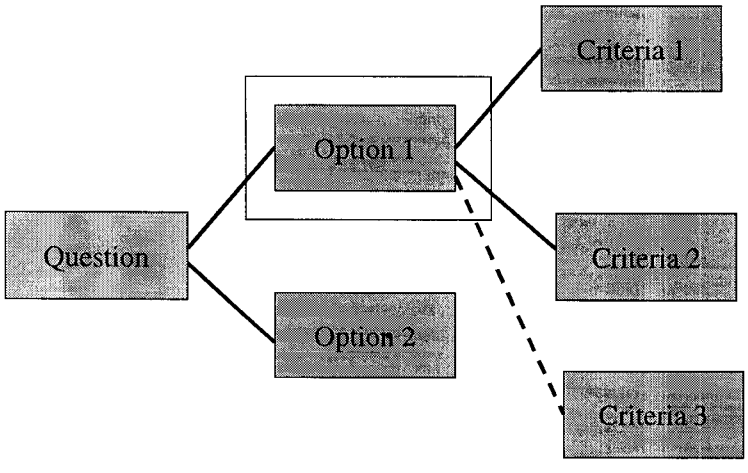
(b) [Bookwork]

Design Space Analysis is part of Design Rationale. Design rationale are techniques for recording the rationale behind designs decisions, so documenting decisions made in the design process and supporting evaluation. Design space analysis is a (post hoc) structuring of design possibilities, exploring alternative designs , so the final result gives a detailed description/justification of why certain design decisions were made, but also an overall better design.

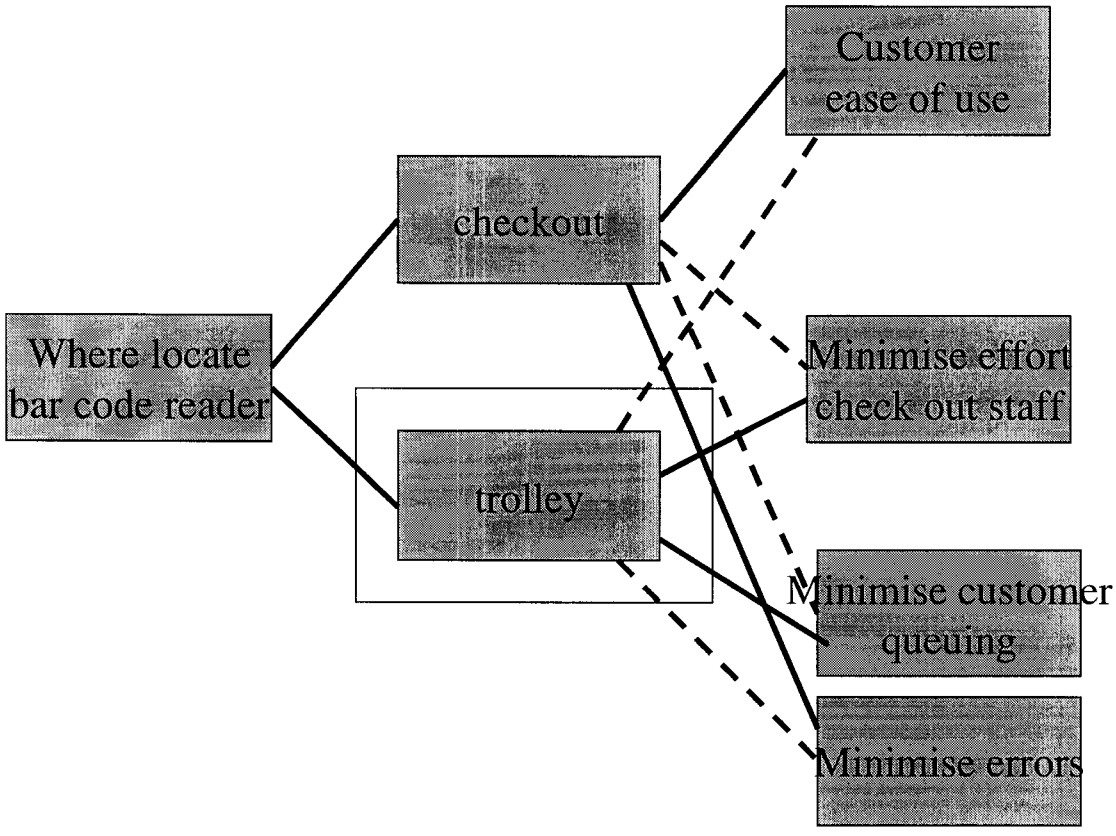
Techniques for Design Space Analysis is QOC (questions-options-criteria) analysis daigrams, where:

questions address important issue sin design space
options are possible answers to design questions
criteria are positive goals to decide between options, arguing for/against alternatives
unbroken lines indicate positive relationship between criteria and option
dashed line indicate relatively negative relationship
most favoured option in box

Example notation



(c) [Application]



One alternative: marks for any sensible options, criteria, and support, up to 5

ANSWER 4

[Each part 4 marks: 1 mark for the definition, up to 3 for the explanation of the role]

(a)

Positioning principles are concerned with how controls and displays should be arranged to ensure their most efficient usage in workspace design.

PRINCIPLE OF POSITIONING	
controls vs controls	trade off: sufficient space for anthropometric considerations given user population vs. excessive distance causing tiredness vs. need to avoid accidental operation keyboards! need to consider position and movement of control distinguishing controls beer keg handles in power station disk eject and on/off in PCs
displays vs displays	need to consider line of sight field of vision eye reaction (oval skewed to right) group display to provide flow process control speedy location of faults natural mapping
controls vs displays	
spatial compatibility	associate control with display via a consistent relationship between physical layout warning sign: left ear left control bad example: TV studio
movement compatibility	keep moving part consistent indicators on cars and bikes sliders and knobs
cognitive compatibility	match user's model of machine capability with actual competence natural language output not recognising natural language input

(b)

Definition: Ergonomics is the study of people's relationship to their work: Physical ergonomics is concerned with analysing and optimising the physical (as distinct from cognitive) aspects of people's work.
Role: Ergonomics role in HCI is to define and design tools and artefacts for different work environments to suit the capacities and capabilities of the users. The objective is to maximize an operator's safety, efficiency and reliability of performance, to make a task easier, and to increase feelings of comfort and satisfaction. Ergonomic factors are an important consideration in workspace design, where the four stages of design are (1) to specify the on- and off-line tasks, including the equipment to be used, (2) to define the population of users and their basic postural requirements, (3) design the workspace to meet ergonomic and anthropometric constraints, and (4) to test a prototype.

(c)
Definition: theory of action that enables system designers to bridge gulf of execution and gulf of evaluation.

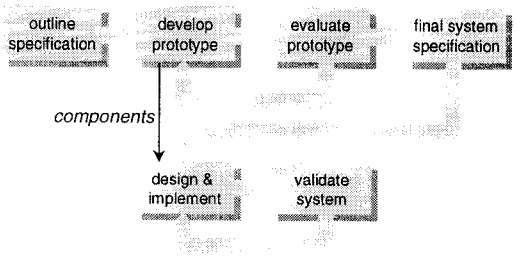
Gulf of Execution: matching what a user wants to achieve (in psychological terms) with what a system is capable of doing (in physical terms), what it is right to do, and doing it
Gulf of Evaluation: matching what actually happens (in physical terms) with what was desired or expected (in psychological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

Norman's Stages

Stage	What	Example 1: central heating	Example 2 shower
1	formulate goal	to be warmer	to be clean
2	formulate intention	use CH system	take shower
3	form an action plan	turn on CH switch	go to bathroom set to shower turn on etc
4	perform actions	flick CH switch	turn on taps
5	perceive change	see lights hear boiler hear pipes	see water from shower hose see force increase decrease more/less steam feel temperature
6	interpret perception	associate light with on flame with heat gurgling pipes with pumped water	hotter or colder according to requirements
7	evaluate state	after a while... feel radiators	right temperature for shower

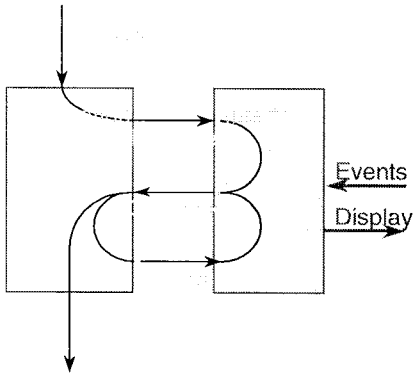
(d)

Definition: building an incomplete experimental system quickly and cheaply, evaluating and discarding, using the feedback to inform the development process.
Role: contrast iterative/incremenatal prototyping with rapid/throw away prototypes. Former used to build system in 'spiral' fashion, latter are 'one-shot' prototypes used to



gather requirements for a new system, or to be used as a demonstration vehicle. Once prototypes are used by representative groups of users to test the requirements of the system The results of the prototyping are fed back into the analysis and design of the system development, and the prototype is discarded, although some components may be 'salvaged'.

(e)
Definition: the cycle of 'wait for event'-'detect event'-'handle event'-repeat in an interactive program as control is passed from interface code to application code in response to user-initiated events.
Role: HCI programs are driven by events. The thread of control is therefore a little more complicated than in conventional programming because we seek to give the user control. So instead of the traditional input/output sequence, an interactive application, once initialised, passes its display requirements nad control of execution to interface code, which just "sits there" in the event loop. In a single tasking OS this loop can be a continuous poll, in a multi-tasking environment some kind of event queue is required. The application code is then called back by the event handlers when required.



ANSWER 5

MARKING SCHEME
(a) 5, (b) 5, (c) 5, (d) 5

(a)
questions:

which aisle is product X in
how much have I spent
have I got such and such in my trolley
how do I replace goods in my trolley I don't want
what special offers
what ingredients for specific menus
what on my shopping list
loyalty scheme

(b)
anything sensible, but could include

hand held device with display mounted on joystick
detachable/mountable on supermarket trolley
trigger on joystick for scan item operated by index finger
WAP-phone like roller for browsing (operated by thumb)
buttons for selection (operated by thumb)
swipe for loyalty and credit card

(c)
Some design on RSVP strongly recommended

(d)

Agent	**Owner**	**Role**	**Representation**
Profile	User (Customer)	Maintains user profile, loyalty points, etc.	Genie
System	Software Mfr	Help	Mechanic
Recommender	Retailer	Make recommendations according to profile Menus etc	Butler
Advertiser	Third party	push advertising to user	Advertising executive
Trust	Trusted third party	reliability of recommendations	Banker, GP

ANSWER 6

MARKING SCHEME
(a) 4, (b) 8, (c) 8

(a)
tasks:
enter search terms
interrupt search
browse results
enter personal details
browse bookmarks
add results to bookmarks

(b)
Anything sensible, but break down may be something like
j: use system
0j: search web
u: enter search term
s: search
s: present
*j: browse results
u: select
s: present
0j: browse bookmarks
j: enter details
s: show personal hierarchy
*j: browse
u: select
s: present
j: logoff

where j-s-u is joint-system-user tasks
0x is alternation, *x is iteration

Difficulties are interrupting search (JSD not good at concurrent task), and ability to enter personal use at any time, (not sequential).

(c)
Anything sensible if based on answer to part b.
notation: state to indicate computer dialogue, arc transition between states, labelled with user action, system conditions on traversal, effects on screen display and physical system effects, bold state is start state, square is sub-dialogue
ability to cancel and interrupt is shown in DND
limitations: same action from every dialogue state, same sub-dialogue (e.g. help) from every state, combinatorial explosion of states

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