School: Business and Humanities
Head of School: Mr. Dermot Finan
Examination: Summer 1998

Course: B.Sc. in Business Computing
Stage: 4
Subject: Human Computer Interaction

Examination Date: Mon. 25\textsuperscript{th} May 1998
Examination Time: 2pm

College Examiner: Mr. John Kelleher
External Examiners: Mr. James O’Dwyer
Mr. John O’Kane

Instructions to Candidates

Time Allowed: 3 Hours
No. of Questions on paper: 4
No. of Questions to be attempted: 3
Compulsory Question(s): n/a
Special Instructions: n/a
**Question One**

**STM Experiment**
You have been asked to prepare an experiment to test the properties of short-term memory (STM) decay.  
Devise an experiment to test the hypothesis you put forward. Be specific as to the:
- subjects chosen for the experiment
- experimental method
- conduct of the experiment
- hypothesis you are testing.

What input and output devices would you use for the following systems? For each, compare and contrast alternatives, and if appropriate indicate why the conventional keyboard, mouse, and CRT screen may be less suitable. Provide a rationale for your choice.
- air traffic control system
- tractor-mounted crop-spraying controller
- digital cartographic system (input map information)
- tourist-information system

A commonly proposed interaction framework suggest four major components in an interaction system – the System, the User, the Input, and the Output. Each component has its own language requiring four translations from one component to another. They are:
- Presentation
- Observation
- Performance
- Articulation

Discuss briefly any 2 of the above mappings, explaining the task involved in each.

**Question Two**

**Direct Manipulation**
Discuss the ways in which a full-page word-processor is or is not a direct manipulation interface for editing a document using Shneiderman’s criteria.

**Usability Engineering**
What is Usability Engineering and who pioneered it?

Consider a usability specification for an electronic meetings diary or calendar. Provide an extract of a usability specification concerning the attribute ‘Guessability’, in other words, how easy it is for new users to perform tasks initially. Briefly describe each entry in the specification and its purpose.

Briefly, describe any problems which are associated with usability engineering.

**Design Rationale**
Briefly, give two distinct reasons why access to design rationale is beneficial and to whom.
Question Three

GOMS
Provide a GOMS description of the task of photocopying a paper from a journal. Discuss the issue of closure in terms of your GOMS description. [15 marks]

Prototyping
Sommerville puts forwards several potential problems inherent to the use of prototyping tools, in particular affecting management. He labelled them:

- Time
- Planning
- Non-functional features
- Contracts

Briefly elaborate upon each. [11 marks]

Task Analysis
Mention three distinct approaches to task analysis with a very brief description of each. [7 marks] [33 marks]

Question Four

Participatory design
Participatory design is often discussed in the context of evaluation. How does it differ from other forms of evaluation, such as field studies? Discuss its origins and mention related fields based on similar principles. Why is it not universally accepted? [11 marks]

Protocol Analysis
There are a number of methods for recording user actions. Choose 3 methods and discuss the pros and cons of each. [10 marks]

Groupware Systems
What is groupware and how does it differ (if at all) from Computer Supported Collaborative Work (CSCW)? Draw a time/space matrix to illustrate the various types of groupware. Provide examples for each type of groupware. Mention three (3) aspects of face-to-face conversation that are difficult or impossible to convey in current computer-mediated communications. [12 marks] [33 marks]
Suggested Solutions

Question One

STM Experiment

Subjects
Ideally selected to represent population, more probably undergraduate students (try to get a range of academic subjects). Sample size: 10+

Experiment
Split subjects into two groups. Each subject studies list of 15-20 words (could try with both nonsense words and actual words to see any difference). Subject has to recall list either (a) immediately or (b) after 20 second delay. Measure the number (or percentage) of the words remembered correctly. A within-groups design can be used to avoid individual bias or group variation (as long as different lists are used for each attempt).

Independent variable – delay in recall
Dependent variable – number correctly recalled.

Group (b) should be given a task to do during the delay period in order to avoid rehearsal. If possible this task should occupy a different channel to minimise interference, e.g. a visual recognition task.

Hypothesis
Those in (b) will perform worse than those in (a) since STM will decay.

Input/Output Devices

Air traffic control system
Emphasis on immediately available information and rapid interaction. The controller cannot afford to spend time searching for information, all frequently used information must be readily available.

- Several specialised displays – including overlays of electronic information on radar
- Lightpen or stylus – high precision direct interaction
- Keyboard – for occasional text input, but consider making it fold out of the way.

Tractor-mounted crop-spraying controller
Hostile environment with plenty of mud and chemicals. Requires numerical input for flow rates etc. but probably no text.

- Touch sensitive keypad – ordinary keyboards would get clogged.
- Small dedicated LED display (LCD not good in strong light) and large screens are fragile.
- No mouse or stylus – would get lost.

Digital cartographic system (input map information)
Requires high precision input and output facilities. Similar to CAD in terms of screen facilities and printing, but in addition will require specialised data capture.

- Large high res. VDU (20” or larger) – those tend to be enormously big (front to back). LCD screens more promising though expensive and not yet commercial at large sizes.
- Digitising tablet – for tracing data on existing paper maps. Could also double up as a pointing device for some interaction.
- Possibly thumbwheels – for detailed pointing and positioning tasks.
- Large format printer – possibly A1 or A2.
Interaction Framework

Presentation
Preserves the relevant system attributes from the domain in the limited expressiveness of the output devices.

Observation
The user must interpret the output to evaluate what has happened. The response from the Output is translated to stimuli for the User which trigger assessment.

Performance
Does the interface permit full, rich access to the functionality of the underlying system?

Articulation
Users's formulation of the desired task to achieve some goals needs to be articulated in the input language of the system.

[10 marks]

[33 marks]

Question Two

Visibility of the objects of interest
The most important objects of interest in a word-processor are the words themselves. Indeed, the visibility of the text on a continual basis was one of the major usability advances in moving from line-oriented to display-oriented editors. Depending on the user’s application, there may be other objects of interest in word-processing that may or may not be visible. For example, are the margins for the text on screen similar to the ones, which would eventually be printed? Is teh spacing within a line and the line-breaks similar? Are the different fonts and formatting characteristics of the text visible (without altering the spacing)? Expressed in this way, we can see the visibility criterion for DM as very similar to the criteria for a WYSIWYG interface.

Incremental action at the interface with rapid feedback on all actions
We expect from a modern word-processor that characters appear in the text as we type them on the keyboard, with little delay. If we are inserting text within a paragraph, we might also expect that the format of the paragraph adjust immediately to accommodate the new changes. Various word-processors do this reformatting automatically, whereas other do it occasionally or only at the express request of the user. One of the other important actions, which require incremental and rapid feedback, is movement of the insertion point, usually by means of arrow keys. If there is a significant delay between the input command to move the insertion point down one line and the actual movement of the cursor on screen it is quite possible that the user will ‘overshoot’ the target when repeated pressing the down-arrow key to move down a few lines on the screen.

Reversibility of all actions, so that users are encouraged to explore without the severe penalties
Single step undo commands in most word-processors allow the user to recover from the last action performed. One problem with this is that the user must recognise the error before doing any other action. More sophisticated undo facilities allow the user to retrace back more than one command at a time. The kind of exploration this reversibility provides a word-processor is best evidenced with the ease of experimentation that is now available for formatting changes in a document (font types and sizes and margin changes). One problem with the ease of exploration is that emphasis may move to the look of the document rather than what the text actually says (style over content).

Syntactic correctness of all actions, so that every operation is a legal operation
WYSIWYG word-processors usually provide menus and buttons which the users uses to articulate many commands. These interaction mechanisms serve to constrain the input language to only allow legal input from the user. Document production systems, such as troff, TeX, and Scribe, force the user to input textual commands (which may be erroneously entered by the user) to achieve desired formatting effects.
Replacement of complex command languages with actions to manipulate directly the visible objects

The case for word-processors is similar to that described above for syntactic correctness. In addition, operations on portions of text are achieved many times by allowing the user to directly highlight the text with a mouse (or arrow keys). Subsequent action on that text, such as moving it or copying it to somewhere else, can then be achieved more directly by allowing the user to ‘drag’ the selected text via the mouse to its new location.

Usability Engineering

Pioneered by Nielsen (at Bellcore) and Whiteside (at IBM and DEC), Usability Engineering (UE) is an approach to user-centered design based on explicit usability goals during the design process. Engineering depends on interpretation against a shared background of meaning, agreed goals and an understanding of how satisfactory completion will be judged. The emphasis for usability engineering is in knowing exactly what criteria will be used to judge a product for its usability.

| Attribute: | Guessability |
| Measuring Concept: | Ease of first use of system without training |
| Measuring Method: | Time to create first entry in diary |
| Now Level: | 30 seconds on paper-based system |
| Worst Case: | 1 minute |
| Planned Level: | 45 seconds |
| Best Case: | 30 seconds (equivalent to now). |

UE relies on measurements of very specific user actions in very specific situations. When the designer knows that what the actions and situation will be, then he can set goals for measured observations. However, at early stages of design, the designers do not have this information. This may well cause the designer to focus on the solution to a new problem without addressing a perhaps-flawed initial design decision.

UE also places the designer in the position of judging what constitutes a better design for all users. He may satisfy a usability goal but this may not improve usability for the user.

Design Rationale

1. In an explicit form, a design rationale provides a communication mechanism among the members of the design team so that during later stages of design and/or maintenance, it is possible to understand what critical decisions were made, what alternatives were investigated, and the reason why one alternative was chosen over the others.
2. Accumulated knowledge in the form of design rationales for a set of products can be reused to transfer what has worked in one situation to another situation which has similar needs.
3. The effort required to produce a design rationale forces the designer to deliberate more carefully about design decisions.

Question Three

GOMS

GOAL: PHOTOCOPY-PAPER
GOAL: LOCATE-ARTICLE
GOAL: PHOTOCOPY-PAGE repeat until no more pages
   GOAL: ORIENT-PAGE
   OPEN-COVER
   SELECT-PAGE
   POSITION-PAGE
   CLOSE-COVER
GOAL: VERIFY-COPY
   LOCATE-OUT-TRAY
EXAMINE-COPY

GOAL: COLLECT-COPY
LOCATE-OUT-TRAY
REMOVE-COPY (outer goal satisfied)

GOAL: RETRIEVE-JOURNAL
OPEN-COVER
REMOVE-JOURNAL
CLOSE-COVER

The closure problem which appears in this example occurs when the copy of the article is removed from the photocopier out tray, satisfying the overall goal for the task. In the example, the original paper is still on the surface of the photocopier and the cover is closed. The user could easily forget to remove the journal.

Prototyping problems

Time
Building prototypes takes time and, if it is a throw-away prototype, it can be seen as precious time taken away from the real design task. Hence, the value of prototyping is only appreciated if it is fast. However, rapid development and manipulation of a prototype should not be mistaken for rushed evaluation which might lead to erroneous results and invalidate the only advantage of using a prototype in the first place.

Planning
Most project managers do not have the experience necessary for adequately planning and costing a design process that involves prototyping.

Non-functional features
Often the most important features of a system will be non-functional ones, such as safety and reliability, and these are precisely the kinds of features that are sacrificed in developing a prototype.

Contracts
The design process is often governed by contractual agreements between customer and designer that are affected by many of these managerial and technical issues. Prototypes cannot form the basis for a legal contract and so an iterative design process will still require documentation that serves as a binding agreement.

Task Analysis

Task decomposition
Looks at the way a task is split into sub-tasks and the order in which these are performed.

Knowledge based techniques
Looks at what users need to know about the objects and actions involved in a task, and how that knowledge is organised.

Entity-relation based analysis
Is an object-oriented approach, where the emphasis is on identifying the actors and objects, the relationships between them and the actions they perform.

Question Four

Participatory Design
Participatory design is a philosophy that encompasses the whole design cycle, not just evaluation. It represents design in the workplace, incorporating the user not only as an experimental subject but as a member of the design team. Users are therefore active collaborators in the design process,
rather than passive participants whose involvement is entirely governed by the designer. The argument is that users are experts in the work context and a design can only be effective within that context if these experts are allowed to contribute actively to the design. Participatory design has three specific characteristics. It aims to improve the work environment and task by the introduction of the design. This makes design and evaluation context- or work-oriented rather than system-oriented. Secondly, it is characterised by collaboration: the user is included in the design team and can contribute to every stage of the design. Finally, the approach is iterative: the design is subject to evaluation and revision at each stage. Participatory design originated in Scandinavia, where it is now promoted in law and accepted work practices. Although principles have been adopted from the approach elsewhere, it has not been widely practised. This may be due to the time and cost involved in what is, by definition, a context-specific design, as well as the organisational implications of the shift of power and responsibility. Participatory design is similar to other ethnographically based design approaches.

**Protocol Analysis**

**Paper and Pencil**
Primitive, cheap, allowing analyst to note interpretations and extraneous events as they occur. Limited by speed of writing though coding schemes to record ‘typical’ or ‘common’ events may be used.

**Audio Recording**
Useful for user ‘thinking aloud’. Difficult to indicate on tape actions occurring in time.

**Video Recording**
Can see what the user is doing (within camera range); Care must be taken with camera positions and angles to yield viewable results. Implicitly restricts user movement (unnatural). Typically need 2 cameras.

**Computer logging**
Relatively easy to have system automatically record key-strokes/mouse movements, though difficult with proprietary software. Documents nothing about why keys were pressed and errors arising from same. Cheap and suitable for long-term studies, though volume of data can pose analysis problems.

**User notebooks**
Subjects themselves asked to keep logs of activity/problems. Coarse level to avoid being intrusive on user’s work. Provides user’s opinions though that may be his opinion hours after the incident and therefore somewhat muted.

**Groupware Systems**
One major area within CSCW is the provision of computer systems to support group working. Groupware can be classified by where and when the participants are performing the cooperative work. This is summarised by a time/space matrix.

<table>
<thead>
<tr>
<th></th>
<th>Same place</th>
<th>Different place</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same time</td>
<td>Face-to-face conversation</td>
<td>Telephone</td>
</tr>
<tr>
<td>Different time</td>
<td>Post-it note</td>
<td>Letter</td>
</tr>
</tbody>
</table>

Eye contact and gaze, Gestures and body language, back channels, confirmation and interruption, turn taking, transfer effects and personal space.