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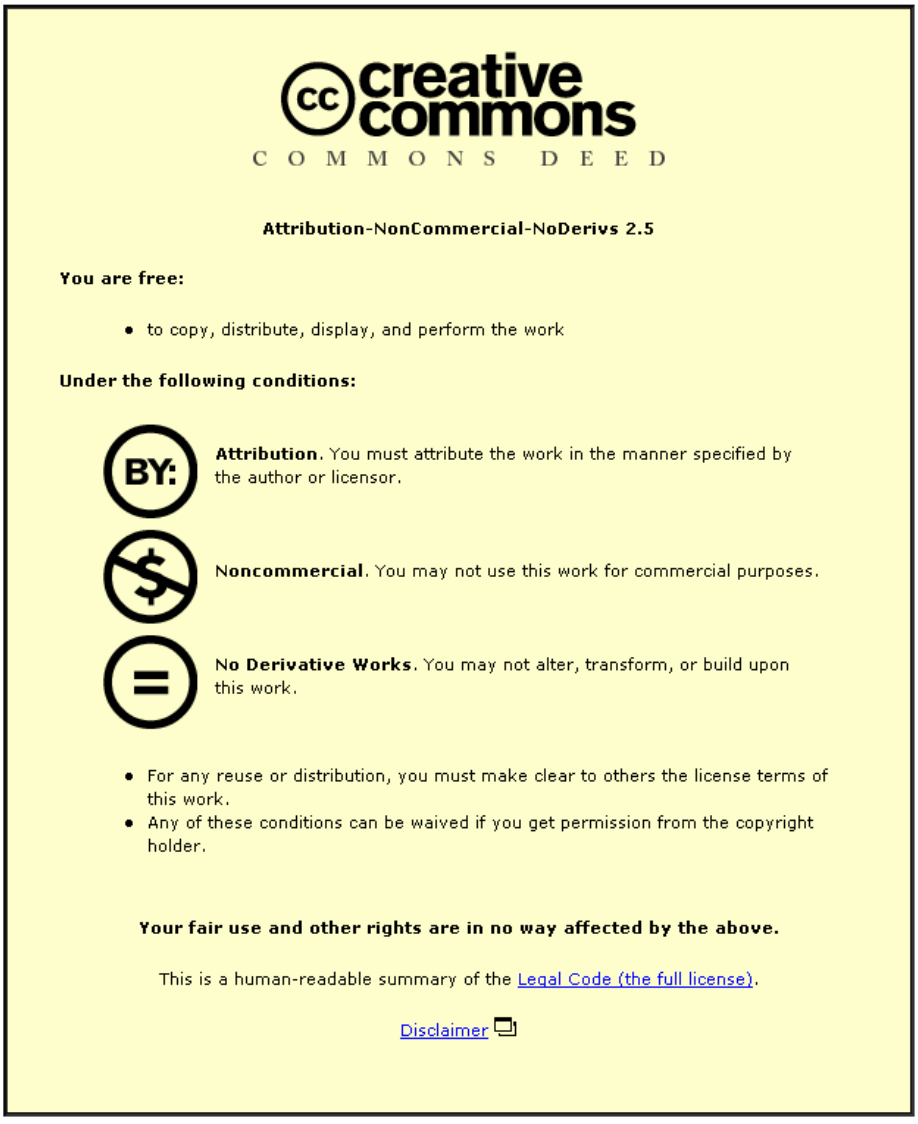

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Developing advanced interface design guidelines from survey based and empirical research

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Abstract
The Guideline project is concerned with the interface and interaction issues of consumer product control and display devices. The main objective of the project is to produce interface design guidelines for emerging or advanced consumer based products for interaction and product designers. The information for the guidelines is being produced using two different approaches; these are empirically based guidelines produced within the project, using software based prototypes of three anticipated advanced interfaces, and information gathered from relevant human computer interaction (HCI) literature. This paper presents an account of the project as a case study and documents some of the findings that have emerged so far.

Introduction

The Guideline project is concerned with the interface and interaction issues of consumer product control and display devices. It is a three year programme funded by the Engineering & Physical Sciences Research Council. The main objective of the project is to produce interface design guidelines for emerging or advanced consumer based products. As electronic consumer based products pervade more and more into different aspects of social life, for example personal digital assistants (PDAs), VCRs and microwaves, the user/product interaction is becoming more complex. This project, therefore, aims to gather information together that will assist interaction designers and product designers to design products which retain effective and usable interfaces. The information will be provided in the form of design guidelines which are being produced using two different approaches, these are:

- empirically based guidelines produced within the project using software based prototypes of anticipated advanced interfaces
- information gathered from relevant human computer interaction (HCI) literature and converted into design guidelines

We have two collaborating partners in the programme, Electrolux and Raychem. To support Electrolux in their own development programme we are initially focusing on a washing machine interface as one of the main 'evaluation' tools for our research. Raychem are interested in the successful implementation of a user centred approach to product development and are therefore involved in the design and appropriate implementation of the guidelines which will be used by designers and non-design specialists. They are also providing support on display technology. We are using other organisations to assist in producing effective design guidelines.

This paper presents an account of the project so far as a case study. The work is still in progress and therefore some research avenues have yet to be explored. As this is a case study and reports only the activities that have been undertaken in the project, this paper is more documentary rather than providing any academic critique at this stage. The stages and process of the project are described diagramatically in Figure 1.

Literature review and building of database

The project began in March 1996. We have completed a comprehensive literature review with over 1000 references related to the development of advanced interfaces (about 80% of these are full references). The basic strategy was to conduct searches in five key areas; these included:

- basic ergonomics principles that can be used and understood by designers in the context of interface design;
- research work in the fields of HCI,

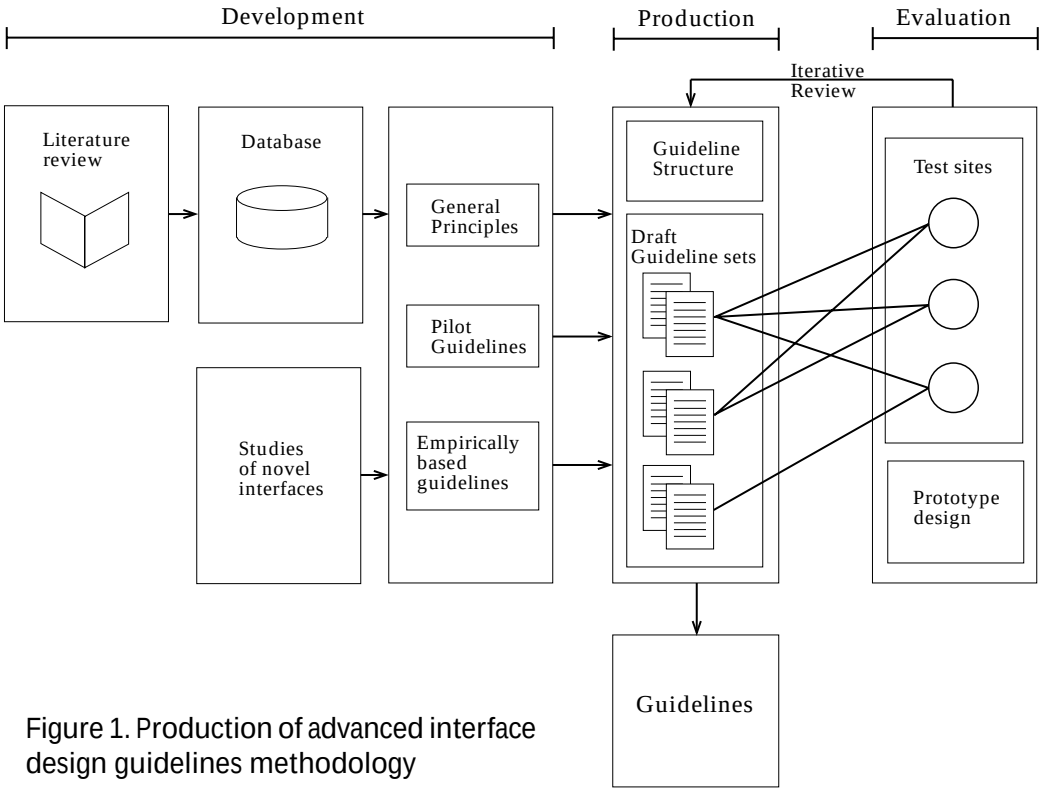

Figure 1. Production of advanced interface design guidelines methodology

ergonomics and industrial design concerned with innovative input and output devices that can be applied to consumer products;
- issues related to the successful and unsuccessful implementation of guidelines into organisations;
- the evaluation of prototype interfaces; and
- gaining an awareness of other related research programmes both national and international.

All abstracts from papers along with summaries of other source material were entered into a database, resulting in a broad ranging interrogation resource tool where key topic areas can be retrieved from the database for the development of guidelines. Although the information domain was large, we decided to adopt a divergent approach to data collection, in order to develop a broad overview of the subject area and capture as many related topics as possible.

The database includes topic areas such as:
- Haptic interaction (three dimensional form and touch): graspable controls, control tactile feedback, touch sensitive devices, morphing interfaces
- Auditory interaction: auditory icons or earcons, music, voice control and recognition
- Kinaesthetic interaction: pointing and manipulating within a 3D virtual environment, field sensing devices, finger operated controls, flying mouse, gesture controls, glove controls, joysticks, pen controls, virtual input devices, eye input devices, using facial expressions as an input device, full body interfaces, head movement interaction
- Dynamic visual interaction: animated images, scroll sliders, facial expression as an output device, graphic representation of complex information
- Static visual interaction: graphic composition, iconic representation, pictorial space, text based dialogues, hypertext

One of the important tasks that we undertook with the literature review was to identify gaps in research. These gaps were determined largely by identifying information that we felt was needed and could not be found or other authors had identified as lacking. There is

virtually no published information or design guidelines[1, 2] on intelligent or adaptive interfaces for consumer products but a reasonable amount on computer based applications [3,4]. However, many of these papers tended to focus on the architecture of the intelligent interface rather than usability issues. Further attention needs to be placed on precise definitions and a deeper understanding of terms such as interaction, intelligent and adaptive interfaces. We found little information about consumers as users of products and the similarities or differences between them and computer users. There is very little development work in the public domain focusing on advanced interfaces for products for example using state-of-the-art displays to convey information[5]. Although, some attention has been given to the development of design guidelines for users with special needs. [6,7,8,9]

Development of guidelines based on the literature

Once a reasonable body of material had been gathered, a critical review of the literature was undertaken at two levels.

- General ergonomics principles that will underpin the guidelines and provide a context in which they can be developed.
- Literature related to innovative or novel control or display devices that could be converted or used as interaction design guidelines for industrial designers.

The first critical review was important to extract from the literature a set of general principles that designers could understand and use. This would set the guidelines into context by outlining a 'user centred' approach to the design of advanced interfaces. The general principles would also bring a common design approach to the guidelines as designers have many different viewpoints and strategies to designing a product.[10,11]

The second critical review was aimed at seeking any published literature which would provide a picture of the types of existing and emerging devices that are being developed. It quickly became apparent that this type of information was more readily available in conference proceedings and other more 'grey' sources such as the World Wide Web. Much of the material has contributed towards the development of pilot guidelines and can be viewed as 'raw' guideline material.

Development of empirically based guidelines

To supplement the guidelines produced through the HCI literature, this project is also producing empirically based guidelines. The rationale for this is threefold. Firstly, we felt that we could monitor and therefore learn about the process of designing and evaluating advanced interfaces by going through the process ourselves. This process would enable us to produce process based guidelines and also provide first hand experience of how the guidelines should be structured. Secondly, it would provide an opportunity to explore emerging interaction styles from a human factors perspective and thirdly we would be able to assess different prototype evaluation methods that are best suited to interface designers. The intention is that the results of the user trials will be generic enough apply to a wide range of other consumer products.

Decisions about what type of advanced interface should be evaluated was dependent upon identified gaps in the literature, anticipated technological trends found in the literature and also discussions with Raychem and Electrolux. This included reviewing the findings from consumer survey reports on white goods. From this some general user requirements could be established.

Three types of interfaces were developed on the basis of these constraints above. All prototypes were principally based on allowing consumers to customise and select default washing programmes. The selected interfaces are:

- Control devices for setting 'vague' washing parameters using abstract graphical images to present program selections. Some of the questions that have been posed are: How do users interact, perceive and understand graphical abstract representations of product functionality? Do users feel confident about selecting vague settings (e.g. changing temperature settings using colour representation rather

Figure 2. Example of 'direct manipulation' touch screen for a washing machine control panel

than numerical values)

- Touch screen, finger controlled 'direct manipulation' (e.g. moving symbols or icons on a display panel to 'design or build' a washing programme). Some of the questions posed are: How effective is it to manipulate icons on a touch screen panel? What are effective feedback mechanisms for touch screen controls? This interface example is given in Figure 2.
- Using the addition of auditory displays to describe washing programs. Some of the questions posed are: What level of tolerance users have of auditory displays? What do users understand and prefer to different types of auditory displays?

A 'contemporary' washing machine has also been produced in software prototype form to act as a control during the evaluation. The pilot studies have been completed and the first round of empirical studies will start in June 1997. There will be two experimental trials (excluding the pilot). A range of structured evaluation methods will take place noting actions such as errors, behavioural patterns and user perceptions. The findings of the trials along with the design and development process will contribute to the guidelines.

Production of guidelines content and structure

The next stage, which is still being undertaken, was to ask designers, at the two test sites (Electrolux and Raychem), what type of information they would like so that we could deliver appropriate and relevant guidelines to design projects currently underway as guidelines are rarely developed in this way [12]. Each test site includes a small group of product designers who require ergonomics information during their design activity. The number of test sites has increased to include a larger number of designers, including a further design centre in Electrolux and a design group at NCR in Scotland. This will help widen the scope of design issues demanded from the guidelines. Each test site is providing about six to eight interaction design questions that may help answer their own current design issues and problems.

In response to these questions, a small set of guidelines are returned to the designers which attempt to answer the original questions. A few weeks later a questionnaire is sent to the designers to establish their relevance, appropriateness and changes which should be made in order to improve the guidelines. This process will be iterative. This approach allows a 'user-centred' philosophy to be applied to the design of guidelines themselves.

Guidelines, by their nature, are often difficult to develop and use [13, 14]. The most common problem being the ability to provide guidelines at the correct level of support: they are often criticised for being either too general or too specific. While the difficulty can never be ameliorated completely, attempts have been made to structure the guidelines to overcome this and other problems as much as possible. The first stage was to develop a 'descriptor' model at a small workshop with designers from Electrolux to examine this problem. The aim of the workshop was to devise a high level taxonomy that would accommodate existing interaction styles as well as those yet to be defined. The workshop resulted in a simple nine celled matrix. However, under closer scrutiny this proved to be too simplistic and not robust enough to explain all interaction styles. The second 'descriptor' model has been more successful in attempting to define advanced interfaces and interactions by categorising devices at a 'sensory' level. That

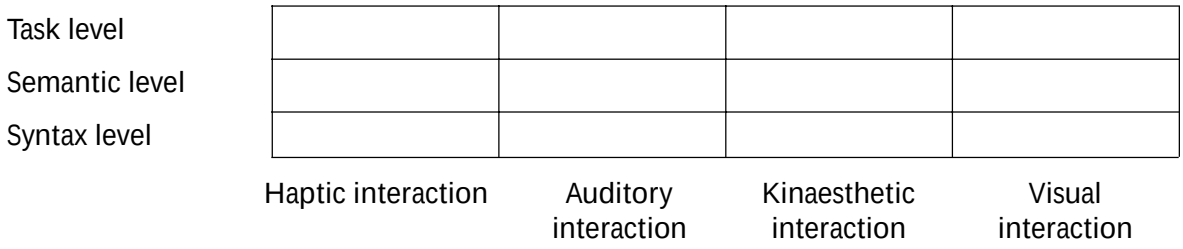

Figure 3. Current taxonomy for guidelines

is to say, the primary human sensory organ which is used for the device governs its classification.

Obviously many devices can fall into one or more categories where more than one sense is used extensively. This 'descriptor' model was also limited in that it focused on isolated devices and does not relate to complex interactions, for example multi-modal interaction or how the interface communicates its functionality. What is required is a model of interaction describing the user's conceptual model of the interface as well as describing the physical actions. Furthermore, this model would have to map onto the design process in order to be used effectively. Currently, a simple taxonomy categorising guidelines by interaction level and main interaction sensory channel is proposed. This is presented in Figure 3. This taxonomy has yet to be validated using the test sites. Undoubtedly this will alter over time. One obvious problem is the lack of design context in which the guidelines could be used. Our research, so far, suggests that some form of selection activity should take place before the guidelines are used. This selection activity should establish the designer's needs for the guidelines before any are suggested.

Future work

We are currently at the stage where the first version of the draft guidelines are being evaluated. Once we have received sufficient feedback, a second generation of guidelines will be produced. It is also anticipated that advanced interface prototypes will be developed using the guidelines more extensively later on in the project in a more controlled environment. One solution may be to use student projects as a mechanism for assessing the guidelines using a set interface design project. Furthermore, we are attempting to devise a field experiment where we can assess differences in design output between design projects that have used the guidelines against a design project without them.

Summary

Providing usable guidelines is both challenging and ambitious and the work so far has produced some issues that will have to be considered. The topic area has proved to be very wide and diverse, making the management and categorisation of such data difficult. The limitations of guidelines must also be a part of the development strategy and it should always be recognised that design guidelines should be a part of a larger tool set. The problems are further compounded in that product designers traditionally tend not to develop design solutions using highly formal methods. This makes the introduction of guidelines more difficult as stages in design development are less rigid.

Designing and developing advanced interfaces for the purposes of the project has been invaluable and provided a useful insight into the process. There have been many occasions where we have had to make intuitive design decisions because design guidelines were not available. This has helped in understanding what type and when guidelines should be provided.

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