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Dynamically modelling interaction

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Abstract

Technological advances are increasing the use of dynamic or changing displays, in many forms of interface. The increasing amount of information held on the Internet and in private government and commercial databases also requires more innovative approaches to retrieval and browsing than existing text-based search engines can provide.

There is recurrent interest in the possibility of being able to move through a virtual representation of data (e.g., the 'Information Visualiser' [RCM93]), requiring the representation to change dynamically in correspondence with the user's changing location or point-of-view. Dynamic aspects of interface design are not currently well understood theoretically, and are not supported by existing design principles, and are a common locus of interaction errors, and arise when elements on the screen mo ve or alter their appearance, windows open and close, and when the whole screen display is replaced by a new screen, independent of or dependent upon user interaction.

While designers are often concerned with the location and layout of static aspects of their interfaces, there is less awareness of the usability difficulties caused by the unpredictable changes in screen location or appearance of interface elements when the screen changes as part of the interaction. As a consequence, these problems are all too common. An interface technique will be adopted because the designer has seen it, or something similar, used elsewhere [CKR91]. This imitative design does not limit itself to using other interfaces as source material. For example, Koons et al [KOFL92] reported that "as designers, we selected elements and styles from each of the areas from which multimedia is evolving: print, television and computers."

Recommendations have been made that designers look to domains ranging from 'form-giving' [KOFL92], to Stage Magic [Tog93]. While many of these domains have interesting parallels with HCI, it is sometimes difficult to see exactly how their craft skills can be transferred to the design of interfaces. I argue that this can only be overcome by an appropriate form of theory, embodied within supportive evaluation techniques which not only identify usability problems, but give designers insight into potential solutions.

An analogy has been made in my previous work between designing display dynamics and the editing of motion picture films, where the editor and director cut different camera shots together in a way that is consistent with the viewer's expectations and perceptual behaviour. A major difference between film and interface design is the relative absence of narrative in human computer interaction, compared to film watching, and the stronger role played by the user's task goals in guiding the interaction. A current project focuses on the empirical validation of the analyses, its extension from the domain of cinematography to interface design, and the development of the supportive evaluation techniques [MBD03]. In this area a century of craft-based skill has been accumulated, and the parallel of early film-theory with HCI is instructive. No sooner had theorists begun to develop theories of montage for the early black and white, silent films, and had started to experiment with multiple simultaneous screens, than they were overtaken by technological change and the introduction of sound, and then colour. Multi-windowing and other complex forms of narrative, which had been used by the avant-garde, were discarded. In the place of a considered theoretical base of knowledge about the form and structure of films, 'rules-of-thumb' have been developed, ranging from the types of cutting between scenes that will be acceptable to an audience, to camera angles and rates of camera motion.

Due to the experiential way in which these rules have been

acquired by film-makers, it is difficult to know when to apply them, or to justify using one rule rather than another. They are all part of the 'craft' of film, learnt through practical application in the film industry, and grounded in the domain of film technology. This makes it difficult to extrapolate directly to the comprehension of display dynamics in general, and to computer interfaces in particular, and even if we could it is debatable whether we should, for there are many differences between the essentially passive experience of watching a narrative film and the interactive, goal directed, experience of using an interface to perform some task. Film scenes are usually of one coherent physical setting, whereas computer interfaces portray several, unconnected views of information related to different tasks.

The approach that I have been pursuing is therefore to search for a correspondence between existing cinematographic guidelines and cognitive theory [MBD03]. Of particular interest to us is the way that different shots can be cut together, for in these situations the whole view portrayed on the screen changes, and yet viewers can quite easily make sense of a sequence of shots, and may not even notice the cuts. By explaining why certain forms of film cutting work and others don't in terms of the viewer's information processing resources, we have shown that it is possible to derive principles that can be applied to the perception of dynamic scenes in general. Twenty years ago, an attempt to develop a cognitive explanation of film theory [Hoc86] succeeded in identifying a number of organisational principles that could account for a range of motion and spatial phenomena in video displays, but because these principles were not linked to a wider psychological body of knowledge, it has not proven possible for succeeding theorists to build on the work, nor for it to transfer into applied or practical settings. By expressing cognitive principles in a form compatible with wider psychological knowledge, we have gone beyond the source material, to make recommendations that are applicable to interactive display dynamics in general.

I use Interacting Cognitive Subsystems, ICS [MB03], to model cognition. ICS is an approximate modelling approach which operates at the level of information flow, and allows us to reason about cognition without implementing it. As an abstract theory, it is suitable for encapsulation within supportive evaluation techniques (SET notations) that can be transferred across domains and evolving technologies. Changes in the screen display that are not coherent with the viewer's comprehension divert processing resources towards understanding the novel scene, relocating the key objects, and reorientation with the spatial layout of the scene, thus interrupting comprehension. The diversion of processing resources from task performance to interface comprehension lies at the heart of our analysis of usability problems in dynamic interfaces: when the changes in the screen display make it hard for the user to know where to look to continue their task, usability suffers.

The ideal display change within a task is one that passes unremarked by a user who is concentrating on their task, and who is not interrupted by the change. When switching between tasks, though, the display dynamics may need to interrupt the user, to ease their transition. This requires designers to have an understanding of the user's conceptual structuring of the task, and of the way that the visual structure of the display can help or hinder the location of information. To make a start at understanding how the attributes and location of the psychological subject of a scene, and its predicate structure, can be manipulated in computer displays, we have identified three broad classes of display dynamics:

Scenic Change - collocation

If the display changes (e.g., a new window appears) and offers a new structure that has an element located close to the preceding subject, this will become the user's new focus of processing. This is a transition by collocation.

Scenic Change - translation

If the display changes, and the new structure does not contain an element that is located close to the preceding subject, the user will establish a new focus either by retopicalizing upon a translation of the previous subject (i.e., in a new location on the screen), or on another significant element. Any new subject will be determined by the salience of the elements of the new structure and their proximity to the previous focus.

Structural Change

If the display does not change entirely, but the structure is altered by changing elements, or the attributes of some elements (e.g., brightness, size or colour), then the user may make an involuntary transition to a new focus.

In these three generalizations we distinguish between a 'scenic change' where the complete structure changes and a 'structural change', where elements of the structure move, or their attributes are altered. This last type corresponds to the 'jump cut', which is generally regarded as 'unfilmic' because of its propositional consequences for the narrative, but which for the same reasons may be valuable in a computer interface, since it serves to interrupt processing and attract the user's attention to the incongruous element of the display.

The main aim of my current research is to build on the existing theoretical analyses by gathering empirical evidence about their accuracy and applicability within computer interface design. This ensures that the results of this research are embedded within ICS theoretical development across domains and research projects, and so influence future work.

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