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Interacting with Future Computers

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Abstract

Many problems that have to be solved in present day humancomputer interfaces arise from technology limitations, quite apart from those arising from lack of appropriate knowledge. Some of the progress we see in the most recently developed interfaces has occurred simply because bit-mapped screens, large memories, colour, compute-power appropriate to local intelligence, and the like, have all become inexpensive at the same time as rising human costs have finally been appreciated, and deprecated, by those who pay the bills. The new technical possibilities, and the now obvious economic advantages of providing *good* interactive computer support to enhance human productivity in all areas of endeavour has created tremendous pressure to improve the human-computer interface. This pressure, in turn, has dramatically highlighted our lack of fundamental knowledge and methodologies concerning interactive systems design, human problem solving, interaction techniques, dialogue prototyping and management, and system evaluation. The design of human computer interfaces is still more of an art than a science. Furthermore, the knowledge and methodologies that do exist often turn out to fall short of what is needed to match computer methods or to serve as a basis for detailed algorithm design.

The paper is addressed to a mixed audience, with the purpose of reviewing the background and current state of human-computer interaction, touching on the social and ethical responsibility of the designer, and picking out some of the central ideas that seem likely to shape the development of interaction and interface design in future computer systems. Areas are suggested in which advances in fundamental knowledge and in our understanding of how to apply that knowledge seem to be needed to support interaction in future computer systems. Such systems are seen as having their roots in the visionary work of Sutherland (1963), Englebart and English (1968), Kay (1969), Winograd (1970), Hansen (1971), Papert (1973), Foley and Wallace (1974), and D. C. Smith (1975). Their emphasis on natural dialogue, ease of use for the task, creativity, problem solving, appropriate division of labour, and powerful machine help available in the user's terms will still be crucial in the future: However, the ability to form, communicate, manipulate and use models effectively

will come to dominate interaction with future computer systems as the focus of interactive systems shifts to knowledge-based performance. Human-computer interaction must be regarded as the amplification of an individual's intellectual productivity by graceful determination and satisfaction of every need that is amenable to algorithmic solution, without any disturbance of the overall problemsolving process.

1. Introduction

1.1. A prospectus

A non-technical vision of the future possibilities for human interaction with computers has been provided in a variety of media including several recent movies. The story that really centered on this interaction and interplay was that involving HAL, the shipboard control computer for a voyage to Jupiter, following the summons of an alien intelligence (200 J: a Space Odyssey, by Arthur C. Clarke). More technical views have been provided, at least in part, by developments in the field, documented in the technical literature, but on a piecemeal, scattered basis. Two recent surveys of directions in humancomputer interaction concentrate on the application of Artificial Intelligence (AI) to interactive interfaces (Rissland 1984, Vickery 1984) and highlight the increasingly important role seen for AI in future human-computer interaction. The Architecture Machine Group (AMG) project, which has been underway at MIT since 1976, provides one of the more ambitious non-fictional views of future interaction. It is based on the exploitation of spatiality and other normal properties of evolved human perceptual motor performance in a computersimulated 'Dataland', and is intended to complement more conventional forms of interaction (Bolt 1979, 1980, 1982, 1984). However, HAL serves as an important different view of possible integrated interfaces of the future, all the more powerful because the view is set in the context of a real task, but forms the background and plausible context for action, rather than being the focus. As in the past (with submarines, space flight, and the weapons of war) art suggests and defines the future goals of our technology.

1.2. Why better interfaces?

In the last year or two, there has been an upsurge of interest in providing better ways for people to interact with information processing systems. There are at least two reasons for this. First, it has become apparent that poor interfaces make it more difficult for users of computer systems (including computer science experts) to do their job. Better interfaces improve productivity, reduce errors, and allow higher quality results. They give a competitive edge to their suppliers and, incidentally, make the users more comfortable in their work. With falling hardware costs and rising labour costs, the emphasis has changed from utilizing machines to their maximum capacity to utilizing their human users and operators to best effect. For once, this is a trend that also benefits these people directly.

Secondly, computers are becoming very widely used, even in areas and in equipment that have previously not been associated with computers. The users of computers, in these circumstances, frequently have little or no computer training and, collectively, may exhibit the whole gamut of educational and career achievement in their various specialities. For such people, the computer should appear as a tool, interfaced in such a way that the user can think about the task goals for which the system is used, rather than the characteristics of the computer tool used to achieve these goals. Some systems must carry the computer power so deeply embedded that it is effectively hidden, just as the electric motor in a dishwasher or clock is hidden. The interface seen by the user is completely task-oriented, and the internal logic of the system (programmed, even in the case of non-computer equipment these days) translates the user's needs into the control and/or power signals required to employ the technology as a subsystem. Of course, the user may well be aware that a computer (or motor) is in there doing essential things, but does not have to be concerned with its characteristics.[1]

1.3. Th economic imperative

Thus, so-called *user friendly interfaces* have become the touchstone for the more widespread and effective use of computer power. Such interfaces have a direct economic and social impact, to the extent they succeed or fail. They allow the computer industry generally to expand markets, hence creating new jobs within the computer industry. Good interfaces also allow other companies that use the new computer power to be more productive and competitive, which may not only expand their existing market shares but also lead to new markets for information technology in previously untouched application areas. There is a warning here for those societies that feel they can remain as mere users of the new technology. Future markets will increasingly deal in the products of the new information technology industry, with employment in traditional areas declining as the new machines make the remaining employees more productive. Balance of payments problems will explode for those countries that face the need to import the new technology to remain competitive, through failure to develop it themselves.

1.4. The basis for progress

A few years ago the graphics area in computer science expanded dramatically as the need, the methodology, and the technology appeared or were generated. Advertising, film-

[1] The analogy to embedded motors was first suggested by Weizenbaum 1975).

making, and design have provided much of the finance and incentive to the graphics expansion. Now that costs have fallen (as research has been amortized, as mass-market software has been developed, and as mass-produced hardware tailored to the specific needs of computer graphics has started to appear), computer graphics is providing part of the base for better human-computer interface design. Other technologies are starting to mature: expert systems; low-cost very powerful desktop computers with high-resolution colour displays; dialogue prototyping and management systems; databases and database access methods (especially limited natural-language-based access); new kinds of input-output devices that are also inexpensive (speech input-output devices, innovative direct manipulation media, etc.); and so on. It is now commonplace to do things that were not possible even as recently as two years ago. Not only does this allow new approaches to human-computer interfacing but it also allows sophisticated interfaces to be created quickly and at low cost. This, in turn, facilitates better and more diverse experimentation related to human-computer interaction, as part of the research needed to expand the body of knowledge concerning the methods and goals of human-computer interface practice.

1.5. The promise and the problem

The Apple *Macintosh*, developed from the *Lisa* (Williams 1983, Morgan et al. 1983) is an example of a current popular application of both new technology and new knowledge. The technology and experience that made this approach to computing possible has its roots in the visionary work of Sutherland (1963) who invented the first 'graphics-land', with elegant graphical interaction techniques, employing unobtrusive machine assistance, to amplify the drawing skills of the draughts-person unconcerned with the technicalities of computers; of Englebart (1968), who originated the mouse and computer-augmented human reasoning at SRI; of Kay (1969, 1972) who developed the first higher-level personal computer, object-oriented programming with windows and multiple views, systems based on message-passing primitives, and simple personal programming systems of great power; of Papert (1973, 1980) who, following in the traditions of Piaget and Montessori, used computers to show how complex ideas could be taught easily when translated into concrete terms in an environment in which it was easy and enjoyable to experiment, catering to the growth of the child rather than mere provison of information; of Foley and Wallace (1974), who made a notable early statement of rules for natural graphical 'conversation'; and of D. C. Smith (1975) who developed direct manipulation and the 'icon' as the basis for computer-aided thought using 'visualization', inspired by the visual simulations and animations of *Smalltalk*, Kay's system. But the *Macintosh* would not have been possible as a popular personal computer without technological advances in microchip design and fabrication, allowing cheap memory and processing power as a basis for bit-mapped graphics, speed, and powerful interactive software. Now we have the Atari 1040 ST that offers similar facilities not for US$2500, but for US$900, and the Commodore *Amiga* at US$1200, both with higher resolution and excellent expansion capabilities.

In the face of this technological cornucopia coupled with an abundance of relevant ideas, it is becoming increasingly clear that interface design is still an art, and that art is being severely taxed as the purely technological limitations disappear and as an increasingly large number of would-be users are able to afford the hardware to support their activities. The remainder of this paper leads up to a discussion of themes and ideas that will be important in interacting with future computer systems (in Section 6). In preparation for this, three important issues are addressed: (a) the ethical and practical constraints on the application of future computers, since these form the context and rationale for interaction; (b) the distinction between *programmers* and *users*, and the nature of the programming task, since programming is an important form of interaction with computers; and (c) the game element in human-computer interaction, because evidence suggests it may be possible to improve interfaces by exploiting some features of games. In Section 5, a futuristic database access system (Rabbit, Williams 1984) is described, because it begins to incorporate ideas that seem crucial in future computer systems interfaces. Finally, there is the discussion. The central theme in future humancomputer interaction will be the formation, representation, communication, manipulation and use of models. Other important themes comprise redundant, multi-modal interaction techniques; and the specification and management of interaction. These are addressed.

2. A context for future interactive systems

2.1. Introduction: the 'do it', or abdication model of interaction

The easiest way to get something done is to ask a competent loyal assistant or colleague to do it for you or, if your involvement is necessary, to assist you in doing it. Given appropriate talent, this may be even more effective than doing it yourself. The metaphor has been used before in the context of a programmer's assistant (Teitelman 1972, 1977), and tends towards one extreme in the continuum of views of the user interface. This extreme looks for an active, intelligent, reasoning mediator that lies between the user and what is to be done. The other regards the interface as a simple passive 'gateway' or membrane between a user and the application (Rissland 1984), that can be tailored to particular needs, perhaps, but is simply

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