

HUMAN-COMPUTER INTERACTION

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David Benyon

After graduating in 1974 David worked as a systems analyst in a software house before becoming a senior systems analyst-designer at a large Leicester-based knitwear company. He left in 1980 and joined Leicester Polytechnic (now De Montfort University) as a lecturer in systems analysis and design. In 1983 he obtained an MSc in computing and psychology and began to concentrate on the human aspects of computer systems. He joined the Open University in 1987 where he has developed distance learning courses on database systems, software engineering and human-computer interaction. He has published over twenty research articles, authored *Information and Data Modelling* (Blackwell Scientific Publications, 1987) and co-authored *A Guide to Usability* (originally published by the DTI, now available from Addison-Wesley) and *Automating Systems Development* (Pitman Press, 1988). David's research interests centre on human-computer system design and the application of knowledge-based techniques to HCI design. David led the authoring of Part IV on design methods.

Tom Carey

Tom is a professor in the Computing and Information Science Department at the University of Guelph in Canada, where he developed the first HCI course at that university in 1982. Currently he directs the university's human-computer interaction laboratory. He was a member of the ACM SIGCHI Curriculum Development Committee and was education editor of the SIGCHI Bulletin from 1989 to 1990. He was a keynote speaker at CHI91 and a workshop co-chair at CHI92 and was Tutorial Chair for INTERCHI93. Tom's research interests include design approaches for HCI and on representation aids for experts.

devices in system design. Similarly, you also need to consider variation in user characteristics. For example, users can vary in knowledge, skills, abilities or disabilities and experience, as well as in more subtle characteristics like culture and gender. Knowing the scope of different kinds of devices is important too, because ultimately you have to match the technology with the user and work needs, not forgetting the work environment.

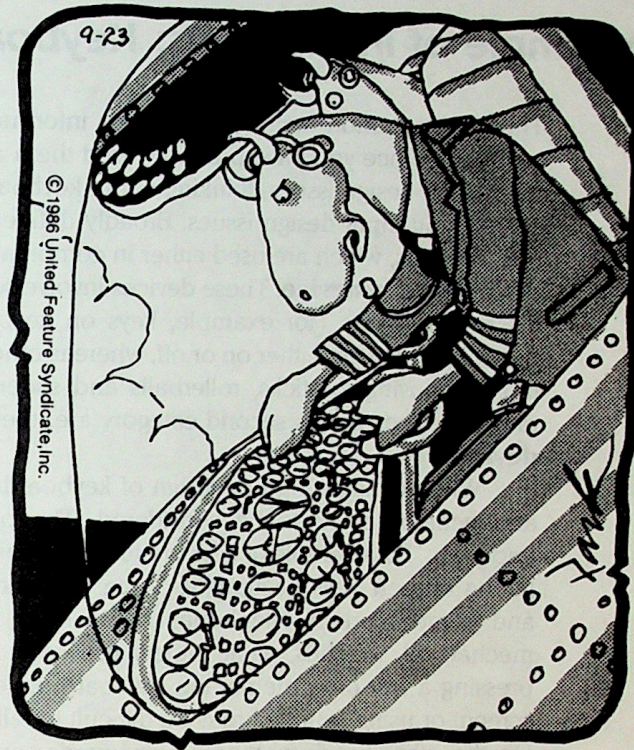
11.1 Input devices

Input is concerned with recording and entering data into the computer system and issuing instructions to the computer. In order to interact with computer systems effectively, users must be able to communicate their intentions in such a way that the machine can interpret them. Therefore, we can define an input device as: a device that, together with appropriate software, transforms information from the user into data that a computer application can process.

One of the key aims in selecting an input device and deciding how it will be used to control events in the system is to help users to carry out their work safely, effectively, efficiently and, if possible, to also make it enjoyable. The choice of input device should contribute as positively as possible to the usability of the system. In general, the most appropriate input device will be the one that:

- matches the physiological and psychological characteristics of users, their training and their expertise. For example, older adults may be hampered by conditions such as arthritis and may be unable to type; inexperienced users may be unfamiliar with keyboard layout.
- is appropriate for the tasks that are to be performed. For example, a drawing task requires an input device that allows continuous movement; selecting an option from a list requires an input device that permits discrete movement.
- is suitable for the intended work and environment. For example, speech input is useful where there is no surface on which to put a keyboard but is unsuitable in noisy conditions; automatic scanning is suitable if there is a large amount of data to be gathered.

Frequently the demands on the input device are conflicting, and no single optimal device can be identified: trade-offs usually have to be made between desirable and undesirable features in any given situation. Furthermore, many systems will use two or more input devices together, such as a keyboard and a mouse, so the devices must be complementary and well coordinated. This means that not only must an



*'Darn these hooves! I hit the wrong switch again!
Who designs these instrument panels, raccoons?'*

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input device be easy to use and the form of input be straightforward, there must also be adequate and appropriate **system feedback** (Norman, 1988) to guide, reassure, inform and, if necessary, correct users' errors. This feedback can take various forms. It can be a visual display on a screen: a piece of text appears, an icon expands into a window, a cursor moves across the screen or a complete change of screen presentation occurs. It can be auditory: an alarm warning, a spoken comment or some other audible clue such as the sound of keys clicking when hit. It can be tactile: the feel of a button being depressed, or a change in pressure, such as occurs when using a joystick. In many cases feedback from input can be a combination of visual, auditory and tactile responses. For example, when selecting an icon on a screen, the tactile feedback from the mouse button or function keys will tell users that they instructed the system to activate the icon. Simultaneously, visual feedback will show the icon changing shape on the screen. This is coordinated with the sound of the button clicking or the feel of the key resisting further pressure. In this chapter the various types of device are discussed in terms of their common characteristics and the factors that need to be considered when selecting an input device. In Chapter 12 we return to the issue of feedback.

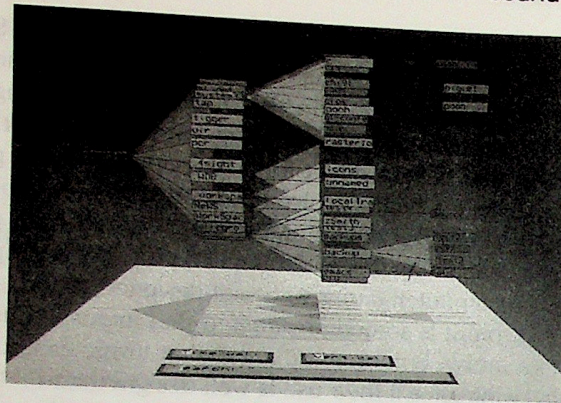


Figure 12.3 A Camtree, one of the three-dimensional animations provided by the Xerox PARC Information Visualizer (Card *et al.*, 1991: © 1991, Association for Computing Machinery, Inc. reprinted by permission).

EXERCISE

If you know a procedural programming language such as Pascal, and if you know any simple general algorithms or data structures, such as sorting algorithms or stacks, see if you can think of a way in which a three-dimensional animation could help a beginner understand how they work. Specify your animation as a sequence of diagrams showing successive stages of the animation. (No comment is provided for this exercise.)

12.4 Sound output

Current uses of sound at the interface are largely for alerting and feedback purposes. For example, various forms of beeps and bells are used to indicate that an incorrect command has been issued or that a process needs attending to. The use of sounds as warning indicators has also been extensive in process control plants. Until recently few computers could generate deliberately designed sounds other than beeps, but this has changed in the last few years. Different kinds of sound, each of which can be either synthesized or sampled (that is, digitally recorded and replayed), include the following:

- speech (see Section 12.5)
- musical sounds
- natural sounds

Some researchers, such as Buxton *et al.* (1989) have suggested that sound can be used in more information-rich ways to show what is happening in a system. In particular, it can be used as a coding method for augmenting graphical representations. They suggest that complex systems might benefit by using sounds that have a direct form of mapping to the processes they represent. Given that we have a highly evolved hearing system capable of gathering very detailed information about our environment, there should be a great potential to improve interfaces by exploiting this capability. To consider a simple illustration, Buxton *et al.* note that in computer games with well-designed sound, scores improve when the sound is turned on. It is sometimes argued that increased use of sound would make computers too noisy. Buxton *et al.* argue that in practical cases, quiet sounds are not perceived as intrusive if their use is well designed and if they provide useful information. In cases where noise pollution is a critical problem, earphones or quiet directional speakers close to the ear could be used.

Sound is of particular value where the eyes are engaged in some other task, or where a complete situation of interest cannot be visually scanned at one time. Sound can be useful for monitoring continuous background processes that are normally not important until something out of the ordinary happens, like hearing an unusual car engine note, or for drawing attention to an unusual one-off event, such as an object hitting a car from the outside. Sound can also be useful for drawing attention when expected background events fail to happen, for example, lack of disk access noise when intending to save a file to disk. These strengths of sound as a means of feedback are reflected in the following list of areas in which sound output has already proved valuable:

- Applications where sound complements a standard visual interface.
- Applications where the eyes and attention are required away from the screen; for example, flight decks, medical applications, industrial machinery, transport and farms.
- Applications involving process control in which alarms must be dealt with, or continuous monitoring is required.
- Applications addressing the needs of blind or partially sighted users.
- Data sonification. That is to say, situations where data can be explored by listening to it (given an appropriate direct mapping).
- Algorithm animation, in which understanding how an algorithm executes can be explored by listening to an appropriate mapping of its operation into sound, sometimes as a complement to visual animation.

Natural sounds

One interesting way of using sound in computer interfaces is to make use of natural sounds, either synthesized or digitally recorded. Gaver (1989) argues that evolution has adapted the human hearing system to be capable of extracting large quantities of information effortlessly from natural sounds such as rustles, thumps, hits, scrapes, tinkles, creaks, patters, reverberations, and so on.

EXERCISE

How might you use sound in an electronic mail system? Think about such things as the length and kinds of message, who they are from and so on.

COMMENT

You may have several suggestions. Bill Gaver (1989), a researcher into the use of sound in interaction design, points out that it might be useful if it were arranged for incoming electronic mail to make a sound something like a letter falling into a real mail box. Such a sound could be interpreted easily by a user concentrating on some other task. So, for example, a lengthy electronic mail message might produce a heavy thud, whereas a short message might produce a light rustle. The degree of reverberation might indicate the extent to which the mailbox was full or empty, with a nearly empty mailbox reverberating most. A metallic clang might indicate the mailing of machine code, whereas a gentler quality of impact might indicate a text file. Different mappings into sound might be preferred by individual users, for example, a deep thud could be set to indicate mail from one's boss, a brief signature tune to herald a mailing from a particular mail group (although this is taking us away from Gaver's ideas, which centre on purely natural sounds), and so forth. Box 12.2 contains another example of the use of sound to provide feedback in the Sonic Finder.

Experiments by Gaver and others (Gaver *et al.*, 1991) have also indicated that sound can be particularly useful in helping a team of users to collaborate on a process control task. For example, in a program that simulated a soft drinks bottling factory (ARKola) implemented in the collaborative SharedARK computer environment, sound was generated from a digital sampler to represent a variety of information. This included the sound of clanking bottles to represent the bottle dispenser and a splashing sound to indicate that liquid was being spilt. The rhythm of the sounds was intended to reflect the rate at which the machine was running, while the rapidity at

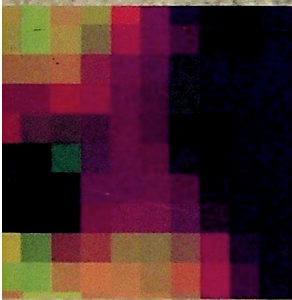
Box 12.2 Sonic Finder

A device called the Sonic Finder (Gaver, 1989) has been used experimentally on the Macintosh (see Figure 12.4) to add sounds to actions such as opening windows, moving, copying and deleting files and so forth. In our experience this program was very useful because the sound cues helped to avoid some common errors, such as intending to drop a file in the trash can but missing.

HUMAN-COMPUTER INTERACTION

Offering the most comprehensive account of the multi-disciplinary field of HCI, this book illustrates the powerful benefits of a user-oriented approach to the design of modern computer systems. It balances the technical and cognitive issues required for understanding the subtle interplay between people and computers, particularly in emerging fields like multimedia, virtual environments and computer supported cooperative work (CSCW).

A unique feature is the inclusion of interviews with many leading authorities in HCI, providing personal insight into their work and conveying the excitement of current research activity.



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Human-Computer Interaction is flexibly structured to allow a variety of learning paths for students in computer science, engineering, psychology and cognitive science. Programmers and system designers will appreciate its emphasis on the design of interactive systems.

The book has been developed from successful modules offered by the UK Open University team chaired by Jenny Preece. Her co-authors are Yvonne Rogers of the University of Sussex, Helen Sharp, David Benyon and Simon Holland (all at the Open University) and Tom Carey of the University of Guelph, Canada.



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