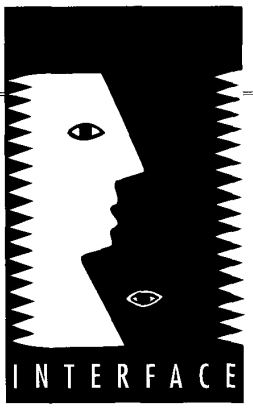

Tools, techniques, and concepts to optimize user interfaces.

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TOUCH SCREENS NOW OFFER COMPELLING USES

If you thought touch screens were a thing of the past, this essay will bring you up to date on improvements to this input device's user interface. I suspect we will be seeing touch screens used for more applications than ever before.

In this essay, Ben Shneiderman shares some of his latest research on improving the user interfaces of touch screen applications. He is a professor of computer science, head of the Human-Computer Interaction Laboratory at the University of Maryland, and author of Software Psychology (Little, Brown, 1980) and Designing the User Interface (Addison-Wesley, 1987).

MICHELANGELO'S FRESCO OF GOD'S finger reaching down to touch a person's hand is compelling. The process of touching is immediately recognizable as the gift of life. Inventors of the touch screen in the 1960s may have been inspired by this image in their cultural unconscious. Touch screens have an unrivaled immediacy, a rewarding sense of control, and the engaging experience of direct manipulation.

First-generation touch screens have been successfully applied in sales kiosks, public information services, and computer-aided instruction — in spite of poor precision, slow and erratic activation, and poorly designed displays. Now, second-generation touch screens are supporting novel applications that are likely to enormously expand access to computing and information resources as well as enjoyable entertainment, art, and music applications.

WHY TOUCH SCREENS? Touch screens have several advantages over other pointing devices:

- Touching a visual display of choices requires little thinking and is a form of direct manipulation that is easy to learn.
- Touch screens are the fastest pointing device.
- Touch screens have easier hand-eye coordination than mice or keyboards.
- No extra workspace is required as with other pointing devices.
- Touch screens are durable in public-access and in high-volume usage.

These advantages mean that touch screens are highly effective in public-access information systems, cash machines, home automation, museums and libraries, medical instruments, education, and many other domains.

Of course, touch screens have some problems:

- Users' hands may obscure the screen.
- Screens need to be installed at a lower position and tilted to reduce arm fatigue.
- Some reduction in image brightness may occur.
- They cost more than alternative devices.

These are real problems, but they can be addressed successfully. Some critics suggest that smudges on the screen may be a problem, but we clean our touch screens no more frequently than our standard monitors or our mice.

WHAT'S NEW? The second generation of touch screens uses several techniques to overcome previous limits. Lift-off strategies was one such technique that offers several advantages in precision of item selection and the movement of elements.

The use of lift-off strategies allows higher precision by showing users a cursor on the screen slightly above their fingers. (My colleagues and I compared three lift-off strategies in "Improving the Accuracy of Touch Screens: An Experimental Evaluation of Three Strategies," *Proc. Conf. Human Factors in Computing Systems*, ACM, 1988, pp. 27-32.) With lift-off, you can drag the cursor smoothly and continuously along the screen's surface. Functions can be activated when users lift their fingers off the surface — something we call the "untouch screen."

Our early study showed that, with lift-off, people could easily select targets the size of a pair of letters. However, we had to add stabilization software to allow single-pixel selection on a 640 × 480 display (a VGA-resolution display) — or less than a square millimeter. Improved hardware and software supporting this high-precision strategy is now available in commercial touch screens (vendors include Microtouch Systems of Wilmington, Mass., and Elographics of Oak Ridge, Tenn.).

Dragging a cursor is only one use of the lift-off strategy. The most engaging applications are those that let users drag icons, buttons, sliders, words, flags, or clock hands. But why not allow dragging of musical notes, paint brushes, or large sections of the screen image? In our experience, there is a delightful sense of magic about dragging images around the screen.

WHAT'S POSSIBLE? Designers' imaginations be-

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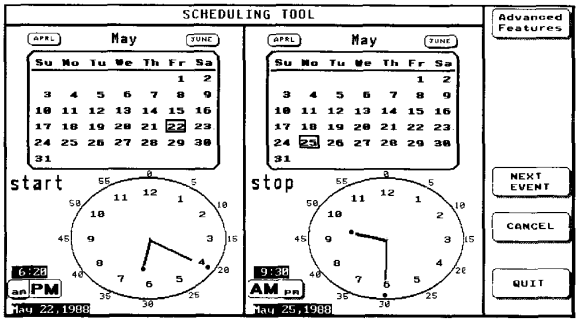

Figure 1. The boxes around dates and the hands on the clock may be dragged via touch screen.

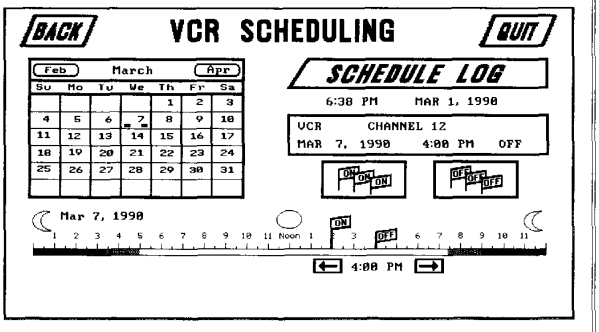

Figure 2. The use of on and off flags was the most effective scheduling metaphor for touch-screen users tested.

come freer when they enter the world of touching, dragging, and drawing with these improved touch screens. Our first application was with our Hyperties hypermedia system (available from Cognetics of Princeton Junction, N.J.) applied to a Smithsonian Institution installation containing information on 200 archaeological dig sites that accept volunteers. Users could touch words in the text for more information or locations on the 11 world maps.

Most users succeeded in using the kiosk immediately. About 15 percent were momentarily confused by the lift-off strategy, but they quickly learned it after one or two touches. We observed and interviewed early users to make improvements and analyzed the log data for the 4,461 users in the first four weeks of the 18-month six-city tour.

As we became more comfortable with the idea of high-precision touch screens and lift-off, we developed several versions of home-control scheduler tasks like scheduling VCRs. Pointing at a day on a monthly calendar was very natural when the user could smoothly drag a box-shaped cursor. Then to choose the time, we let the users drag the hands on an analog clock, as Figure 1 shows. Participants in our usability test had great fun doing this, but the most effective scheduler used a 24-hour time-line with on and off flags (as Figure 2 shows). Users could drag the flags onto the time-line, slide them around to adjust, or drag them off to delete.

A common pursuit with touch screens is developing visually appealing metaphors that react predictably. Opening a book, touching lettered tabs, and turning pages are natural in the touch-screen environment. While we built two museum versions of books, Cognetics's artist, Paul Hoffman, made a strikingly realistic ring-binder telephone book for a conference messaging system that eliminated the keyboard and used touch screens and scanners only, as Figure 3 shows.

Smiles were common when demonstrating an art and music environment that allowed electronic finger painting. In Playpen II, created by Andrew Sears, users select colors, textures, sounds, and shapes with their fingers. Figure 4 shows an example. The results depend not only on finger position but also on the velocity and direction of motion. This additional information can be used in other applications, such as touch-screen versions of musical instruments in which the volume depends on the velocity of touch on a set of strings or piano keys.

Touch-screen keyboard replacements be-

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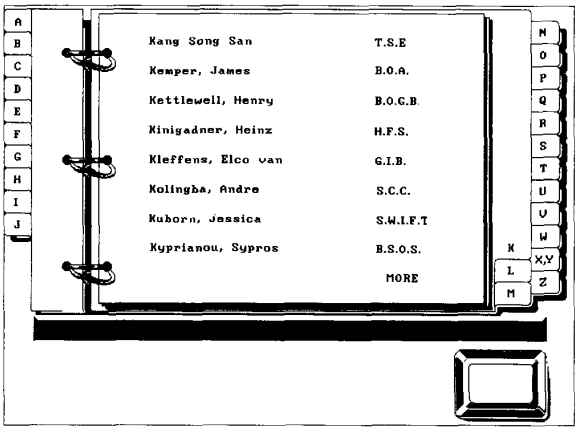

Figure 3. The ring-binder metaphor worked very well as a touch-screen application.

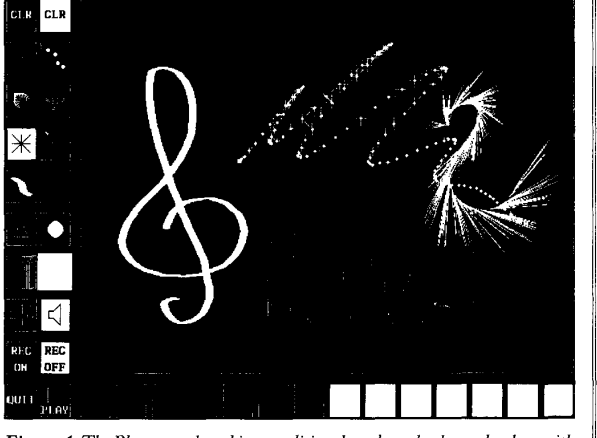

Figure 4. The Playpen tool combines traditional touch-and-select technology with velocity and motion sensing. This added information can be used to control volume, pitch, brightness, speed and other such attributes.