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4.3 Touchscreens now offer compelling uses

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If you thought touchscreens 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 touchscreens being used for more applications than ever before.

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 touchscreen in the 1960s may have been inspired by this image in their cultural unconscious. Touchscreens have an unrivaled immediacy, a rewarding sense of control, and the engaging experience of direct manipulation.

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First-generation touchscreens 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 touchscreens 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 touchscreens? Touchscreens have several distinct 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.
Touchscreens are the fastest pointing device.
Touchscreens have easier hand-eye coordination than mice or keyboards.
No extra workspace is required as with other pointing devices.
Touchscreens are durable in public access and in high volume usage.

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

Of course, touchscreens 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 touchscreens no more frequently than our standard monitors or our mice.

What's new?

The second generation of touchscreens uses several techniques to overcome previous limits. Lift-off strategies were one such technique that offers several advantages in precision of item selection and the movement of elements.

The use of lift-off strategies enables 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. of the Conference on Human Factors in Computing Systems*, ACM SIGCHI, NY, 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 "un-touchscreen."

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 x 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 touchscreens (vendors include MicroTouch Systems Inc., Wilmington, Mass. and Elographics Corp., Oak Ridge, Tenn.).

Dragging a cursor is only one use of the lift-off strategy. The most engaging applications are those that enable users to 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 become freer when they enter the world of touching, dragging, and drawing with these improved touchscreens. Our first application was with our Hyperties hypermedia system (available from Cognetics Corp., Princeton Jct., NJ) 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.

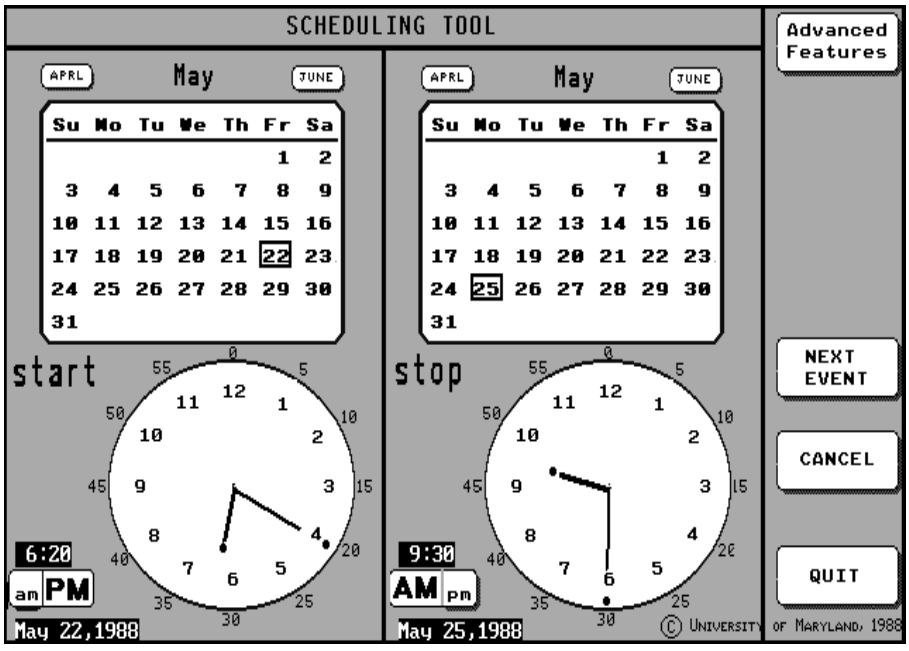

Figure 1. The 12-hour clock scheduler - Each start and stop portion of the screen consists of a Gregorian calendar and a 12-hour analog watch. Users first select the day on the calendar then rotate the hands of the clock to the desired position. An A.M./P.M. toggle is available.The boxes around dates and the hands on the clock may be dragged via touch screen.

Most users succeeded in using the kiosk immediately. About 15% 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 4461 users in the first four weeks of the 18-month six-city tour.

As we became more comfortable with the idea of high precision touchscreens and lift-off, we developed several versions of home control scheduler tasks such as 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

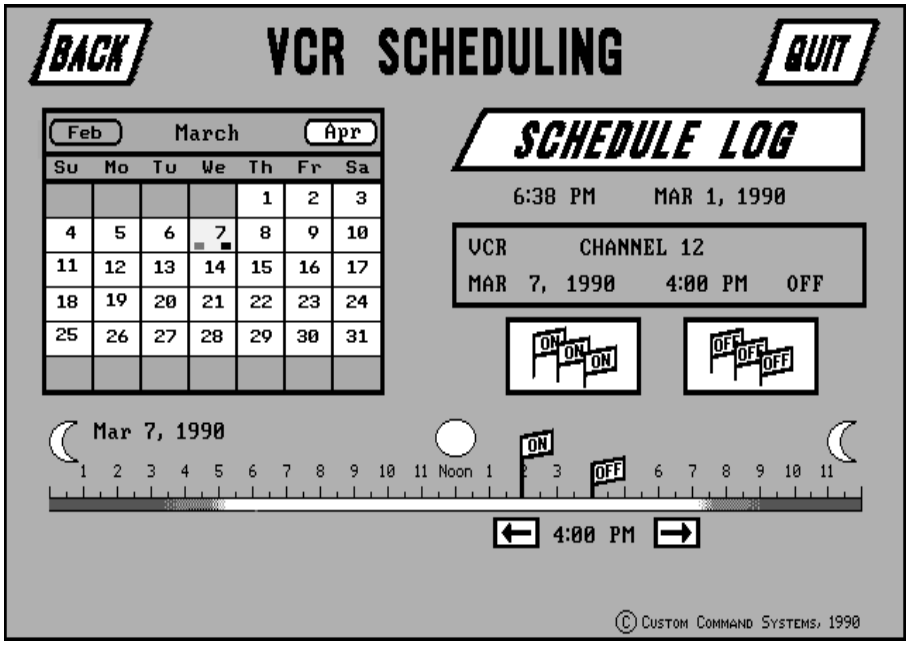

Figure 2. The final version currently used in Custom Command's system. The use of on and off flags was the most effective scheduling metaphor for touchscreen users tested.

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 touchscreens is developing visually appealing metaphors that react predictably. Opening a book, touching lettered tabs, and turning pages are natural in the touchscreen environment. While we built two museum versions of books, Cognetics Corporation's artist, Paul Hoffman, made a strikingly realistic ring binder telephone book for a conference messaging system that

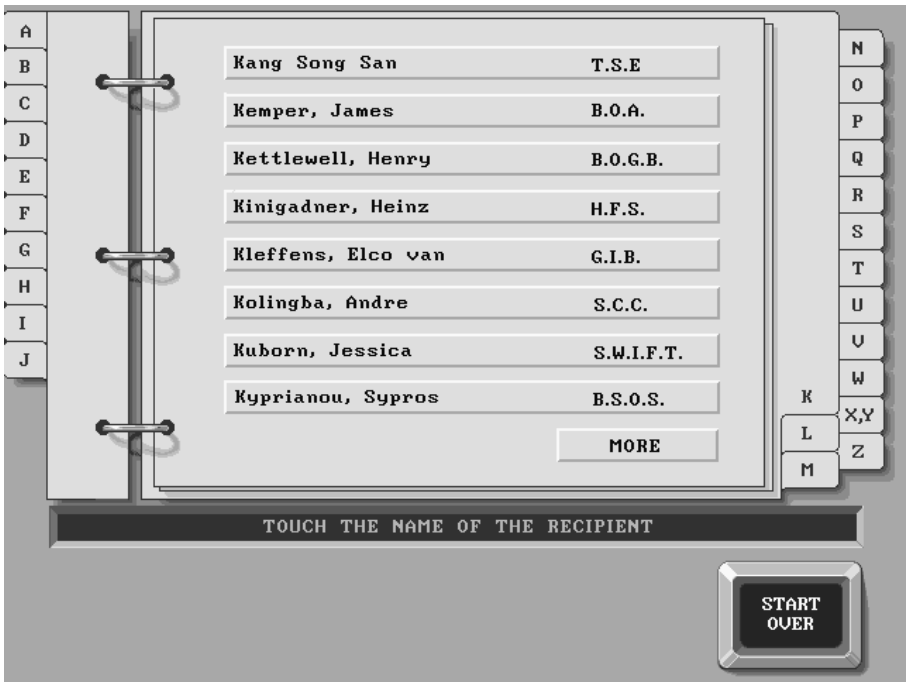

Figure 3. The ring-binder metaphor worked very well as a touchscreen application.

eliminated the keyboard and used touchscreens 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 touchscreen versions of musical instruments in which the volume depends on the velocity of touch on a set of strings or piano keys.

Touchscreen keyboard replacements become attractive when only occasional data entry is necessary. Typists achieved 25 word per minute speeds with our near normal-size touchscreen keyboards, compared with 58 words per minute using standard keyboards and 17 words per minute using a mouse to select the keys (Figure 5 shows the touchscreen typing screen). However, the touchscreen keyboard can be adjusted to reduce the size to less than 2.5 inches wide and still preserve reasonable typing speed. A small keyboard is applicable for portable or pocket sized computers, as a pop-up tool to enter data on a medical form or sales receipt, or to enter a search string in an electronic book.

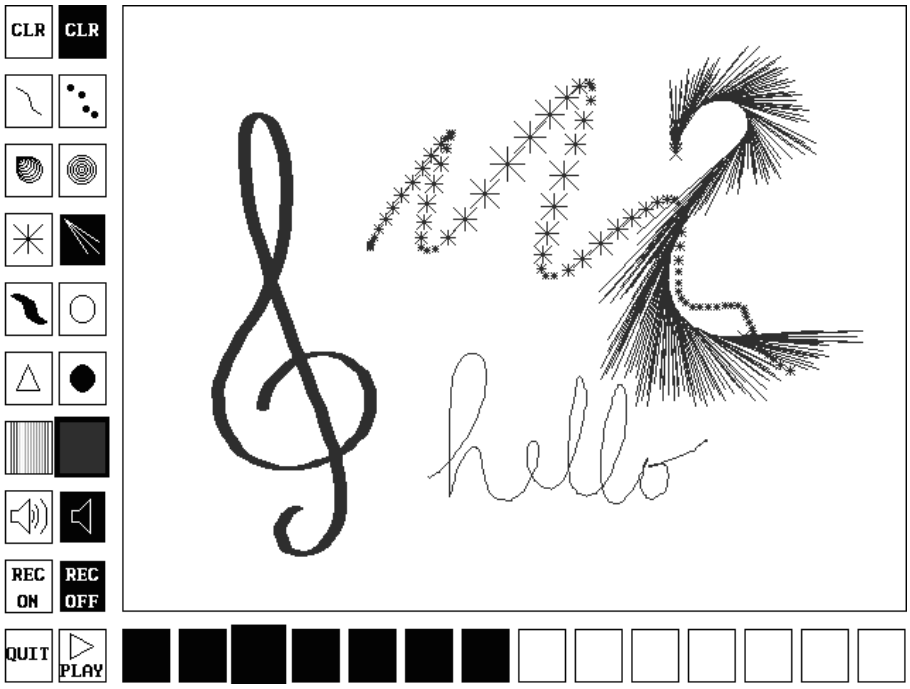

Figure 4. The PenPlay II tool combines traditional touch-and-select technology with velocity and motion sensing. This added information can be used to control volume, pitch, brightness, speed and other such attributes.

What's next?

Further advances with high precision touchscreens seem very likely, in both the hardware technology and the software designs that apply lift-off. While some touchscreens can provide 3-4 levels of touch pressure, improvements are needed to make this notion viable. Another improvement would be to allow multiple simultaneous touches to support the pressing of a SHIFT key while typing, selecting colors while drawing, touch typing, or selecting an object and an action simultaneously.

The most exciting breakthroughs will probably be in innovative applications, like controlling three dimensional artificial realities (let your fingers do the walking), selecting irregular shaped objects (for example, pointing at human body parts and getting lab results), or selecting moving objects (for example, pointing at fish swimming in a pool to find out more about the species, or pointing at a rotating globe to select countries).

We found that the challenge was to break free from the older notion that touchscreens are for buttons, and to explore how we might use sliding, dragging, and other gestures to move objects and invoke actions.

Figure 5. A touchscreen keyboard. Although slower than a traditional keyboard, it works well for note-taking, forms-entry, and other applications that require small amounts of input in a portable or small device.

Who knows what new forms of video games are possible if we let our imaginations go free? Why not a touchscreen Ouija Board or labyrinth? Who will be the first to make a magical Aladdin's lamp with a genie that pops-out when you rub it?

Soon enough we can envision a pocket-sized computer with two folding halves each having at least 80 characters x 25 line high precision touchscreens. Your calendar, address book, current projects, and the morning newspaper could all be a touch or an un-touch away. And why not high-resolution LCD touchscreens next to museum art works to give you the artist's biography, provenance, and description? Every refrigerator door, automobile dashboard, household main entry doorway, or TV is a potential place for un-touchscreens with useful information, assistance, and data entry.

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