USER CENTERED SYSTEM DESIGN

New Perspectives on Human-Computer Interaction

Edited by

DONALD A. NORMAN
STEPHEN W. DRAPER

University of California, San Diego

LAWRENCE ERLBAUM ASSOCIATES, PUBLISHERS
1986 Hillsdale, New Jersey London

CHAPTER 15

There's More to Interaction Than Meets the Eye: Some Issues in Manual Input

WILLIAM BUXTON

Imagine a time far into the future, when all knowledge about our civilization has been lost. Imagine further, that in the course of planting a garden, a fully stocked computer store from the 1980s was unearthed, and that all of the equipment and software was in working order. Now, based on this find, consider what a physical anthropologist might conclude about the physiology of the humans of our era? My best guess is that we would be pictured as having a well-developed eye, a long right arm, a small left arm, uniform-length fingers and a "low-fi" ear. But the dominating characteristics would be the prevalence of our visual system over our poorly developed manual dexterity.

Obviously, such conclusions do not accurately describe humans of the twentieth century. But they would be perfectly warranted based on the available information. Today's systems have severe shortcomings when it comes to matching the physical characteristics of their operators. Admittedly, in recent years there has been a great improvement in matching computer output to the human visual system. We see this in the improved use of visual communication through typography, color, animation, and iconic interfacing. Hence, our speculative future anthropologist would be correct in assuming that we had fairly well-developed (albeit monocular) vision.

Valve Exhibit 1055
Valve v. Immersion

ı our example, it is with the human's effectors (arms, legs, hands, that the greatest distortion occurs. Quite simply, when compared her human-operated machinery (such as the automobile), todays outer systems make extremely poor use of the potential of the ın's sensory and motor systems. The controls on the average s shower are probably better human-engineered than those of the outer on which far more time is spent. There are a number of rea- for this situation. Most of them are understandable, but none of should be acceptable.

y thesis is that we can achieve user interfaces that are more al, easier to learn, easier to use, and less prone to error if we pay attention to the "body language" of human-computer dialogues. I e that the quality of human input can be greatly improved gh the use of *appropriate gestures*. In order to achieve such bene- 1owever, we must learn to match human physiology, skills, and tations with our systems' physical ergonomics, control structures, unctional organization.

this chapter I look at manual input with the hope of developing a understanding of how we can better tailor input structures to fit uman operator.

W WORDS ON APPROACH

to constraints on space, I restrict myself to the discussion of l input. I do so fully realizing that most of what I say can be l to other parts of the body, and I hope that the discussion will rage the reader to explore other types of transducers.

> *Just consider the use of the feet in sewing, driving an automobile, or in playing the pipe organ. Now compare this to your average computer system. The feet are totally ignored despite the fact that most users have them, and furthermore, have well-developed motor skills in their use.*

the temptation to discuss new and exotic technologies. I want k with devices that are real and available, since we haven't come o using the full potential of those that we already have.

ılly, my approach is somewhat cavalier. I will leap from example mple, and just touch on a few of the relevant points. In the pro- t is almost certain that readers will be able to come up with les counter to my own, and situations where what I say does not *But these contradictions strengthen my argument!* Input is com- nd deserves great attention to detail: more than it generally gets.

That the grain of my analysis is still not fine enough just emphasize how much more we need to understand.

> *Managing input is so complex that it is unlikely that we will ever totally understand it. No matter how good our theories are, we will probably always have to test designs through actual implementations and prototyping. The consequence of this for the designer is that prototyping tools (software and hardware) must be developed and considered as part of the basic environment.*

THE IMPORTANCE OF THE TRANSDUCER

When we discuss user interfaces, consideration of the physical tran ducers too often comes last, or near last. And yet, the physical prope ties of the system are those with which the user has the first and mo direct contact. This is not just an issue of comfort. Different devic have different properties, and lend themselves to different things. Ar if gestures are as important as I believe, then we must pay caref attention to the transducers to which we assign them.

An important concept in modern interactive systems is the notion *device independence*. The idea is that input devices fall into gener classes of what are known as *virtual devices*, such as "locators" ar "valuators." Dialogues are described in terms of these virtual device The objective is to permit the easy substitution of one physical devi for another of the same class. One benefit in this is that it facilitat experimentation (with the hopeful consequence of finding the be among the alternatives). The danger, however, is that one can easily lulled into believing that the technical interchangeability of the devices extends to usability. Wrong! It is always important to keep mind that even devices within a class have various idiosyncrasies. It often these very idiosyncratic differences that determine the approp ateness of a device for a given context. So, device independence is useful concept, but only when additional considerations are made wh making choices.

Example 1: The Isometric Joystick

An "isometric joystick" is a joystick whose handle does not move wh it is pushed. Rather, its shaft senses how hard you are pushing it, a in what direction. It is, therefore, a pressure-sensitive device. T isometric joysticks are shown in Figure 15.1. They are both made

Two isometric joysticks. (Measurement Systems, Inc.)

nanufacturer. They cost about the same, and are electroni- cal. In fact, they are plug compatible. How they differ is in the muscle groups that they consequently employ, and the force required to get a given output.

nember, people generally discuss joysticks vs. mice or kballs. Here we are not only comparing joysticks against ticks, we are comparing one isometric joystick to another.

ld one be used rather than the other? The answer obviously the context. What can be said is that their differences may ore significant than their similarities. In the absence of one , it may be better to utilize a completely different type of (such as a mouse) than to use the other isometric joystick.

: Joystick vs. Trackball

an example in which subtle idiosyncratic differences have a ct on the appropriateness of the device for a particular tran- this example we look at two different devices. One is the

springloaded joystick shown in Figure 15.2A. In many ways, it is very similar to the isometric joysticks seen in the previous example. It is made by the same manufacturer, and it is plug-compatible with respect to the X/Y values that it transmits. However, this new joystick moves when it is pushed, and (as a result of spring action) returns to the center position when released. In addition, it has a third dimension of control accessible by manipulating the self-returning, spring-loaded rotary pot mounted on the top of the shaft.

Rather than contrasting this to the joysticks of the previous example (which would, in fact, be a useful exercise), let us compare it to the 3-D trackball shown in Figure 15.2B. (A 3-D trackball is a trackball constructed so as to enable us to sense clockwise and counter-clockwise "twisting" of the ball as well as the amount that it has been "rolled" in the horizontal and vertical directions.)

This trackball is plug-compatible with the 3-D joystick, costs about the same, has the same "footprint" (consumes the same amount of desk space), and utilizes the same major muscle groups. It has a great deal in common with the 3-D joystick of Figure 15.2A. In many ways the the joystick in Figure 15.2A has more in common with the trackball than with the joysticks shown in Figure 15.1!

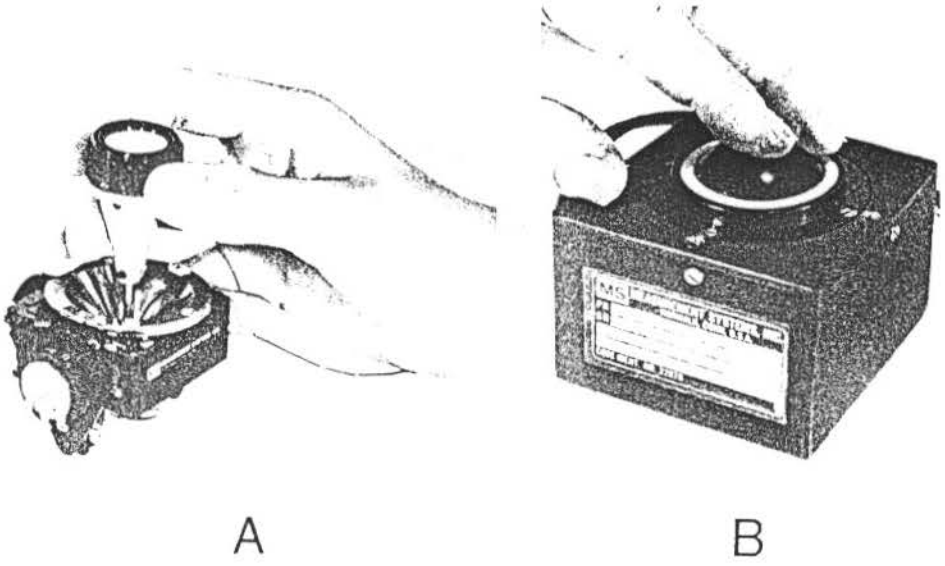

FIGURE 15.2. Comparison of joystick (A) and trackball (B). (Measurement Systems, Inc.)

you are starting to wonder about the appropriateness of
ays characterizing input devices by names such as "joys-
" or "mouse," then the point of this section is getting
oss. It is starting to seem that we should lump devices
ether according to some "dimension of maximum signifi-
ice," rather than by some (perhaps irrelevant) similarity in
ir mechanical construction (such as being a mouse or joys-
). The prime issue arising from this recognition is the
blem of determining which dimension is of maximum signi-
ince in a given context. Another is the weakness of our
rent vocabulary to express such dimensions.

ir similarities, these two devices differ in a very subtle, but
way. Namely, it is much easier to simultaneously control all
nsions when using the joystick than when using the trackball.
plications this will make no difference. But for the moment,
ut instances where it does. We look at two scenarios.

o 1: We are working on a graphics program for doing VLSI
e chip on which we are working is quite complex. The only
ie entire mask can be viewed at one time is at a very small
examine a specific area in detail, therefore, we must "pan"
d "zoom in." With the joystick, we can pan over the surface
iit by adjusting the stick position. Panning direction is deter-
he direction in which the spring-loaded stick is off-center,
is determined by its distance off-center. With the trackball,
control by rolling the ball in the direction and at the speed
nt to pan.

nning is easier with trackball than the spring-loaded joys-
. This is because of the strong correlation (or compatibil-
between stimulus (direction, speed, and amount of roll)
response (direction, speed, and amount of panning) in
example. With the spring-loaded joystick, there was a
tion-to-motion mapping rather than the motion-to-motion
pping seen with the trackball. Such cross-modality map-
s require learning and impede achieving optimal human
formance. These issues address the properties of an inter-
that Hutchins, Hollan, and Norman (Chapter 5) call
mal directions."

cation demands that we be able to zoom and pan simultane-
we have to reconsider our evaluation. With the joystick, it

is easy to zoom in and out of regions of interest while panning. One need only twist the shaft-mounted pot while moving the stick. However, with the trackball, it is nearly impossible to twist the ball at the same time that it is being rolled. The 3-D trackball is, in fact, better described as a 2+1D device.

Scenario 2: I am using the computer to control an oil refinery. The pipes and valves of a complex part of the system are shown graphically on the displays, along with critical status information. My job is to monitor the status information and, when conditions dictate, modify the system by adjusting the settings of specific valves. I do this by means of *direct manipulation*. That is, valves are adjusted by manipulating their graphical representation on the screen. Using the joystick, this is accomplished by pointing at the desired valve, then twisting the pot mounted on the stick. However, it is difficult to twist the joystick-pot without also causing some change in the X and Y values. This causes problems, since graphics pots may be in close proximity on the display. Using the trackball, however, the problem does not occur. In order to twist the trackball, it can be (and is best) gripped so that the finger tips rest against the bezel of the housing. The finger tips thus prevent any rolling of the ball. Hence, twisting is orthogonal to motion in X and Y. The trackball is the better transducer in this example *precisely because of its idiosyncratic 2+1D property.*

Thus, we have seen how the very properties that gave the joystick the advantage in the first scenario were a liability in the second. Conversely, with the trackball, we have seen how the liability became an advantage. What is to be learned here is that if such cases exist between these two devices, then it is most likely that comparable (but different) cases exist among all devices. What we are most lacking is some reasonable methodology for exploiting such characteristics via an appropriate matching of device idiosyncrasies with structures of the dialogue.

APPROPRIATE DEVICES CAN SIMPLIFY SYNTAX

In the previous example we saw how the idiosyncratic properties of an input device could have a strong affect on its appropriateness for a specific task. It would be nice if the world was simple, and we could consequently figure out what a system was for, find the optimal device for the task to be performed on it, and be done. But such is seldom

Computer systems are more often used by a number of peo-
umber of tasks, each with their own demands and charac-
One approach to dealing with the resulting diversity of
s to supply a number of input devices, one optimized for
of transaction. However, the benefits of the approach would
reak down as the number of devices increased. Usually, a
stic solution is to attempt to get as much generality as possi-
smaller number of devices. Devices, then, are chosen for
of applicability. This is, for example, a major attraction of
ablets. They can emulate the behavior of a mouse. But
mouse, they can also be used for tracing artwork to digitize
machine.

raised the issue, I continue to discuss devices in such a way
on their idiosyncratic properties. Why? Because by doing
to identify the type of properties that one might try to emu-
emulation be required.

en useful to consider the user interface of a system as being
f a number of horizontal layers. Most commonly, syntax is
separately from semantics, and lexical issues independent
ax. Much of this way of analysis is an outgrowth of the
acticed in the design and parsing of artificial languages, such
esign of compilers for computer languages. Thinking of the
is way has many benefits, not the least of which is helping to
les-and-bananas" type comparisons. There is a problem,
n that it makes it too easy to fall into the belief that each of
s is independent. A major objective of this section is to
ow wrong an assumption this is. In particular, I illustrate
ons at the lowest level, the choice of input devices, can have
ed effect on the complexity of the system and on the user's

e 2: Two children's toys. The *Etch-a-Sketch* (shown in Fig-
is a children's drawing toy that has had a remarkably long
marketplace. One draws by manipulating the controls so as
stylus on the back of the drawing surface to trace out the
ge. There are only two controls: Both are rotary pots. One
t-right motion of the stylus and the other controls its up-
on.

doodle (shown in Figure 15.3B) is another toy based on very
ciples. In *computerese,* we could even say that the two toys
ically identical. They draw using a similar stylus mechanism
ave the same "erase" operator (turn the toy upside down and
However, there is one big difference. Whereas the Etch-a-

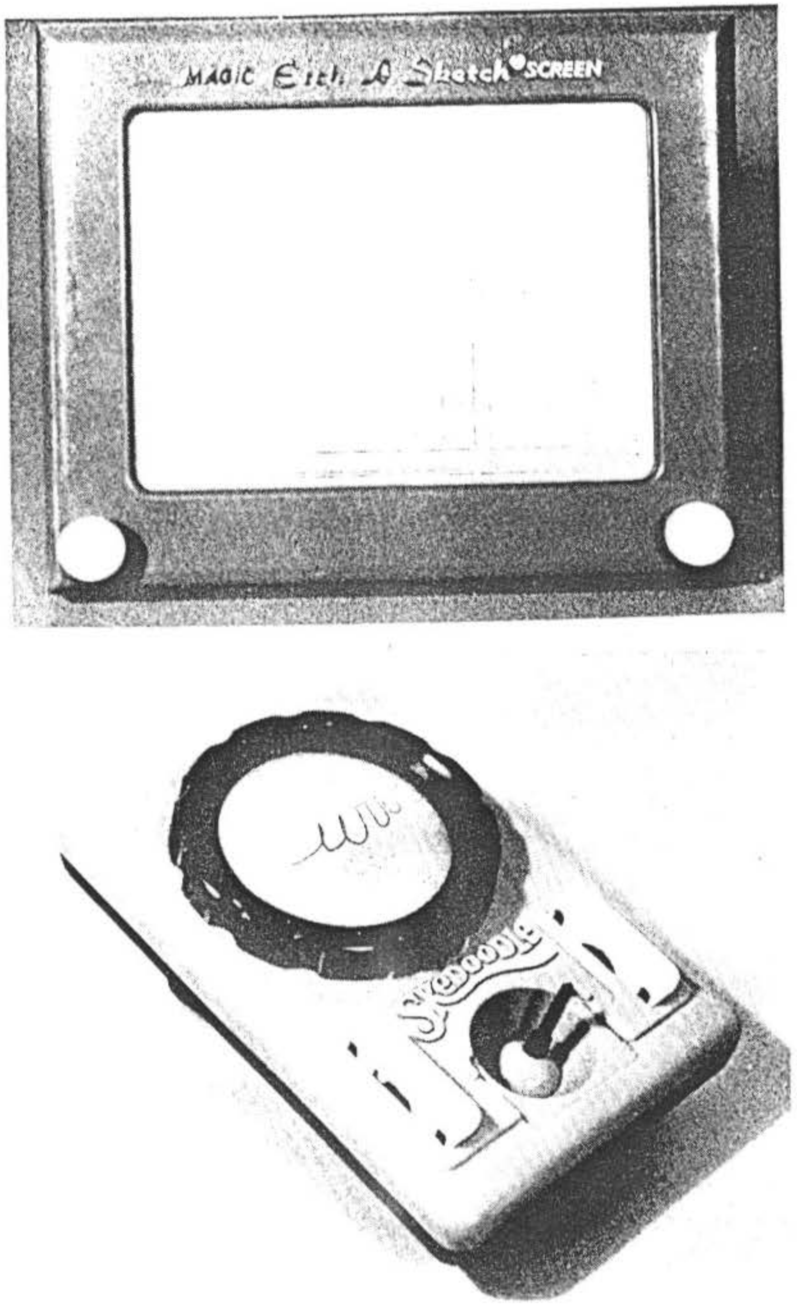

FIGURE 15.3. Two "semantically identical" drawing toys.

DOCKET
ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.

WHAT WILL YOU BUILD? | **sales@docketalarm.com** | **1-866-77-FASTCASE**

fastcase®
Smarter legal research.