2-D Pointing While Walking

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ABSTRACT
A frequent assertion in wearable computer discussions is that WIMP (windows/icons/mouse/pointer) interfaces are inappropriate for wearable computers, in part because 2-D (two-dimensional) pointing is difficult while walking. This paper summarizes findings from user studies conducted by Tangis Corporation on the usability of pointing devices for wearable computers. The author finds that, with changes, 2-D pointing could be an adequate interim solution.

INTRODUCTION

WIMP interfaces assume 2-D pointing as a primary input mode. That WIMP interfaces have dominated desktop computing for two decades testifies to their advantages over the command-line interfaces that preceded them, especially for novice users: they make user options visible, and they support direct-manipulation interactions.

Unfortunately for the designers of wearable computing systems, 2-D pointing isn't easy when you're walking, at least not with the input devices currently available. Post-WIMP or "fourth-generation" user interfaces—based on natural language, gesture, speech, non-command, or multi-modal input—are largely experimental, though they may become widespread within the next decade.

Last year Tangis Corporation—which designs software for wearable computers and other platforms that support computing while in motion—began a series of user studies on a wide range of pointing devices. The goal: to identify and ameliorate usability problems related to point-and-click user interfaces on wearable computers.

DEVICES EVALUATED

Few 2-D pointing devices designed for wearable computing are commercially available. We evaluated two stand-alone hand-held pointing devices that might work while walking: a Twiddler mouse/keyboard combination and a Thumbelina mini trackball. We also evaluated an optical mouse, a wireless (ball-driven) mouse, several full-size trackballs, a touch pad, and the built-in pointing device of the Xybernaut MA-IV, a commercially available wearable computer.

HARDWARE FACTORS

Our staff doesn't include an ergonomics specialist, so our findings are restricted to usability issues.

Body-mounted vs. hand-held devices

A body-mounted device seems ideal for the intermittent use widely envisioned as typical for wearable computing: it would always be within reach, and it would occupy the hands for the least possible time. But body-mounted devices are highly susceptible to "ambient motion," a term used here to describe the jiggle that's translated from the body to the pointing device while the user is walking.

We began with the wearable computer's built-in pointing device. When used with a waist belt, the pointing device rests above one hip. We found this position awkward and tiring. A belt-mounted trackball at the body's midline was better. Users could complete the pointing tasks while walking with either device, but they found it demanding.

We investigated hand-held devices as an alternative to body mounting, beginning with the Twiddler, a small combined keyboard/pointing device. We found it difficult to control the pointer while walking, as the device is sensitive to ambient motion. We rejected a number of wireless pointing devices for the same reason.

An optical mouse seemed promising, as it works at any angle and on virtually any surface, including clothing. We concluded that the chest or abdomen provides the most stable surface while walking, but the thigh can serve as a secondary surface when the user is standing still. Unfortunately, the optical mouse was more susceptible to ambient motion than the waist-mounted trackball.

A mini-trackball and a touch pad were also tested. Although the mini-trackball was designed for hand-held use, we found that it performed poorly even when the user was standing perfectly still. Using the touch pad one-handed was also unsuccessful. It was nearly impossible to hold the device and operate its buttons with the same hand, even when standing still. Tapping the pad itself—an alternative to pressing the buttons—was difficult when walking. None of the full-sized trackballs could be held and operated with one hand.

Of the 2-D pointing devices we tested, the one that offered the best control was the least viable: two-handed use of a wireless mouse. The mouse itself was held in one hand, and a cloth-bound book in the other hand served as a mouse pad. We discovered that arms make remarkably effective shock absorbers. Pointing was a breeze. Unfortunately, this solution occupied both hands, and it was tiring for the arms.

An option we haven't pursued is to alter the pointing devices' drivers to filter out ambient motion.

Design of the controls

Trackballs can be designed for control by the thumb, the index finger, or the middle finger. The index finger has the greatest fine motor control, followed by the thumb. (These digits have the largest neural representations in the human brain.) We evaluated one trackball designed so that the index finger controls the trackball, and the thumb operates the mouse buttons. Of the devices we tested, this one afforded the best pointing control. However, users tended to rest their thumbs on the mouse buttons, resulting in unintended mouse clicks. We also tested a trackball designed so that the thumb controls the trackball, and the fingers operate the buttons and scroll wheel. This device offered adequate pointing control without the unintended mouse clicks.

We learned that buttons that respond to light pressure are easy to activate accidentally while walking. This is especially true for scroll wheels, which the user must be able to rotate without inadvertently depressing.

The wearable computer's buttons did require adequate force to avoid unintentional activation. However, this product is designed so that the user operates the pointing device with the middle finger, a third-rate digit in terms of fine motor control. Moreover, it uses a rate-control pointing device: changing its position affects the rate of the pointer's movement across the screen. A trackball, mouse, or touch pad is a position-control device: changing its position affects the pointer's position on the screen. Position-control pointing devices have a slight advantage in terms of functional mapping, though researchers are divided on which type is actually easier to use. Our users were also split on this issue, with some finding this pointing device easy to use and others difficult.

Regardless of the device, users found it difficult to double-click the buttons while walking. If the buttons were easy to push, then users inadvertently double-clicked them. If they were more resistant, then users inadvertently single-clicked them when trying to double-click.

SOFTWARE FACTORS

Fortunately for software development companies (like Tangis) that have little influence on pointing device design, software factors can also influence pointing ease-of-use.

Target properties

Fitts' law indicates that the time to acquire a target is a function of the distance to the target and the target's size. Because Tangis designs for the optical qualities of head-mounted displays (HMDs), our interfaces generally offer targets that are close together and relatively large. In most of our tests, pointing tasks were confined to a text menu approximately 200 pixels wide and 250 pixels high. Since earlier user testing identified optimum text legibility at 18-points double-spaced, we ended up with relatively large contiguous (vertically stacked) targets. In other words, making our targets legible automatically made them easy to acquire.

Acquisition feedback is another significant target property. Users reported that hover feedback (highlighting a target when the pointer is over it) was useful in their pointing tasks.

Pointer Properties

We found the standard Windows pointing scheme too small for good visibility on the HMD. Switching to the Windows Standard Extra Large pointing scheme improved the pointer's visibility, but users found that the arrow sometimes obscured the targets. We have identified alternative pointer shapes as an area for future study.

It's possible for the pointer itself to provide target acquisition feedback, for example by changing shape. We didn't test this variable, reasoning that feedback from the target would be more useful in our interface designs.

Spatial Mapping

Our examination of belt-mounted devices revealed an issue with mapping between the real world and the display. Most users experienced at least intermittent confusion in directing the movement of the onscreen pointer. Is "up" toward the sky, or in the direction that the hand points? The mapping problem was even worse with the optical mouse, which allowed the user to alternate between waist and thigh use.

Interaction Design

One way of addressing the 2D pointing problem is to restrict pointing to one dimension, a tactic with huge implications for interface design. The obvious options are to (1) design a 1-D user interface that maps directly to a 1-D device, or (2) design a pointing scheme for navigating a 2-D interface with a 1-D device. Tangis is investigating both alternatives. Preliminary testing of a 1-D interface suggests that most users prefer a 1-D pointing scheme while walking, but want 2-D interaction the moment they become stationary. We're in the early phases of designing a 1-D pointing scheme for a 2-D interface.

CONCLUSION

None of problems we've encountered in our investigation of 2-D pointing seem insurmountable. A coordinated hardware/software design effort would surely produce mobile pointing devices far more effective than those currently available. Using today's technology, the best pointing device would probably be a large-ball trackball with both hardware and software designed for hand-held, mobile use. Quick holstering would be an added benefit. With appropriate interface design, 2-D pointing might suffice until the next generation interfaces come of age.