# Isometric Pointer Interfaces for Wearable 3D Visualization

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## ABSTRACT

3D visualizations will soon be important wearable computer applications. However, 3D interaction can be problematic, especially in a wearable computing environment. We evaluated four 3D interaction methods using isometric joysticks common to wearable computing. Subjective and objective results favor a two-handed, aircraft-like interface mapping.

## Keywords

Wearable computing, 3D interfaces, two-handed interfaces.

## INTRODUCTION

The growth of 3D computing power, wireless networking, and GPS tracking will enable wearable computers to display 3D visualizations of a user's surrounding environment, overlaid with traffic, weather, navigational, and other types of information. The interfaces to such applications face two major design challenges. First, navigation and wayfinding are more difficult in 3D computer interfaces than in typical 2D interfaces [3]. Second, wearable computers have additional constraints on input devices and the manner in which they can be used:

- Fatigue is important since the computer may be worn and used for long periods of time (8 hours or more).
- Input devices must not require a desktop surface, like a typical mouse or keyboard [6].
- Input devices should be usable when the user is sitting, standing, or walking [2].
- The input devices must not be too encumbering. Engaging and disengaging the devices should be quick and easy.
- Interaction should not distract the user from perceiving and dealing with the world; i.e. it should not make great demands of the user's attention or cognitive resources [1].

Many of the input devices used in 3D environments (joysticks, spaceballs, and electromagnetic trackers) are too cumbersome or unusable in wearable computer environments. We are exploring 3D navigation methods that use isometric joysticks common to wearable computer input devices.



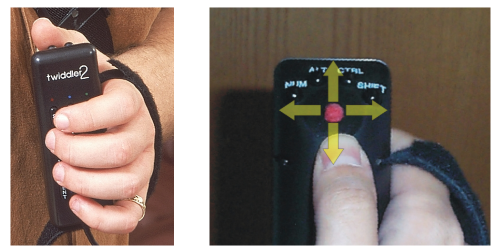


**Figure 1:** Twiddler2 Chording Keyboard and Isometric Joystick.

## RELATED WORK

Our interaction techniques are based on Zeleznik's discussion [7] of 2D devices for 3D manipulation and navigation and Zhai's "bulldozer" navigation metaphor [8]. They do not require direct reference to points on the display, which is difficult with eyeglass-mounted wearable displays. We have also employed a tilt sensor in two of our 3D navigation methods. Tilt sensors have been used with small screen devices and PDA's [4]. However, tiltable display interface techniques are not amenable to eyeglass-mounted wearable displays.

## EVALUATION

Our first interface uses a "bulldozer" metaphor, which requires coordinated input from both hands to initiate movement. The second interface uses an airplane metaphor. The right hand controls pitch and yaw. The left hand controls forward and backward movement.

The two other interfaces use a tilt sensor that was added to the Twiddler2 input device. The tilt sensor acts as a binary switch between panning and elevation such that the joystick's plane of control corresponds with the plane of motion.

The third interface combines the bulldozer metaphor with tilt. In the basic bulldozer interface, a user zooms in by moving the left and right joysticks apart laterally. This "zoom" is not very intuitive because the bulldozer metaphor becomes forced. With the tilt sensor, the user can simply tilt to select horizontal or vertical motion.

The fourth interface combines the airplane style of interface with tilt, again using the tilt sensor to select between horizontal or vertical motion. Thus, only a single hand is necessary for controlling zoom, elevation, and yaw.

### Procedure

Twenty four students from an introductory computer graphics course participated in the study. Each participant performed a two part navigation task for each of the four interfaces. The interfaces were presented in every possible order to balance any order effects, such as learning or fatigue. VGIS, a whole Earth 3D terrain visualization system[5] was used to provide the 3D environment for the study.

In the exocentric part, participants were asked to zoom in on white target cubes that appeared at various locations in North America. As the participants drew closer, the target became smaller and smaller, until a symbol was revealed. Participants zoomed out, located the next target, and zoomed in again. Four targets were presented. Afterwards, a test required them to recall the symbols they encountered, the order in which they were presented, and their locations.

In the egocentric part, users began south of the city of Atlanta. A similar four target task was used, but with tall white columns instead of cubes for visibility against the city skyline. Again, participants were given a test requiring recall of the symbols, order, and locations for each target.

Travel times to each target were recorded. Questionnaires allowed participants to score each interface on characteristics such as speed, ease of use, ease of learning, comfort, and errors. Open response questions collected comments on likes, dislikes, and suggestions for improvements.

### Results

Mean travel times (Fig. 2) in the exocentric mode showed significant differences for interface type under ANOVA ($p = .008$). A Tukey post-hoc comparison indicates that the airplane interface target time was statistically smaller than the bulldozer and airplane w/tilt interfaces. There were no significant differences between interfaces at the $p = .05$ level within the egocentric or exocentric tasks for target symbol, location, or order recall.

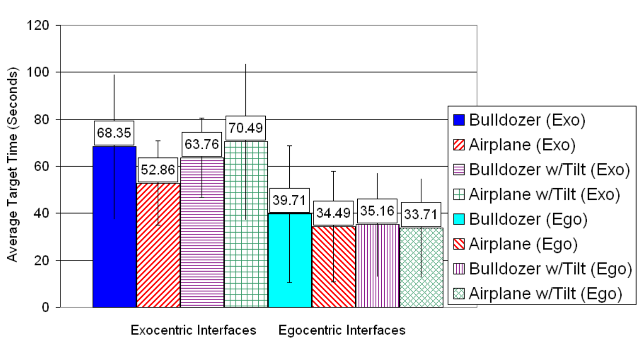


**Figure 2:** Average travel time to each target for each interface.

Participants rated each interface on several characteristics and made a number of suggestions and comments. A common negative comment focused on difficulty and discomfort in using the isometric joysticks. Also, participants disliked the interfaces with the tilt sensor because they could not pan and zoom simultaneously. Participants favored the airplane interface because they could pan and zoom simultaneously, using separate controllers to independently control pan and zoom.

## CONCLUSION

We had hypothesized that the airplane-like interfaces would encourage better performance in speed and information gathering. We also felt that the tilt sensor would also be advantageous in simplifying the bulldozer interface and enabling a single hand airplane interface.

The airplane-like interface was the most favored and had the best exocentric travel time. Although the single hand airplane w/tilt may be useful in certain circumstances, in general, the tilt sensor was not advantageous. In the exocentric task, the ability to pan and zoom simultaneously was probably the most important characteristic.

While not significantly different, the bulldozer interface's exocentric target time was worse than the airplane interface but better than the interfaces with tilt sensors. The bulldozer interface allowed some simultaneous pan and zoom, but it was more difficult to perform since users had to coordinate activity in both hands.

The lack of significant differences for target recall may be due to wide variation in spatial abilities in the general population. Also, while the task required participants to remember the symbol, order, and location for four different targets, this measure may not have been sensitive enough to reflect interface type effects.

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