Studying the Movement of High Tech. Rodentia: Pointing and Dragging

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ABSTRACT

This study compares seven input devices (mouse, touchscreen, two trackballs, mousepen, touchpad, and joystick) performing a star tracing task. Along with the device comparisons, the difference between moving with the selector button pressed (dragging) or with the button released (pointing) is examined. Recent work has found that dragging is slower and more error prone than pointing when using a mouse, stylus or trackball [1,2,3]. In the present study, 28 subjects used all seven input devices for both dragging and pointing tasks. Highly significant device differences were found for both speed and accuracy (p's <.001). The touchscreen and mouse were the best devices and the joystick and touchpad were the worst. The fastest devices also produced the fewest errors. The main effect for the button position was also significant, (p's <.005) with dragging being slower and more error-prone than pointing. However, there was a significant interaction between input device and button position. For one of the devices, the mousepen, dragging was actually faster and less error prone than pointing. What is different about the mousepen? Some possibilities are considered along with how these results can be applied to the design of input devices and interaction techniques.

KEYWORDS: Human performance modelling, input devices, input tasks.

INTRODUCTION

With the increasing use of graphical user interfaces, there is a strong interest in research to aid in the selection of non-keyboard input devices. The prevalent paradigm for this research is the comparative study. Several devices are used to perform a benchmark task. The fastest device is proclaimed the optimal input device. There are plenty of comparative studies already in the literature with a plethora of tasks and input devices. One criticism of the extant research is that due to the variety of tasks and devices employed, it is difficult to generalize the results.

Recent work has tried to get beyond this problem by looking for features of computer input which are common across a wide range of tasks and devices. Understanding these commonalities can serve to inform the selection of existing input devices as well as guide the design of future devices.

One example of such a common feature is in the study of pointing and dragging. Recent studies have found that dragging is slower and more error prone than pointing for the tasks of text selection [1], simple target acquisition [2] and hierarchical menu selection [3]. The input devices studied include the mouse [1,2,3], trackball and stylus [2].

The present study seeks to generalize this finding to a qualitatively different task and for a wider variety of input devices. The cited studies used discrete movements to a well-defined target. This study explores continuous movement without a specified end point. In an HCI context, examples of this include gesturing, or navigating in a virtual environment. This study examines the more modest continuous movement of tracing a geometric figure (a star).

METHOD

Subjects

Twenty-eight computer literate college students (12 male, 16 female) served as paid volunteers. All subjects were right handed and had 20/20 corrected vision.

Equipment

Tasks were performed on an Apple MacIntosh II using the following input devices: (1) MacIntosh Mouse, (2) Touchstar Touchscreen, (3) MacTrac Trackball, (4) MicroTrac Trackball, (5) MousePenPro, (6) Unmouse Touchpad, and (7) Gravis Joystick. The two trackballs differ in the ball size. The MousePenPro is a stylus-like device which is grasped like a pen and uses a mechanical ball located in the tip. The Unmouse is a 3 x 4 1/2 in. touchpad using relative mapping.

Procedure

Star Tracing Task: We utilized the motor skills module from the MacLaboratory software package developed by

Douglas Chute of Drexel University. A white, five sided star was displayed on a black background. The subject moved the cursor around the star as fast as possible while keeping within the boundaries of the figure (approx.1/4 in. wide path). Each trial consisted of 20 seconds of tracing. Subjects received immediate visual feedback on how far they had moved during the trial and how much of the time (in seconds) was spent outside of the figure.

Using a within-subject design, each subject used all seven devices for both pointing and dragging. The device ordering was counterbalanced across subjects. For each device, subjects performed six pointing trials and six dragging trials. Pointing and dragging trials were alternated with a five second break between each trial. Subjects were allowed to take a longer break before going to a new device.

RESULTS

Data Used in Analyses

With any motor skill experiment, warm-up effects must be considered. Our subjects did twelve trials with each device A one-way ANOVA found that performance stabilized by the eighth trial. Therefore, it is the last four trials on each device which are included in the following analyses.

Speed

The program recorded the distance (in mm) that the cursor moved within the star boundaries for each trial. A three way repeated measures ANOVA (Input Device (7) X Point/Drag (2) X Trial (2)) indicated that all of the main effects are significant at the .001 level. The ordering of the input devices from best to worst were as follows: Touchscreen, Mouse, MousePenPro, MacTrac, MicroTrac, Joystick, Unmouse. Dragging was worse than pointing overall. An interesting interaction was found between Input Devices and Point/Drag (F 6,156=7.89, p<.0001). For the MousePenPro and to a lesser extent the Touchscreen, dragging was superior to pointing (see figure 1).

Accuracy

Along with the distance on target, the program also recorded the total distance moved. The error measure which we report here is the distance moved inside of the target as a proportion of the total distance. ANOVA results showed that the main effects of Input Device and Point/Drag were significant at the .005 level. The ordering of input devices from best to worst were as follows: Mouse, Touchscreen, MousePenPro, MacTrac, MicroTrac, Unmouse, Joystick. The interaction was again found between Input Devices and Point/Drag (F 6,156=4.39, p<.0005). Four of the devices displayed higher errors for dragging, the touchscreen and mouse had equivalent, and very low error rates, and the MousePenPro again showed the reversed pattern of better performance for dragging than pointing (see figure 1).

DISCUSSION

The ordering of the devices also matches the general pattern found in other comparative studies, with the mouse and touchscreen as high performers and the joystick near the bottom. Taken as a whole, this study also supports the finding that dragging operations are more difficult than pointing operations. One lesson for designers is that whenever possible, pointing operations should be chosen over dragging operations for frequent tasks or those requiring high accuracy. For example, click open menus are superior to walking menus [3].

However, the MousePenPro results run counter to this general prescription. Part of the answer for this disparity may lie in the placement of the buttons on the device. The button for the MousePenPro is located right under the forefinger when grasping the device like a pen. Since this is a natural position it is possible that the extra pressure of pressing the button serves to stabilize the movement of the device relative to moving while the button is released. The placement of the buttons on the other devices requires extra pressure in a location which is not directly related to the movement, thus increasing the movement complexity. The designers of future input devices should consider the placement of the selector buttons/motions and how they impact the muscular tension of the user, and hence speed and accuracy of movement.

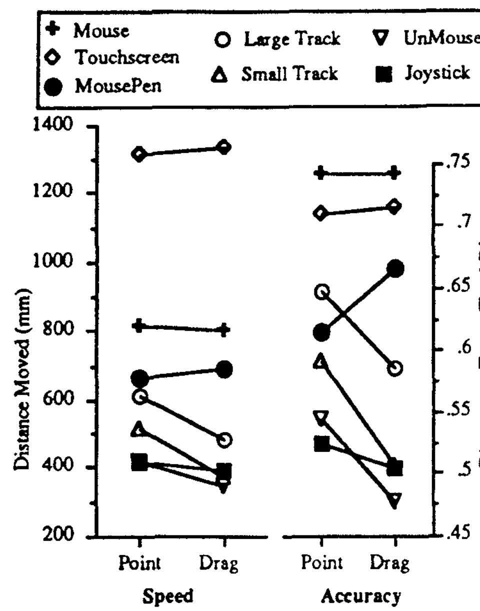

Figure 1. Speed and accuracy scores for Pointing and Dragging

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