Some Effects of Angle of Approach on Icon Selection

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ABSTRACT

Over the past decade, research related to various aspects of human-computer interactions has become increasingly prominent within the human factors field. In that regard, the speed and accuracy of human motor movements associated with computer input devices has often been modeled by Fitts' law. However, most such analyses have not considered the angle of movement as a factor. Accordingly, the present study investigated the effects of the angle of approach for a mouse as the input device to select icon-like targets presented on a VDT. The angle of approach had a significant effect on movement time.

KEYWORDS: Icon selection, Fitts' Law, input devices, human performance modeling.

INTRODUCTION

With the recent proliferation of windowing-type, icon-based software systems, the mouse has become the most utilized direct manipulation interface device. While several studies have compared the mouse with other devices, few have examined the effect of the angle of approach on movement time. Fitts' law [2] has proven to be robust under a wide variety of conditions and subject populations for target acquisition tasks; however, it does not account for the angle of approach. Selection of icon-like objects on a screen is not limited to the horizontal movements of reciprocal tapping (Fitts' task). For example, higher mean movement times (MT) have been reported for helmet-mounted sights [3] and joysticks [1] along diagonal axes. For the mouse, angle of approach had no effect on MT [1]. However, the angles used did not exercise the full range of movement on a computer desktop (screen), as movement was restricted to the right of the vertical axis on the left-hand side of the screen.

Under OS/2 and Windows, default icons are generally square and approximately 1.5 cm per side (0.3 cm per side for minimized icons). The use of icon-like targets, in size and shape, is a viable alternative to actual icons (which could carry confounding semantic meanings) to test direct manipulation devices in human-computer interactions.

This study examined the relationship between movement time and angle of approach for a mouse as the direct manipulation device for the selection of icon-like targets.

METHOD

Subjects

Twenty-two undergraduate students in Information Systems participated for course credit (9 male, 13 female, and 1 left-handed). All subjects reported over 30 days experience with personal computers (PCs) and mice.

Materials

System Configuration. This experiment used an Eclipse PC 486/33, 4M of RAM, 5.25 and 3.5 inch floppy drives, and an Orchid 280°F graphics board with 1M RAM. Cursor control and target selection were controlled by a Logitech two-button serial mouse. The screen on the CTX Proscan 17 inch monitor was 31x23.5 cm (800x600 pixels). The background color for target selection was black, the starting block was gray, and the targets were yellow.

Software. The study was run using software developed using Microsoft's Visual Basic for Windows, 2.0.

Procedure

Participants were tested individually. Subjects were interviewed to gather demographic and experiential data. Subjects read a single page of written instructions and were walked through a sample trial block (16 targets) to familiarize them with the task and environment. Subjects were instructed to move the cursor and capture the target as quickly and accurately as possible.

Amplitudes and angles were measured from the center starting position to the center of the target. Each trial presented an icon-like square target (0.25, 0.5, 1.0, or 1.5 cm/side) at an amplitude of 1, 2, 4, 8, or 10 cm, and at an angle of 0, 45, 90, 135, 180, 225, 270 or 315 degrees.

Each subject completed four trial blocks. A trial block consisted of 160 randomly presented, successful trials representing each target size, amplitude, and angle of approach (4X5X8 within subjects design). The subject positioned the cursor arrow in the starting block and, when ready, depressed the mouse button; a target then appeared at its angle and amplitude. The subject moved the cursor to the target and depressed the mouse button to complete the selection. If the tip of the arrow was within the target, the subject went to the next trial. If the tip of the arrow was outside the target, an error was recorded and that trial remained in the pool of trials to be run within the block. A trial block was not completed until all possible targets (160) were successfully captured. At the end of each block, the subject's performance feedback was displayed with the number of errors and the mean movement time for each block. Between blocks, subjects commented on their interaction, and were told to flex or stretch their arm and hand. The mean participation time for each subject was 45 minutes with a one minute break between blocks.

The software recorded subject, block, size, amplitude, angle, response and movement time for hits. Response time was measured from the appearance of the target on the screen to the movement of the cursor off the starting block. Movement time was measured from the time the cursor moved from the starting point to the selection of the target. Errors were written and analyzed separately.

RESULTS

Angle of Approach

The angle of approach had a significant effect on mean movement time overall, in pairwise contrasts, and in interaction with the smallest target size.

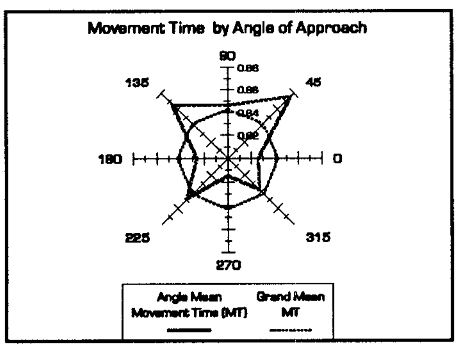

Figure 1

Figure 1 presents a comparison of MT for each angle averaged across target size and distance.

A MANOVA for repeated measures showed a significant effect of angle on MT, $F(7,15)=5.39$, $p<.005$. Pairwise contrasts (Bonferonni corrected, $p<.05$) showed significant differences between angle pairs 0/45, 45/270, 135/180, 45/180, and 45/315. A significant size by angle interaction was obtained, $F(16,6)=3.98$, $p<.05$. The interaction was interpreted by examining the variability in MT across all angles within target sizes. The variance for the .25 cm target is more than twice the variance on any other target size. Pairwise contrasts showed significant differences between target-size pairs .25/1.0 cm and .25/1.5 cm.

Error Rate

The error rate for all subjects across all blocks was 2.96%. Card [1] reported mouse error rates ranging from 3.5% to 5%. The lower error rate could be attributable to the subjects' experience with PCs and mice.

CONCLUSIONS

The angle of approach for the selection of icon-like targets by a mouse had a significant effect on movement time. Movement times along the diagonals were slower than along the horizontal and vertical axes. Upward movements (45, 90, 135 degree angles) were slower than downward moves (225, 270, 315 degree angles), while movement on the horizontal axis was the most efficient.

From these results, arranging icons, 0.5 to 1.5 cm square, at a distance of 4 cm or less, and with an angle of approach of 0, 180, or 270 degrees from the starting point on a computer desktop would improve performance of icon selection, where movement time is an issue.

Further research into the effect of the angle of approach on target selection tasks will attempt to define its role in Fitts' model.

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