Effect of Touch Screen Target Location on User Accuracy

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EFFECT OF TOUCH SCREEN TARGET LOCATION ON USER ACCURACY

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Users can be frustrated by touch screen applications that inaccurately record their touches. Enlarging touch sensitive regions can improve touch accuracy, but few specific quantitative guidelines are available. This paper reports on a controlled experiment that investigated the effect of target location and horizontal viewing location on user accuracy. Measurements showed that persons tended to touch below the target, with touch distance increasing as the target location moved down the screen. In addition, they tended to touch toward the sides of the screen. Using collected data for each of nine screen sectors, graphs were prepared that show the relationship between touch target size and expected accuracy. For example, a 36 mm^2 target in the top left sector would be expected to accurately record 99% of its touches. The empirically-derived, quantitative guidelines will help designers create screens that decrease user errors and frustration.

INTRODUCTION

Many computer applications use touch screen devices to communicate with users. Reported applications include power plant monitoring (Usher and Illet, 1986), vehicle control panels (Olson, 1987), hospital patient monitoring (Weisner, 1988), aircraft instrumentation (Berringer and Bowman, 1989), and a public nutritional information system (Winett *et al.*, in press). In addition, the public uses touch screens in literacy/training programs, retail merchandising, and shopping mall information systems.

Some touch systems, particularly public information systems, are used by many persons, but each person often touches the screen only a few times before finishing. Many persons do not return to reuse the system. Designers must simplify such systems as much as possible, since most users are new and have little time to "learn" accuracy. Previous research has examined the effect of horizontal and vertical viewing angles and parallax on the accuracy of a user attempting to touch a target on a touch screen. This study investigated the effect of target location on accuracy and predicted target accuracy based on location. The study tested a worst case scenario because of the physical surroundings (a grocery store, with glare, noise, and other distractions) in which it was conducted, and because it gave no feedback on accuracy to participants.

RELATED WORK

Several studies have measured user performance on touch screens (Berringer and Peterson, 1985; Hall *et al.*, 1988; Potter, Weldon, and Shneiderman, 1988; Berringer and Bowman, 1989). These studies agree that horizontal and vertical viewing locations and parallax decrease touch accuracy. They agree that persons touch toward the sides of the screen, but some report users touching above the targets while others report touching below.

Previous research has described techniques to improve performance by training users (Berringer and Peterson, 1985; Potter *et al.*, 1988), modifying touch strategies (Valk, 1985; Pickering, 1986; Potter *et al.*, 1988), compensating for user tendencies (Berringer and Peterson, 1985; Pickering, 1986), and designing error tolerant targets (Pickering, 1986; Hall *et al.*, 1988). Unfortunately, in public access systems, only the last technique — error tolerant targets — can be expected to work well. Training is impractical due to the number of users and their short term usage, modified touch strategies are non-intuitive and often confusing, and user characteristics are too variable to allow effective compensation. *Error tolerant targets* have large touch sensitive regions around the visual target and are usually surrounded by *buffers*, touch insensitive regions.

METHOD

xperimental Setup

n IBM InfoWindow Touch Monitor and an IBM 'S/2 housed in an information kiosk at the front f a local grocery store were used for the study. 'he monitor was tilted back 15° and its center vas 131.8 cm above the ground. Touch targets vere red squares on a black background.

'articipants

'orty-five participants were recruited in the rocery store as they walked past the kiosk. election criteria were simple: less than 30 ninutes of prior touch screen use, unimpeded notion in the arm to be used for touching the creen, corrected vision, no bifocals, normal olor perception, and at least 18 years of age.

Experimental Design

User performance was assessed by a 3 x 3 x 9 (target size x horizontal viewing location x target location) factorial analysis. *Target size* was a between-subjects variable, while *horizontal viewing location* and *target location* were within-subjects variables.

Three visual target sizes were used: 7.5 mm^2, 12.2 mm^2, and 20 mm^2. The first two were used in similar tests (Baggen, 1987; Hall *et al.*, 1988), while the largest size closely maintained an increasing ratio of areas among targets. Each participant saw only one size target to avoid an asymmetric transfer of skill.

Three horizontal viewing locations were tested for each subject: perpendicular to the screen, 20° to the left of perpendicular, and 20° to the right of perpendicular. Side viewing locations represented the locations from which two 50 percentile US adults standing side by side would view the screen (Hall *et al.*, 1988). Target locations were ordered randomly for each participant.

The screen was divided into three rows and three columns, forming nine logical sectors of equal size. Each sector was subdivided into four logical quadrants. A target was centered in each quadrant, resulting in 36 targets.

Experimental Task

A pretest familiarized participants with target appearance and force required to activate the touch screen. The experimenter stressed accuracy when pressing targets, not speed. During the test, participants stood at each of the three viewing locations and saw the 36 equal

When the participant pressed anywhere on the screen, the monitor beeped, the target vanished, and another target appeared.

RESULTS AND DISCUSSION

X and Y offsets from target center to touch location were collected and analyzed to determine user accuracy (i.e., the straight line distance), as shown in Figure 1. Analysis of variance tests showed that horizontal viewing location significantly affected user accuracy in both the horizontal direction ($F(2,84)=136.67$, $p<.0001$) and in the vertical direction ($F(2,84)=32.97$, $p<.0001$). Mean X offset was -1.77 mm when standing to the right, -0.29 mm when standing to the center, and 2.13 mm when standing to the left. Mean Y offset was 5.28 mm from the right, 5.51 mm from the center, and 6.58 mm from the left. ANOVA tests showed that varying target size (7.5 mm^2 to 20.0 mm^2) had no effect on user accuracy ($p>.05$).

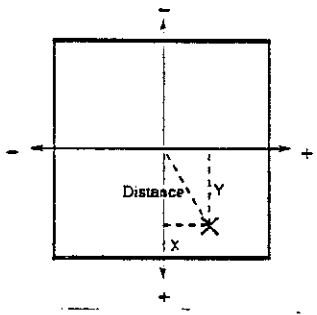

Figure 1: Relationships among target center and touch location.

ANOVA tests showed that target sector significantly affected user accuracy. *X offsets* differed significantly among columns ($F(8,336)=428.14$, $p<.0001$), ranging from 6.07 mm to the left of center to 4.90 mm to the right, as shown in Figure 2a. *Y offsets* differed significantly among rows ($F(8,336)=943.35$, $p<.0001$), ranging from 3.75 mm above target center to 14.21 mm below target center, as shown in Figure 2b. In general, *distance from target center to touch location* increased significantly as the target row approached the bottom (except that the top left and middle center sectors were not significantly different), as shown in Figure 2c. Figure 3 shows touch variation among sectors by plotting the mean X and Y offsets.

Differences among X offsets are due primarily to parallax of the touch screen. The technological design of the screen and its touch overlay bend light toward screen edges, causing the perceived target to shift toward the edges. Therefore, target centers in right hand sectors appear further to the right than they actually are. Likewise, target centers in left hand sectors