Adaptive Click-and-Cross: An Interaction Technique for Users with Impaired Dexterity

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ABSTRACT

Computer users with impaired dexterity face difficulties with traditional pointing methods, particularly on small, densely packed user interfaces. Past research in software-based solutions can usually be categorized as one of two approaches. They either modify the user interface to fit the users' needs or modify the user's interaction with the cursor. Each approach, however, has limitations. Modifying the user interface increases the navigation cost of some items by displacing them to other screens, while enhanced area cursors, a pointing technique for small, densely packed targets, require users to perform multiple steps to acquire a target. This study aims to minimize the costs of these two approaches through a new interaction technique, Adaptive Click-and-Cross. The technique was found to lower error rates relative to traditional pointing (8.5% vs 16.0%) with slightly faster acquisition times compared to two other techniques for modifying the user interface or cursor.

Categories and Subject Descriptors: H5.2 **[Information interfaces and presentation]**: User Interfaces–*Input devices and strategies*, K4.2 **[Computers and society]**: Social issues–*assistive technologies for persons with disabilities*

Keywords: Accessibility, area cursors, adaptive user interface

1. INTRODUCTION

Computer users with impaired dexterity face difficulties with traditional pointing methods, particularly when selecting a target from a set of small, densely packed user interface elements. In the past few decades, a variety of software-based techniques have emerged to assist such users. These approaches fall broadly into two categories: those that modify the user interface itself (e.g., generating personalized user interfaces through SUPPLE [1]) and those that modify the user's interaction with the mouse pointer (e.g., increasing the size of the pointer as an area cursor [2]).

Approaches that adapt the user interface, such as SUPPLE [1], often increase the cost of navigation. For example, enlarging a large set of items makes it easier for a user to acquire an item. However, the modification will either increase the scrolling needed to reach some items or force them to another tab pane, requiring the user to perform additional actions to reach them.

Adaptations based on modifying the pointing technique do not modify the user interface. For example, *enhanced area cursors* reduce the number of precise movements that a user must make to acquire a target but often require multiple steps to complete [3]. With the *Click-and-Cross* technique, when a user clicks near or on a target, a circular overlay of nearby targets appears. The user can then cross through a target to acquire it. This trades off click precision for an extra movement: the initial click can be imprecise, but it must be followed by an additional crossing action to complete the selection.

While Click-and-Cross reduced both errors and acquisition times on smaller targets, Findlater et al. found that users with motor impairments were still faster with traditional point cursors on larger targets (16 pixels). This suggests that, for larger targets, the two-step click-and-cross is not necessary [3].

Based on these observations, this work aims to unify the two approaches of interface modification and enhanced area cursors through a novel interaction technique: *Adaptive Click-and-Cross*. In this study, we hypothesize that Adaptive Click-and-Cross will reduce the number of errors and decrease the acquisition time of small, densely packed targets for users with impaired dexterity. This technique differs from previous techniques in that it both modifies the user interface and the interaction with the cursor.

In Adaptive Click-and-Cross (illustrated in Figure 1), a small number of elements predicted to be of immediate use to the user are automatically enlarged and can be acquired with a normal pointing cursor. Predicting elements for normal cursors, but not Click-and-Cross, has previously been tested with able-bodied users [4].

When the user clicks near or directly on normally sized targets, the Click-and-Cross cursor is triggered. Adaptive Click-and-Cross employs the enhanced area cursor only when targets are small enough such that it would be difficult for the user to acquire them with normal pointing. Since only some aspects of the interface are modified, this design minimizes the navigational cost of scrolling from modification. This unifies the two concepts but reduces the shortcomings of both.

We implemented and evaluated four designs: *Baseline* (all small targets), *Enlarged* (all large targets), *Click-and-Cross, Adaptive Click-and-Cross*.

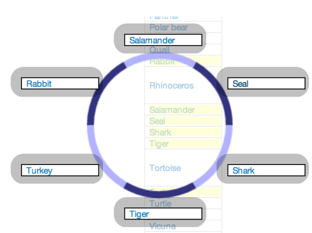

Figure 1: Adaptive Click-and-Cross. Some items are enlarged, but clicking near small targets activates the Click-and-Cross cursor.

2. EXPERIMENT

Participants. Eight people with dexterity impairments of various severity participated in the study remotely. Participants had a variety of conditions, including rheumatoid arthritis, repetitive strain injury, cerebral palsy, and fibromyalgia. The study took 40 to 60 minutes depending on individual abilities.

Task. The designs were evaluated through an experiment consisting of acquisition tasks in a 60-item menu interface. Normally sized items in the Baseline, Click-and-Cross, and Adaptive Click-and-Cross conditions were 80×10 pixels. Enlarged items in the Enlarged and Adaptive Click-and-Cross conditions were 80×40 pixels. Items in the Adaptive Click-and-Cross condition were enlarged with 70% *predictive accuracy*, representing the proportion of participants' selections that were predicted correctly.

In total, each participant performed $4 \times 5 \times 10$=200 acquisition tasks. The order of the four conditions was counterbalanced using a partial Latin square design. As one of the five blocks in each condition was a practice block to allow the participant to become accustomed to the design, the results were taken from the $4\times4\times10$= 160 acquisition tasks in experimental blocks.

3. RESULTS AND DISCUSSION

Statistical analysis was performed on the natural logarithm of acquisition times to account for deviations from a normal distribution. Results outside of two standard deviations of the mean were considered outliers and discarded (20 trials, 1.56% of the data).

There was a significant main effect of condition on acquisition time ($F_{3,5}$=12.96, p<.01) found through repeated measures multivariate ANOVA. Average acquisition times are shown in Figure 2. A binomial logistic regression showed a significant main effect of condition on error rate (p<0.0001). The error rates of each condition are shown in Figure 3. Finally, whether or not the target was on the first screen had a significant interaction effect with condition ($F_{3,5}$=15.32, p<0.01), corresponding to the navigational cost of scrolling in the menu interface.

While participants had the lowest mean acquisition rates in the Baseline condition (3.13 s), they also had a high rate of errors (16.0%). This reflects the difficulty that users with impaired dexterity have in accurately acquiring small targets, performing multiple clicks before successfully acquiring the target.

For items *on the first screen* displayed to the participants (those that required no scrolling), the Enlarged condition had the lowest mean acquisition times but had longer acquisition times for items off of the first screen. This is to be expected, as items on the first screen were both large and immediately accessible. Although it is initially surprising that Enlarged had the highest error rate of 19.6%, it should be noted a majority of the errors in this design were from a single participant.

Adaptive Click-and-Cross had greatly fewer errors than Baseline did (8.5% vs 16.0%) but longer acquisition times (4.19 s vs 3.13 s), indicating that participants' accuracy with small, densely packed links (present in both Adaptive Click-and-Cross and Baseline) improved greatly. The error rates of Adaptive Click-and-Cross and Click-and-Cross were comparable (8.5% vs 7.87%). Adaptive Click-and-Cross had only slightly lower acquisition times than Click-and-Cross and Enlarged (4.19 s vs 4.23 s vs 4.27 s, respectively).

Participants commented on both the navigational cost of scrolling and the ease of clicking large targets. One participant stated, "If you eliminate having to scroll, the time to complete the tasks would decrease tremendously." Another commented, "The big squares were easier to click on." These comments suggest that the goals of Adaptive Click-and-Cross, to minimize the navigational costs of scrolling while improving accuracy, coincide with the users' perception of the Enlarged design.

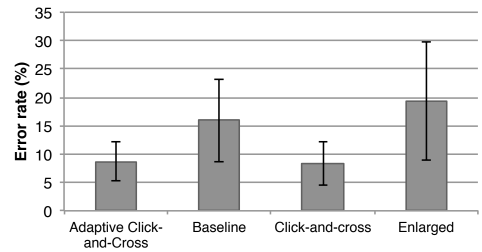

Figure 2: Mean acquisition times for each condition. Error bars represent ±1 standard error.

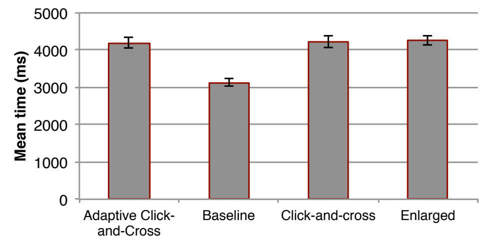

Figure 3: Mean error rates for each condition. Error bars represent ±1 standard error.

4. CONCLUSION

The Adaptive Click-and-Cross design gave rise to fewer errors traditional pointing did. The technique yielded marginally lower acquisition times than interface modification through enlargement and traditional Click-and-Cross, suggesting that improvements could further reduce the costs of interface modification and enhanced area cursors. Future analysis could more closely examine the individual differences in interacting with the design and user preferences. Adaptive Click-and-Cross is a promising start for exploring the design space of interaction techniques that both modify the user interface and the user's interaction with the cursor.

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