Gaze-Assisted Pointing for Wall-Sized Displays

Hans-Joachim Bieg, Lewis L. Chuang and Harald Reiterer

University of Konstanz, HCI Group,
Box D 73, Universitätsstraße 10, 78457 Konstanz, Germany
Max-Planck Institute for Biological Cybernetics,
Box 2169, Spermannstraße 38, 72012 Tübingen, Germany
{hans-joachim.bieg, harald.reiterer}@uni-konstanz.de
Lewis.Chuang@tuebingen.mpg.de

Abstract. Previous studies have argued for the use of gaze-assisted pointing techniques (MAGIC) in improving human-computer interaction. Here, we present experimental findings that were drawn from human performance of two tasks on a wall-sized display. Our results show that a crude adoption of MAGIC across a range of complex tasks does not increase pointing performance. More importantly, a detailed analysis of user behavior revealed several issues that were previously ignored (such as, interference of corrective saccades, increased decision time due to variability of precision, errors due to eye-hand asynchrony, and interference with search behavior) which should influence the development of gaze-assisted technology.

Keywords: Eye-Tracking, Eye-Hand Coordination, Multimodal

1 Introduction

Advances in display technology and the user's need for more screen real-estate are likely to lead to considerable display size increases in the coming years. Already, displays typically extend beyond the size of 20”, up to that of large walls. With this comes a host of fresh challenges – such as the exploitation of large screen real-estate [1] and complex display configurations [2] – that could be addressed by utilizing knowledge of a user’s current point of gaze on the screen.

A technique for gaze-assisted pointing was previously presented by Zhai, Morimoto, and Ihde [3] that was based on the simple assumption that users tend to look at display items that were potential targets for selection. Using information from a gaze-tracking system, they were able to translocate the pointer to the user's current point of fixation. In other words, the pointer followed the user's gaze and reduced the movement that was typically required of the user. To enable uninterrupted manipulations, the pointer was only translocated if a fixation occurred with considerable (120 px) distance to the current pointer position and if the device was not in motion at that time. In addition, the users were still able to use their pointing device to override this modification. Zhai and colleagues showed that gaze-assisted pointing techniques resulted in (marginally) faster response times on a simple pointing task.

We expected gaze-assisted pointing techniques to be especially useful on wall-sized displays, given the large movement amplitudes that are required on such interfaces, Furthermore, we decided to test these techniques on two tasks that reflected the complexities of a user's typical experience with display interfaces. The goals of this study were to evaluate whether the MAGIC technique would lead to substantial improvements of pointing speed and to see how the technique was affected by perceptual demand.

2 Method

The experiment was carried out by 12 participants with normal or corrected-to-normal vision. In this study, participants were equipped with a mouse and were asked to perform different search and drag-and-drop tasks of varying complexity (see Fig. 1). On half of these trials, participants were provided with gaze-assisted pointing (MAGIC) and this modification was disabled on the remaining half. This order was counterbalanced to control for practice effects.

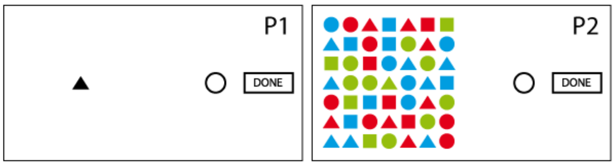

Fig. 1. Schematic representation of two experimental tasks. Left: in the first task, a single target had to be selected and dragged to a circular homing area, followed by a click on a button to confirm task completion. Right: in the second task participants had to visually search a 13 × 13 item grid for a single item, specified by shape (triangle, rectangle, circle) and color (red, green, blue) before performing the same drag-and-drop task. Such a combination of search and selection is frequently required during a range of human-computer interaction tasks [4]. The size of each item was approximately 20 px (3.3 cm, 1.92° visual angle).

Participants sat 100 cm in front of a back-projected display (resolution 1400 × 1050 px, size 94.1° × 89.1° visual angle). Subjects wore a head-mounted eye-tracker, with attached markers for head-tracking. These tracking data could thus be combined to compute the point of the user's gaze, on the screen [5]. This information was provided to the system in real-time and at 120 Hz. Experimental sessions lasted around 90 minutes and the system was recalibrated regularly to assure that gaze was tracked accurately.

3 Results and Discussion

Comparison of task completion time and selection times showed better task completion times for trials without MAGIC, relative to trials that enabled MAGIC for task p1 (mean difference: 1094 ms, $t(11)=6.6$, $p < 0.01$) and task p2 (mean difference:

1720 ms, t(11)=6.7, $p < 0.01$). This was the case despite latencies of approximately one second between fixations on the target and selections on the MAGIC trials. Although users fixated the target early, triggering a translocation of the pointer in the MAGIC condition, they were not able to benefit from this translocation and required equal or even more time to carry out fine-adjustments for the selection. A detailed analysis of user behavior with MAGIC revealed several reasons for this and suggests potential improvements:

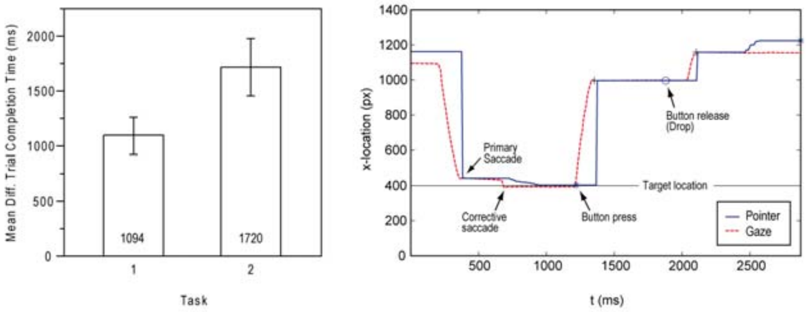

Fig. 2. Left: difference in mean trial completion time (ms) between trials with MAGIC enabled and disabled (whiskers show std error). Right: movement profile of a trial during task 1. The pointer is translocated to the first inaccurate fixation (primary fixation). This fixation is followed by a corrective saccade which is below the 120 px threshold.

Large saccades tend to generate considerable error in their landing positions, relative to the intended targets. These are typically followed by small corrective saccades (see Fig. 2 right) which fall below our adopted threshold of 120 px [6]. In turn, these could have led to conflicts between the users' expectations and the displayed position of the pointer. A solution to this problem would be to make the threshold dependent on the amplitude of the preceding saccade or disabling it for a fixed time span after a saccade. Based on our current data, we believe that a better threshold would be one that adapts to the saccade amplitude. A separate investigation of the effect of saccade length on fixation errors could provide more information about the benefits of such an adaptation and whether the function of this adaptation could be calibrated to fit the individual's actual performance.

Precision variability could also have increased selection time by requiring an additional cognitive task of evaluating if the pointer was displayed "accurately". If the pointer was translocated precisely, the user was able to directly select the item underneath it. If it was off, a corrective action was required. This problem could be remedied by not translocating the pointer directly to a fixation but by introducing an artificial offset so that a more predictable correction can occur during the final manual acquisition movement.

Errors also occurred when gaze moved away from targeted locations before the mouse actions were completed. For instance, participants sometimes started searching for the next target before they had dropped the item. This idiosyncratic tendency could be calibrated on an individual level by modifying the latency of pointer translocation to suit the given individual's behavioral patterns.

A comparison of the second task against the first task showed an increase in task completion times because users required time to search for the target [7]. However, the increment was larger when MAGIC was enabled (see Fig. 2 left, $t(11) = 3.5$, $p < 0.01$). This result gives rise to the assumption that participants were distracted by translocations of the pointer while searching for the target. Comparison of fixation duration showed that fixations during search were much shorter (mean = 281 ms, SD = 108 ms) than fixations directly preceding target selections (mean = 988 ms, SD = 455 ms). An adaptive mechanism that prevents translocation during series of short fixations could increase the performance of gaze-assisted pointing by reducing distractions due to unintended pointer motion during search.

Conclusion

The applicability of MAGIC, a gaze-assisted pointing technique was tested with a large display. Contrary to our initial expectations, this technique did not induce any movement time savings during basic selection and search tasks. However, the experiment also revealed several issues that negatively affected performance. Specifically, we discuss how gaze-assisted pointing can benefit by being adapted to basic coordination patterns and individual differences in eye-movement behavior. The appropriate parameters for these adaptations can be approximated from a larger dataset.

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