

# High-density cursor: an improved mouse cursor that accelerates target acquisition

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## ABSTRACT

As bigger screens and multi-monitor configurations become more popular, users employ higher mouse accelerations in order to traverse the screen reasonably quickly. The faster the mouse cursor moves, however, the more it seems to jump from one position to the next because it is updated only at the refresh rate of the monitor. This lack of visual continuity increases the risk of users losing track of the cursor. *High-density cursor* addresses this issue by filling in additional cursor images between actual cursor positions. Unlike existing techniques, such as the Windows *mouse trail*, the proposed technique preserves the responsiveness of the mouse cursor. In our user study, high-density cursor improved participants' performance for target acquisitions across long distances, often without the conscious awareness of any visual change in the cursor.

## Keywords

Mouse cursor, large displays, temporal super sampling, motion blur, Fitts' law, mouse trail.

## INTRODUCTION

As more users switch to multi-monitor display configurations [3] or very large screens, users have to move across larger distances on their screens. The increased distances often affect how users handle their mice. To avoid excessive clutching, users who want to get across the screen reasonably fast have to set their mice to higher speeds or acceleration values. A resulting problem is that the mouse cursor appears to jump from one position to the next, as illustrated by Figure 1a. (*temporal aliasing* [2]).

These jumps are caused by the fact that current operating systems can update the cursor *visibly* only at the refresh rate of the monitor. Unfortunately, current LCD monitors have even lower refresh rates than traditional CRTs (60Hz vs. 80Hz) so the apparent gaps in the path of the mouse cursor get even larger. On a triple LCD setup, for example, we observed cursor jumps of over 500 pixels—about half the width of a regular computer screen.

These large gaps between the individual appearances of the cursor make it hard for users to visually track the cursor, to predict its trajectory, or to detect it as it approaches a target. This limits the speed at which users can reliably operate the mouse.

## HIGH-DENSITY CURSOR

*High-density cursor* (*hd cursor*) [1] addresses this issue by creating a denser cursor track. As shown in Figure 1b, this is accomplished by filling in additional cursor images

into the space between the current cursor position and the previous cursor position (temporal supersampling, e.g. [2]). Figure 1b shows the same mouse motion as Figure 1a; both images were created by overlaying two successive images on the computer screen, so-called frames. The left-most cursor image in each frame in Figure 1b is rendered at the newest position read from the mouse device. The other three cursor images of each frame are filled in to make the mouse trail appear denser.

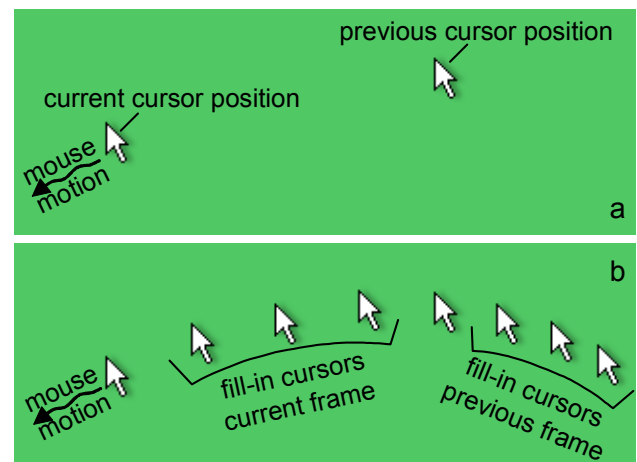


Figure 1: (a) The problem: at high mouse speeds, the mouse cursor seems to jump from one position to the next. (b) *High-density cursor* makes the mouse cursor appear more continuous by inserting additional cursor images between actual cursor positions.

Hd cursor determines the number of filled in cursor images based on mouse speed. To prevent clutter, hd cursor inserts cursor images only when the mouse speed exceeds a certain threshold. As the mouse accelerates beyond the threshold, more and more cursor images are inserted. However, while hd cursor can be configured to keep the space between cursor images constant, by default the distance between cursor images is configured to grow slowly with mouse speed. This way, distance between cursor images still provides a certain visual indicator for mouse speed. Hd cursor uses smooth interpolation for determining cursor positions, making the filled-in cursors virtually indistinguishable from the real ones (unlike other techniques designed for enhancing the detectability of the mouse cursor, such as cursor scaling [4]).

High-density cursor addresses two main objectives. First, it increases the visual continuity between cursor images in

order to help users track and extrapolate the path of the cursor. Second, the denser track created by hd cursor makes it easier to visually acquire than a regular cursor. The larger number of cursor images on the screen gives hd cursor more saliency or “visual weight”, which makes it easier for users to detect as it approaches a target. For example, there are four times more cursor images in the example shown in Figure 1.

High-density cursor achieves these objectives without sacrificing the responsiveness of the mouse. Techniques that enhance the visibility of the cursor by displaying individual cursor images for a longer period of time (e.g. the Windows mouse trail, shown in Figure 2a) result in the appearance of a trail *following* the cursor. Since trailing cursor images continue to move after the user stops moving the mouse, this approach leads to the perception that the mouse does not immediately respond to the user’s action. Hd cursor is free from such artifacts because it obtains its enhanced visual weight from using a new set of cursor images for every frame, rather than keeping the same set of cursor images alive longer. The hd cursor approach removes all cursor images in the following frame, so that trailing effects cannot occur and the perceived responsiveness of the mouse is preserved<sup>1</sup>. Figure 2 shows the two techniques in direct comparison.

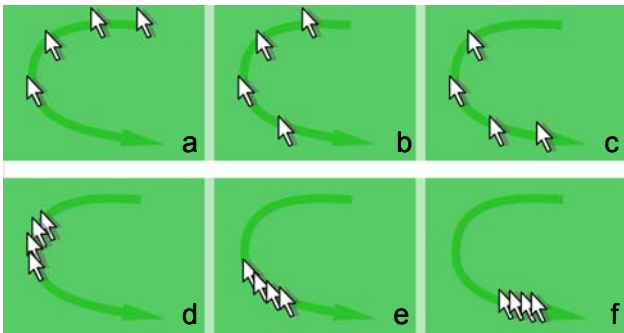


Figure 2: (a-c) Three successive screenshots from a mouse movement enhanced with the Windows mouse trail. Trailing cursor images lag behind. (d-f) The same traversal with high-density cursor; additional cursor images are inserted *between* the two most recent cursor positions, resulting in a dense and lag-free trail.

### USER STUDY

To objectively evaluate performance using the high-density cursor, we performed a user study using a Fitts’ Law task. We tested three versions of high-density cursor (a reference implementation *HD\_cons*, a denser version *HD\_triple*, and one version that also scales the cursor with mouse speed *HD\_scale*) against a control of the default Microsoft Windows system cursor.

<sup>1</sup> Responsiveness is hard to communicate using non-interactive media such as images, video, or text. An interactive demo of the hd cursor written in Macromedia Flash can be tried out at <http://research.microsoft.com/users/baudisch>

All three high-density cursor interfaces performed significantly better than the control interface as shown in Figure 3. The largest effect of the high-density cursor visualization was in very large mouse movements, but it was surprising to see across-the-board improvement as well. The majority of users were not able to tell the presence of the inserted cursor images. The results of a subjective comparison backed that data. See [1] for details on this study.

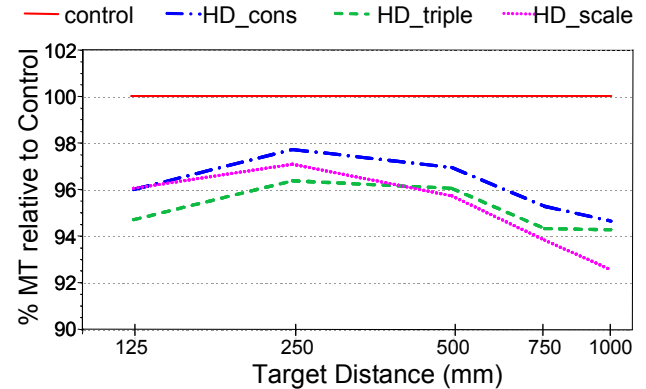


Figure 3: Mean movement time for each condition expressed as the % relative to the control for each distance moved.

### CONCLUSIONS

Despite their relatively modest size, the findings can be expected to have a significant impact on people’s daily work. Target acquisition tasks, like those tested in the user study, occur as part of virtually all everyday computer tasks. The speed-up caused by the high-density visualization can therefore be expected to lead to small, but omnipresent time savings, especially as display sizes continue to increase. Finally, the confirmed unobtrusiveness of hd cursor is of particular importance for the application of the technique in a real-world operating system or mouse driver. As the majority of users were not able to tell the presence of the inserted cursor images, introducing hd cursor into an existing system can be expected to pass without causing legacy issues or need for adjustment among users.

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