What can a mouse cursor tell us more? Correlation of eye/mouse movements on web browsing

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ABSTRACT
In this paper, we describe a study on the relationship between gaze position and cursor position on a computer screen during web browsing. Users were asked to browse several web sites while their eye/mouse movements were recorded. The data suggest that there is a strong relationship between gaze position and cursor position. The data also show that there are regular patterns of eye/mouse movements. Based on these findings, we argue that a mouse could provide us more information than just the x, y position where a user is pointing. This implies that we can use an inexpensive and extremely popular tool as an alternative of eye-tracking systems, especially in web usability evaluation. Moreover, by understanding the intent of every mouse movement, we may be able to achieve a better interface for human computer interaction.

Keywords
Eye tracking, eye movements, mouse movements, cursor, gaze, web evaluation.

INTRODUCTION
Eye tracking technique has been used as a powerful tool for various psychology experiments. It provides concrete data that may reflect the cognitive states of individuals. However, due to many technical constraints, to track eye movements usually requires sophisticated calibrations and the results are not always acceptable. One of the serious problems we, as researchers, often face is that the tracker goes off-calibration gradually. Although drifting-correction or even re-calibration could be done between trials, it simply doesn't work for experiments comprised of only one single long session. If it were possible to predict the gaze position, we could use these predictions to constantly recalibrate without interrupting the experiment. From a human-computer interaction point of view, mouse is the most widely used, and closest device to the eye tracking on the spectrum of various modalities. Therefore, we started to study the relationship between eye movements and mouse movements.

Previous research shows that sometimes cursor follows gaze, sometimes not [1]. It is reasonable to assume that the relationship between cursor and gaze position will vary under different settings. For example, one might expect stronger gaze/cursor relationships in graphics software than in text editors. To optimize the potential applications of this study, we chose web browsers as the context for our study. The web is so popular that usability on the web has more impact on the society than some others have. Some eye-tracking studies have been done on web [2], and some companies even started to provide eye-tracking services for web evaluation. Therefore, it will be beneficial if we have a "mouse-tracker" as an alternative to an eye-tracker. Where there is a web browser, there is a mouse. Web usability specialists could have a plug-in installed and remotely collect huge amounts of data over the Internet without interrupting users.

EXPERIMENT DESIGN
A customized web browser was used to communicate with EyeLink eye tracking system, record mouse movements and log web-browsing activities. We chose four different styles of web sites[1] in order to accommodate the diversity of web design. To prevent any delays due to network traffic, web pages up to 3 levels deep from the top page of the web site were pre-downloaded in a local drive. Five subjects were asked to surf web sites for 5 minutes in each website. Their eye/mouse movements were recorded and visited pages were logged. Subjects were not instructed to do any specific task. They could freely navigate through on each web site and stay on a specific web page as long as they wanted.

For the purpose of data analysis, several regions were defined for each visited page. These regions falls into 7 categories: button, menu, title, text, graphics, banner and nowhere. Different pages may have different numbers of

1 www.cmu.edu, www.cmoa.org, www.apple.com, www.sapient.com

regions. The mouse and eye data were merged and analyzed based on those regions for each page.

RESULT

In total, 100 minutes of eye/mouse data were recorded, and 595 visits were made on 235 different web pages. The dwell time on each page ranged from 0.5 seconds to 105.8 seconds, with 8.9 seconds average. The distances between gaze and cursor range from 0.1 pixels to 1137.4 pixels, and 290.5 pixels in average. In term of regions, eye gaze visited about 50% of regions in average, and cursor visited about 38%. Of the regions that a mouse cursor visited, 84% of them were also visited by an eye gaze. Furthermore, among the regions that the eye gaze didn't visit, 88% of them were not visited by the mouse cursor, either.

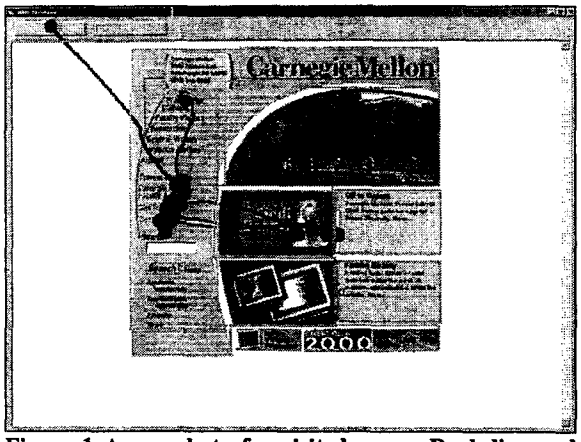

Figure 1 A snapshot of a visited page. Dark line and dots stand for the cursor path and cursor fixations (the lighter one for gaze). Thin frames stand for various regions defined for this page.

For each page, we calculated dwell time of both gaze and cursor for every region in that page. Then we looked at the correlation between these two for every page. The average of 595 correlations is 0.58. More than 50% of these pages were associated with correlations larger than 0.8.

We also looked at the distance between gaze and cursor when the mouse moved in a saccade-like manner. Not all of a screen consisted of meaningful regions. We call the non-meaningful regions "nowhere" and classified mouse saccades into four categories depending on where they originated and where they wound up: *Stay Nowhere, Go Nowhere, Stay the Same Region, Move to New Region.* About 47% of mouse saccades were made to *Stay the Same Region*, 28% *Move to New Region*. In terms of the mouse saccades staying the same region, eye gaze was directed to the same region either in the beginning of the mouse saccade (76%) or in the end of the mouse saccade (77%). Among the mouse saccades moving to a new region, eye gaze was directed to the new region in the end of the mouse saccade in 70% of the cases.

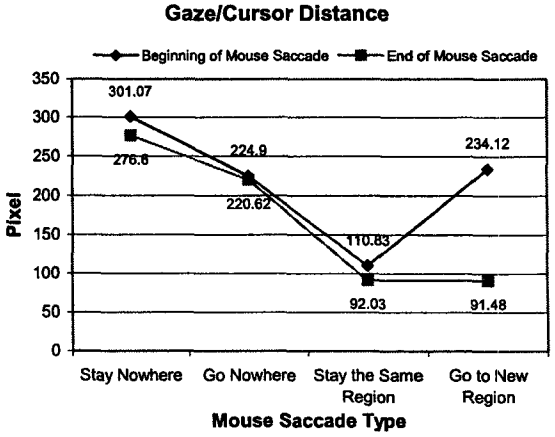

Figure 2 Gaze/cursor distance based on different types of mouse saccades.

Furthermore, the average distance between gaze and cursor for those mouse saccades landing on meaning regions is about 90 pixels. The distribution of distances revealed that gaze/cursor distance under 35 pixels explained over 40 percent of the entire distances, which is about 1 degree of visual degree.

CONCLUSION

Our data show that the dwell time of cursor among different regions has strong correlation to how likely a user will look at that region. Also, in over 75% of chances, a mouse saccade will move to a meaningful region and, in these cases, it is quite likely that the eye gaze is very close to the cursor.

This result implies that, by predicting the users' interests on web pages, mouse device could be a very good alternative to an eye-tracker as a tool for usability evaluation. By predicting the gaze position, we might be able to infer user's intent based on the mouse data [3], and use this to evaluate interface design.

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