Affordable Eye Tracking for Informed Web Design

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Abstract. Eye tracking hardware and software can be used to analyze and improve websites. If conducting an eye tracking study is too costly, examining mouse movement data can also provide similar insights into user behavior as eye gaze data. Prior research has shown eye gaze and mouse cursor position can strongly correlate. The strength of the correlation, however, depends on the design of the website. It is important to determine if mouse tracking is a reliable substitute for eye tracking as new design patterns emerge. Today, there are low-cost eye tracking solutions available, enabling a wider audience to conduct their own eye-mouse correlation studies. In this paper, we use The Eye Tribe Eye Tracker and the analysis software, EyeProof, to find the relationship between eye gaze and mouse position on the Florida Institute of Technology Human-Centered Design Institute website. The results indicate that mouse tracking data may be a suitable substitute for eye tracking data on the studied website and it may be feasible to use consumer-grade eye tracking products to conduct similar assessments.

Keywords: Eye tracking · Mouse tracking · Web design · Web analytics

1 Introduction

When redeveloping a website, web designers often use web analytics to make decisions to improve the current or next design. Web analytics can provide designers with usage statistics including information about user mouse movements. By examining the mouse movements of website visitors, it is possible to infer which features on a web page attract the most visual attention [2].

The most popular visual elements on a screen can also be determined by recording eye movements with an eye tracker [6]. Eye tracking hardware is now integrated into consumer products such as cell phones and laptops. Standalone eye trackers for consumers are also available. However, data from consumer-grade eye trackers is not yet readily accessible to web authors in aggregate. Instead, designers must trust the data gathered from tracking mouse movements is closely related to eye gaze position.

Prior research has shown that mouse position can strongly correlate with eye gaze position. The strength of the correlation varies, though, based on a number factors such as the arrangement of elements on a user interface [11]. It is important for web designers and researchers to determine if mouse movement patterns provide a fair representation of visual attention on new websites.

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In the past, the price of research-grade eye tracking hardware and analysis software could prohibit people from conducting eye tracking studies. With lower-cost, consumer-grade equipment, it is now possible for more people to gather data about eye movements. More web designers and researchers can now determine if eye gaze position correlates with mouse position on a website they are developing.

In this study, the low-cost, standalone Eye Tribe Eye Tracker and companion testing software, EyeProof, were used to determine if a relationship between eye fixations and mouse cursor position existed on the Florida Institute of Technology (FIT) Human-Centered Design Institute (HCDI) website.

Twenty-one participants were recruited and given a search task on three different pages on the HCDI website. Among the participants and on the selected web pages, a strong positive correlation ($r > .5$) was found between eye fixations and mouse position. The results indicate passively collected mouse movement data from visitors to the website may show where the users were looking on each page. Better informed decisions can in turn be made when redesigning the website in the future. Content and aesthetic elements can be retained, removed, or repositioned based on the estimated visual attraction of each item.

2 Related Work

2.1 Low-Cost Eye Trackers

The accuracy of low-cost, consumer-grade eye trackers has been examined by other authors. Dalmaijer compared the accuracy of The Eye Tribe Eye Tracker with the EyeLink 1000 from SR Research [4]. Dalmaijer determined The Eye Tribe could provide reliable data about eye fixations but warned against using it to track saccades (movements between fixations).

Both Popelka et al. [13], and Ooms et al. [12] tested The Eye Tribe against an SMI RED250. Both groups found the lower-cost system from The Eye Tribe could provide comparable results to the more expensive hardware.

The Tobii EyeX is another low-cost eye tracker available today. Although, primarily intended for video games and interaction, Gibaldi, Vanegas, Bex, and Maiello found the EyeX could track eye fixations with a high degree of accuracy [5].

2.2 Eye-Mouse Coordination

Early research into eye-mouse coordination sought to confirm that a connection existed between gaze and mouse cursor movement. Chen, Anderson, and Sohn allowed users to freely browse a website and found mouse and eye gaze matched 75% of the time [2]. Only one method for defining areas of interest was explored, however. The researchers defined regions around text, images, and additional HTML elements on each page. If both the mouse cursor and user's eye gaze moved into a region, it was considered a match.

Cooke found eye movement and mouse behavior matched 69% of the time in a later study [3]. Cooke's methodology included a wider-range of user behaviors. If a participant visually scanned up and down the page, and used the mouse to vertically scroll the page, it was considered a match.

More recent research focused on eye-mouse coordination on search result pages. Rodden and Fu found mouse movement could be an indicator of which results the user saw and considered clicking on [14]. Rodden et al. identified three distinct mouse movement behaviors on search result pages [15]. They discovered some people used their mouse to mark a potential result that they would click later. Other people moved their mouse horizontally or vertically and kept it near the text they were actively reading.

Guo and Agichtein also looked at search result pages [7]. As eye gaze and mouse cursor position are not always near each other, the researchers sought to automatically predict the areas on the page in which eye and mouse position were most likely to be within 100 pixels of each other.

The relationship between clicks and eye gaze was examined by Buscher et al. [1]. Clicks were not necessary related to visual attention.

Huang, White, and Buscher found that the strength of eye and mouse correlation varies depending on the user's current behavior [9]. The relationship between eye and mouse changed when users were inactive, reading, acting, or examining.

Liebling and Dumais have questioned earlier eye and mouse tracking studies for being too controlled and unrealistic [10]. They found the user's behavior was more complex than reported in other students when the users could work at their own desks and on tasks of their own choosing.

3 Research Method

Twenty-one participants were recruited at FIT for this study. The eye tracking tests were conducted between November 2015 and January 2016.

Prior to administering the eye tracking test, participants were asked to complete a survey. The ages reported by the participants ranged from 22 to 60. The median age was 31. Thirteen users were male and eight were female. The users self-rated familiarity level with the HCDI website is shown in Fig. 1.

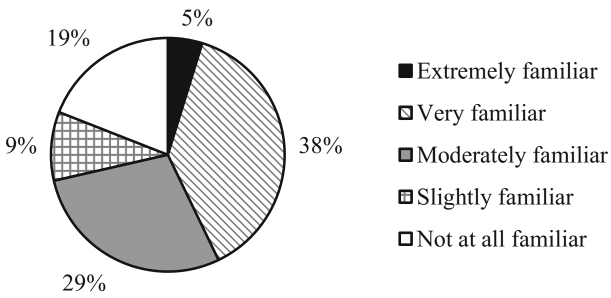

Fig. 1. Responses to the survey question, "how familiar are you with the Human-Centered Design Institute website?"

Participants were also asked about their primary computing device. Three people reported using a cellphone or tablet with a touch screen as their main device. The remaining 18 participants said they used a laptop or desktop with a mouse and keyboard as their primary computer.

Finally, users were asked to rate their confidence in using a keyboard and mouse on a five-point Likert scale. Fourteen of the users indicated they “extremely confident” and seven said they were “quite confident” - the highest and second highest possible ratings.

3.1 Hardware Configuration

The Eye Tribe Eye Tracker was used to record the eye movements of all 21 participants. The Eye Tribe Eye Tracker was released in 2014 for $99 [8].

The eye tracker was set to capture data at 30 Hz. The eye tracker was placed below a 19-in. monitor with a resolution of 1280 × 1024 pixels. A keyboard and mouse were also provided in front of the eye tracker and monitor. During the test, however, users were instructed to only use the mouse as pressing a key on the keyboard could interrupt the testing software, EyeProof. Participants were also asked to keep their head as still possible, so the system would not lose track of their eyes.

3.2 Scenarios

Three pages on the HCDI website were assessed: the news, courses, and publications pages. While the content varied on each screen, some aesthetic and navigation elements were consistent. Every page on the HCDI site featured a two-column, fixed-width layout and a global horizontal navigation menu at the top.

Due to limitations of the testing tool, EyeProof, only one web page could be presented at a time to the users as a static image. The users were not free to roam the site. The pages were presented in a random order for each test, and the order was determined by the EyeProof software.

Before each page was displayed, users were asked to read a paragraph that provided them with a scenario and search task related to the forthcoming page. All scenarios asked people to imagine they were “a master’s student at Florida Institute of Technology.” The tasks then required them to find and click a link on the next screen.

On the news page, the participants had to find and click the link to a specific news article among a list of 10 article titles and summaries. On the courses page, the goal was to retrieve a class syllabus among a list of 13 course names and syllabus links. For the publications page, users were asked to find a link to a paper among a reference list of 70 publications.

After clicking on the screen, the users were taken to the next scenario description, or if it was the third and final page, the program exited.

3.3 Analysis

Eye gaze and mouse movement data recorded during each session was stored on the EyeProof website. The EyeProof website also provided tools for analyzing the captured data.

Instead of comparing the raw x, y coordinates of eye and mouse movements, aggregate statistics were generated from areas of interest on each page. The EyeProof site had tools for creating rectangular, round, and irregular shaped areas of interest. However, the system offered no method for drawing shapes with precise dimensions or at exact screen coordinates. To avoid overlapping shapes and inaccuracies due to drawing areas of interest by hand, a user interface automation tool was developed that created shapes with explicitly defined dimensions and coordinates. A result from running this tool can be seen in Fig. 2.

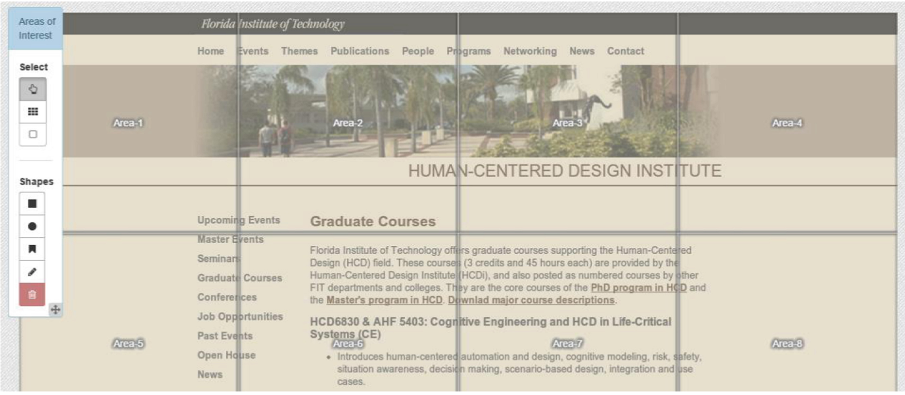

Fig. 2. Screenshot from the EyeProof website where a user interface automation tool was used to create a square grid with each cell measuring 640 × 640 pixels.

Also, while EyeProof recorded mouse position data and the mouse movement was visible during playback of each session, no statistics were available about mouse movement. For example, the software would not automatically calculate the number of

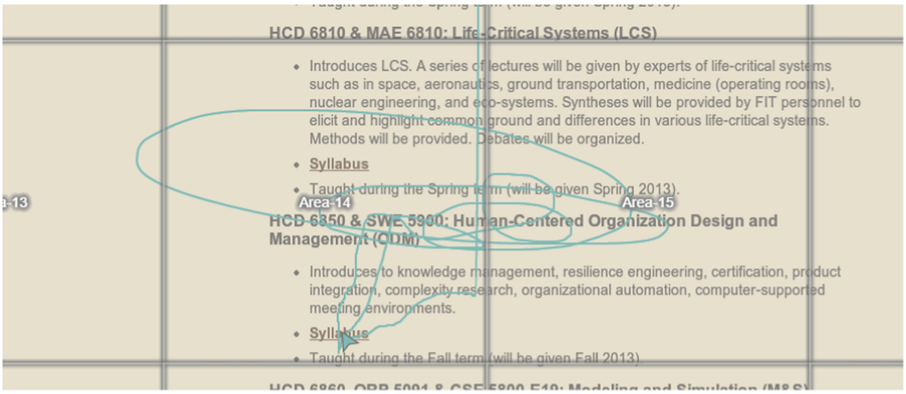

Fig. 3. Screenshot from the EyeProof web tool showing the mouse movement path of a participant. The mouse cursor path is teal colored.

times the users mouse moved into an area. Only metrics about eye movements were provided in EyeProof's data outputs.

To calculate mouse movement statistics, the number of times the participants mouse entered an area of interest was manually counted by playing back each session.

Some users moved the mouse cursor quickly or in complex patterns. Figure 3 shows an example of a complex mouse movement pattern generated by one participant. In these cases, the playback in EyeProof was recorded using a desktop screen recording program and played back in slow motion in an external video player. EyeProof lacked a built-in method for slowing down the session playback.

4 Results

Only 11 of the 21 users completed every task successfully. Seventy-one percent of the participants found the requested article on the publications page. The courses page saw the highest success rate with 86% of the users finding the link to the desired paper. On the news page, 81% clicked on the correct news article link.

A weak relationship existed between the user's familiarity with the HCDI website and successful task completion, although, the results were not statistically significant [$r = .221$, $n = 21$, $p = .336$].

In any case, successful completion of each scenario was not seen as essential in this study. The goal of this research was to find the relationship between eye and mouse movement on the HCDI website. Even when the task was not completed successfully, eye and mouse movement data was still captured and could be evaluated.

The cumulative count of eye fixations and mouse visits were evaluated in areas of interest. Three different methods were used to create areas of interest. On the publications page, a 2×4 grid was created where each area of interest was 640×640 pixels. Another grid was used on the courses page; however, the boxes were reduced to 320×320 pixels each. For the news page, outlines of the HTML elements were created instead of a square grid. A rectangular area of interest was drawn around each paragraph, list item, heading, and link.

A Pearson product-moment correlation coefficient was used to analyze the relationship between mouse visits and eye fixations in the defined areas of interest. The correlation between two sets of variables were examined.

First, the total number of mouse visits was compared to the total number of eye fixations in each area of interest.

The percentage of users who visited an area of interest with their mouse was also compared with the percentage of users who fixated on the area of interest. In other words, mouse visits and eye fixations were only counted once for each user in this measurement.

4.1 Publications Page (640 × 640 Areas of Interest)

Areas of interest were drawn in a 2×4 square grid on the publications page. Each cell on the grid measured 640×640 pixels. The size of 640 was chosen as it evenly divided the page which had a width of 1280 pixel.

Using a large grid for areas of interest resulted in a strong correlation between the total count of eye fixations and total count of mouse visits [$r = .697$, $n = 8$, $p = .001$]. When comparing the unique or percentage of participants that visited and fixated on area of interest, the relationship was strong between the two variables, however, the result was not statistically significant [$r = .931$, $n = 8$, $p = .055$].

4.2 Courses Page (320 × 320 Areas of Interest)

Smaller areas of interest were created on the courses page. Areas of interest were generated in 4 × 8 square grid where each square was 320 × 320 pixels. Figure 4 shows a scatterplot of the total mouse visits and total eye fixations in each area.

A strong relationship was found on the courses page when comparing the total number of mouse visits and total number of eye fixations [$r = .667$, $n = 32$, $p = .001$]. A strong connection was also found between the percentage of visits and fixations [$r = .901$, $n = 32$, $p = .001$].

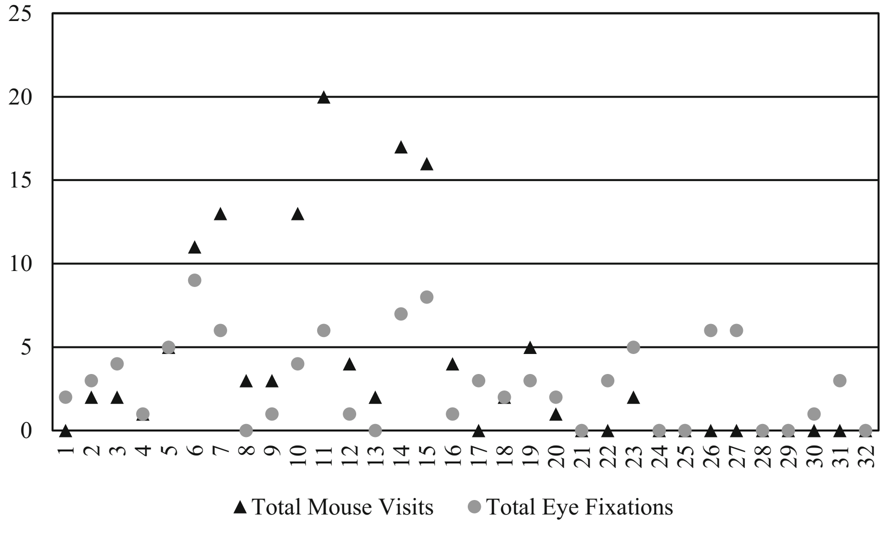

Fig. 4. The total number of mouse visits and total number of eye fixations in each area of interest on the courses page. The x-axis lists the number assigned to the area of interest and the y-axis shows the number of visits or fixations.

4.3 News Page (HTML Areas of Interest)

A different pattern for the areas of interest was tried on the news page. Rectangles were drawn around the estimated shape of the HTML elements instead of the grid pattern that as was used on the publications and courses page. Fifty-eight HTML elements were marked and tracked on the page. A scatterplot in Fig. 5 shows the data for 29 elements and the percentage of the users who visited or fixated on each element.

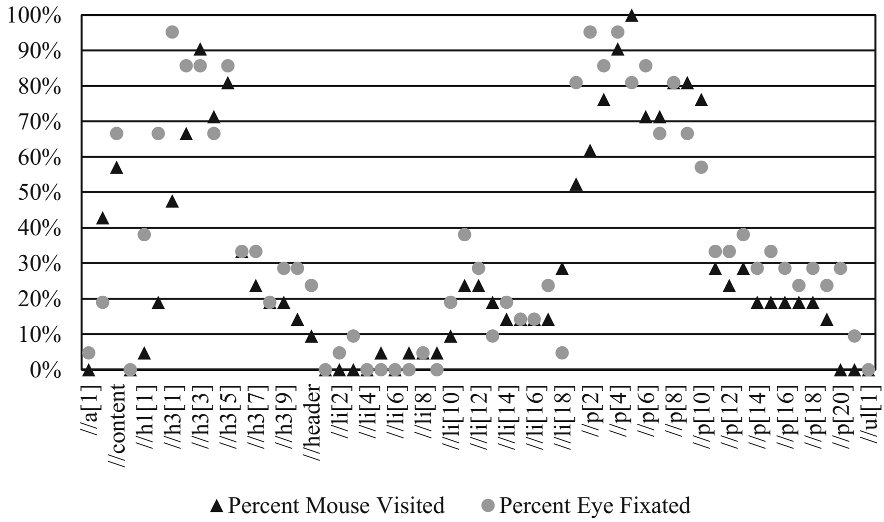

Fig. 5. The percentage of users who visited an area of interest with the mouse at least once or fixated at least once on an area of interest with their eyes. The XPath of the element is displayed on the x-axis.

On the news page and with the HTML element-sized areas of interest, the relationship was strong between the percentage of mouse visits and percentage of eye fixations [$r = .889$, $n = 57$, $p < .001$]. Likewise, a strong correlation existed between the cumulative number of mouse visits and eye fixations [$r = .846$, $n = 57$, $p < .001$].

5 Future Work

This study made use of a single, consumer-grade eye tracker. Because of cost constraints, the results from the low-cost eye tracker were not compared to a research-grade eye tracking solution. In future work, ideally results from consumer products would be confirmed with professional systems.

Because of limitations in EyeProof, mouse visit duration was not measured in each area of interest. Comparing mouse visit duration and fixation duration should be explored in the future with low-cost eye trackers.

Future research should also continue to examine different screen layouts and different types of software. Shifts in interface and product design trends may alter people's behavior, which in turn may affect the strength of the correlation between eye gaze and mouse position.

6 Conclusion

On all three web pages examined and among the 21 participants tested, there was a strong positive correlation between the total number of mouse visits and total number of eye fixations. The correlation was stronger when multiple eye fixations and mouse visits were removed from the data. However, the findings were not statistically significant on the publications page, which used the largest areas of interest.

The findings suggest if eye tracking data is unavailable, mouse tracking data may be a suitable substitute for determining which elements on the HCDI website draw a user's visual attention.

Researchers without access to research-grade eye tracking equipment may be able to use consumer-grade solutions to conduct similar eye and mouse tracking studies. It is important to repeat eye-mouse correlation tests as other research has shown the strength of the relationship between eye and mouse position can vary depending on an interface's design.

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