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# Human Computer Interaction Using Eye-tracking Data

Sukwon Lee
*University of Wisconsin-Milwaukee*, sukwon@uwm.edu

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sukwon@uwm.edu

**ABSTRACT**

The eye-tracking device records users' eye movements in order to better understand users' information-seeking behavior. One of our research goals was to investigate the search behavior when participants interact with a health-related online database. Another research goal was to explore how participants browse for health information inquiries. The result shows that the health professional participants studied spent more time on our proposed or recommended browsers which are called help mechanism comparing to general participants.

**Keywords**

Information retrieval, health information, eye-tracking research.

## INTRODUCTION

The eye-tracking technique was introduced to academic research a few decades ago and has re-emerged as the cost of these tools has reduced while the quality of eye-tracking devices has increased. Eye-tracking is a technique that involves recording participants' eye movements to determine the specific locations that a participant's eye studies at a given time (Poole & Ball 2006). The application of eye-tracking research methods has received a large amount of attention in recent years. Many scholars from multiple discipline, such as medicine, psychology, communication science, and computer science are adopting eye-tracking research methods (Duchowski 2007).

## LITERATURE REVIEW

Eye-tracking is an emerging technique which observes subjects' eye movements. The examination of eye movements was originally invented in the psychological field. Nowadays eye-tracking technique is being used in various fields of studies: psychology, cognitive science, information science, computer science and so on for reasoning decision-making processes (Rayner 2009). Since eye-tracking got more and more researchers' attentions so that a growing number of studies have conducted with eye trackers—the main devices of eye-tracking technique—were improved from a single device to a complex system. Recently, scholars in computer science conducted a study of Java programmers and source code summarization methods using eye-tracking techniques so that they tried to develop a decent summarization tool (Rodeghero et al. 2015).

Most eye-tracking research uses scan-path data as a basic analysis. A classic application of this technology found that subjects tend to fixate on identifiable regions of interest; the study revealed that scan-path showed the order of eye movements over these regions varies (Noton & Stark 1971). Scan-path might reveal the order or sequence of the fixations, and help to depict the experience of users while they are engaging with Web pages or search engine results pages. By analyzing scan-path of users' eye movement, researchers not only acknowledge where the users paid attention, but also the pattern and changes over time during the task.

In addition, the eye-tracking method provides data regarding dwelling time on the specific part of an interface that is called Area of Interests (AOIs). Most dwelling time is associated with fixations which mean that a user's eye movements were stable. If a user stays long in a particular area, there is definitely an interaction between the user and the interface. It is possible that dwelling time on a document indicates the document's usefulness (Kelly & Cool 2002). Task difficulty and domain knowledge can impact how long users spend time on search result pages (Liu et al. 2011).

In the Library and Information Science field, the eye-tracking technique allows researchers to perform a usability test in order to better understand users' information-seeking behaviors. There was a study on users' basic eye movements and studied sequence patterns throughout 10 different search tasks performed on Google (Granka et al. 2004).

## RESEARCH PURPOSE

The aim of this paper is to understand users' relevance judgment on Information Retrieval (IR) systems based on the eye-tracking method. The central research question has two components. First, how users' eye-tracking data are associated with their determination of relevance of portions of the content displayed. Next, what are the relationships between eye-tracking data and cognitive loads during the search tasks? One of our research goals is to investigate users' search behavior when they are interacting with the health-related online database. We also want to examine how a user interacts with help mechanisms such as the help browser or the visualized MeSH (Medical Subject Heading) browser.

## METHODOLOGY

### Data collection

Firstly, we developed a new health information retrieval interface design based on TF (term frequency) – iDF (inverse document frequency) algorithm and additional features such as visualization technique. In order to use the eye-tracking device, we set three different Area of Interests (AOIs); first, search browser and corresponding results as search AOI, help mechanism browser including both MeSH browser and visualized MeSH browser as help AOI, and finally a hierarchical structure of related terms named as tree AOI.

### Data analysis

We analyzed eye-tracking data based on several eye metrics, for instance, dwelling time, fixation count, first fixation time, pupil size and so on. One explanation for the reason why saccadic metrics were not used is that the interpretation of the saccadic variables is still controversial. This controversy might have arisen because most researchers in eye-tracking studies have used primarily fixation data. Dwelling time on a document, or the amount of time the eyes rest in a given place, indicates the document's usefulness (Kelly & Cool 2002). After finishing recording users' eye movements during the search tasks, we analyzed the eye-tracking data based on several eye metrics.

## RESULT

Based on the statistic testing, the preliminary results showed that there are differences between the two groups of participants in terms of users' eye movements based on the eye metrics in terms of total fixation time and total fixation count. For the second research question, there is no significant difference between the two groups of participants in terms of users' eye movements based on the scan-path analysis. Surprisingly, the general participants spent more time on the help mechanism which might represent their curiosity about health-related inquiries.

| Trial | AOIs | Dwelling Time (ms) |
|---|---|---|
| 33 | Search | 8593.1 |
| | Help | 242 |
| | Tree | 1001.2 |
| | White | 183.4 |
| | Total | 10019.7 |
| 36 | Search | 307037.8 |
| | Help | 1251.3 |
| | Tree | 1952.3 |
| | White | 26473.5 |
| | Total | 336714.9 |

**Table 1. Dwelling Time on AOIs**

Dwelling time data of one participant who was a nurse are represented as a table above. During the 4 search tasks, she spent little time both on help and tree AOIs, for example, she spent about one second in Tree AOI at trial 33, though she spent

almost two seconds in the same Tree AOI at trial 36 as shown in table 1. In the case of Search AOIs, she spent almost 300 seconds for trial 36. The reason why she spent so much time on trial 36 on Search AOI is perhaps that she looked up the search results more carefully than the trial 33—which was easier than the trial 36. In fact, she looked up more than 8 pages of search results. We assume that this is because of her personality or background knowledge and clinical experiences.

## CONCLUSION

The implication of this paper is that the new health IR system is an improvement for the health professionals compared to original one without help features. This result also can be applied to other types of IR systems that have specialty audiences. It seems natural that eye-tracking methodology can be applied to library settings in order to better serve patrons with different academic backgrounds. It also may improve the help features in library software. There is additional room for future researchers to investigate information-seeking behaviors on general search tasks on IR systems with different contexts for the theory development.

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