Where Is The Mouse In The House: Mouse Movement Tracking To Analyze User Attention

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ABSTRACT

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INTRODUCTION

Opportunity. As the global population becomes more comfortable using digital technology, people are more frequently turning to online sources for their reading. Newspapers, textbooks, and books are now widely available online. Companies and organizations are interested in such online user behavior to better suit their needs. In this paper, we will reproduce a small mouse tracking experiment for information retrieval purposes.

Task. The previous authors completed the study in 2009-2010 [8] then revisited the topic in 2014 [7]. The initial study revealed fairly inconclusive results. The second study surfaced a relationship related to document complexity and mouse movement. Our task is to reassess the 2014 study with participants from the class.

Proposed Solution: Our team believes that there is an opportunity to reproduce the paper *Mouse Movement During Relevance Judging: Implications for Determining User Attention*. With this in mind, our project goals are:

- To establish a prototype that records mouse tracking from the user to other formats to better connect existing user behavior to document classification.
- To create a scalable solution that handles multiple users simultaneously completing the experiment that perform in different environments.
- To monitor system performance and perform experiments on mouse movement to show how mouse position can be used for determining user attention.

Our solution includes two parts: (i) A front-end web application that allows users to classify documents and (ii) a back-end application that records mouse movement and is responsible for saving mouse positions for evaluation.

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The application will be hosted online. The front-end will be developed as an Angular 5 application. The clients will connect to the client web application and classify 10 documents. The front-end interface will provide an intuitive process for the user to complete the experiment in a timely and accurate manner.

The back-end application is responsible for tracking mouse movements accurately. Mouse movement accuracy is essential to meaningful results. We utilize D3 to visualize user mouse movement. For each user interaction we will record their activity with a screen shot.

Overall, we aim to have 50 students classify 10 documents in each. 500 data samples will be the end result. Our contribution will look to make use of this data to provide insight into user attention when reading documents with varying complexity.

Outline. In the next section of the report, we present more on our mouse movement application, including the project requirements. In the **Approach**, we breakdown the system design and explain its core functions so the experimental results in **Preliminary Results** can be understood. At the end of our intermediate report, we provide a discussion of our work results in **Conclusions**.

BACKGROUND

The general purpose of the application is to guide users to categorize documents as relevant or non-relevant, while tracking mouse movement from *users* for later analysis. The users will be given various flexibility to select one of eight topics of interest. The user will be told they are part of a study to determine user attention. The system will facilitate the experiment. The system will monitor the user mouse movements and record the user behavior to classify a total of ten documents as relevant or non-relevant. When the user completes the classification experiment, the system puts the data for the ten classifications in a *.zip* and sends this to our team for evaluation purposes.

The information retrieval community has spent mentionable time towards user attention for search [1, 3, 4, 5, 6]. Unlike this study, which focuses on document classification, many papers look into the relationship between mouse movements and eye movements to predict user behavior such as clicks. In a paper from Google and UNC [6], the relationship between mouse movements and eye movements were studied, and resulted in the identification of three eye-mouse movement patterns. The movement patterns apply to our study, however, we will only be using mouse tracking, which Cooke's paper

TREC 2015 Hard Track	
Number	*Topic Title*
310	Radio Waves and Brain Cancer
336	Black Bear Attacks
362	Human Smuggling
367	Piracy
383	Mental Illness Drugs
426	Law Enforcement, Dogs
427	UV Damage, Eyes
436	Railway Accidents

Table 1. The document types used by the previous authors from the TREC 2005 Hard Track dataset.

describes as the poor man's eye tracker [2]. While we could look into eye movement as well, we are instead interested in doing a replication of the simple document classification study completed by Smucker in 2009-2010 and 2014 [8, 7]. With our contribution, we will provide results to compare against four and eight years prior.

The previous studies [8, 7] use the TREC 2005 Hard Track dataset. TREC, the text retrieval conferance, is co-sponsored by the National Institute of Standards and Technology (NIST) and U.S. Department of Defense, and dates back to 1992. TREK is a facilitator for research in the field of text retrieval, we will be using its 2005 Hard Track dataset for its completeness and portability. The dataset is desirable because it contains a collection of documents spanning across a multitude of topics. The documents come from the AQUAINT news collection. We could incorporate all topics in our study, however, to give our results structure we chose to maintain the list of topics used by the previous authors. Specifically, our study will allow users to classify documents from one of eight categories listed in Table 1 where each category has ten documents. In other words a distribution of 6 relevant documents to 4 non-relevant documents for each category making 80 documents total.

Application Requirements

The application must meet several mandatory requirements:

- *Automation:* The application must function with as little human intervention as possible.
- *Performance:* The application should monitor user behavior efficiently and process mouse positions behind the scenes.
- *Reliability:* The application should provide a high degree of robustness.
- *Monitoring:* The application should provide means for recording its performance across multiple dimensions.
- *Scalability* The application must scale to different platforms and support multiple users simultaneously.

In addition, we have chosen to implement two more optional requirements:

- *Aesthetics:* The application must be visual appealing to replicate real-world use by the user group.
- *Security:* The users identity will remain anonymous.

APPROACH

The system employs a simple website incorporating Front-End-Back-End architecture. The front-end will be tasked with capturing and sending mouse movement data to the application's back-end using JavaScript, which will, in turn, process the position data, and visualize the mouse movement data on the fly using D3 and JavaScript.

The following, is a brief description of the envisioned application components:

- *Mouse Listener:* this component captures and handles incoming mouse movements from the application's clients. The data is processed and stored into an array of object containing X and Y coordinates of the mouse while it is active on the browser window. The array is updated every 200 ms for better precision to capture and track user's mouse movement during relevance judgment. The Mouse Listener directly communicates with the Mouse Manager through the means of sending the array containing position data.
- *Mouse Manager:* this component manages the mouse movements which have been passed on to use D3 for further processing. For each document it stores the mouse movement data and as soon as the user makes a judgment regarding the relevance of the document given a specific topic, our application draws the mouse movement on top of the document depicting exactly how the user used the mouse to read the document during each document session.
- *Statistics Manager:* this component tracks the performance of the system, across multiple dimensions, including the make span measure on a per document and per experiment level.

Mouse Manager

We track mouse movement by drawing a line connecting all the X-Y coordinates of the mouse position captured during relevance judgment of the user and also indicating hot spots, where the mouse is relatively still, with circles. We indicated the start position with an opaque orange circle and the end position with a purple one. Furthermore, we used transparent circles to indicate the mouse being idle. The bigger the radius is of such circles, the more the idle time. Finally, we used html2canvas to render the final image for analyzing in later stages.

1. Lines are used to represent mouse movement
2. Circles are used to indicate hot spots

To carry out these tasks, the system employs the usage of mouse tracking protocols. If the mouse data is successfully recorded, it will be stored to the *mouse position* array.

Statistics Manager

The statistics manager will record the make span time per document and the make span time per experiment.

1. Make span per document for users

2. Make span per entire experiment for users

This information will be matched up to mouse movement data during analysis.

User Interface

Currently, the system makes use of Angular 5 to provide the platform for user experiments. We plan to utilize Material Design components and Bootstrap 4 components to further style the application to be comparable to a real-world web environment.

1. Angular 5 for responsive UI

2. Material Design for website components such as buttons

3. Bootstrap 4 for further website navigation and templates

Evaluation

In light of [7], we will classify mouse movement identical to the previous study. To properly evaluate the rendered mouse position we will use the image summaries of user activity shown in Figure 1 and Figure 2. The following list describes the list of user actions we will classify.

- *Decision-Only:* Mouse movement is classified as decision-only when a user is seen to only click the"orRelevant" buttons. Commonly, movement is from one button to another or from the same button. As well, the user may move to one of the buttons from a random point on the page, i.e. the user's only goal was to use the mouse to click a button.

- *Horizontal:* This behavior occurs when the mouse moves back and forth in the horizontal direction and appears to show the user moving the mouse while reading lines of text. Behavior should occur in more than one line of text in a row and movements should at least cover 25% of the text on that line.

- *Vertical:* This behavior occurs when the mouse moves in a continuous movement that does not have to occur on text but might. It is identified by back-and-forth movement and/or stalling of the mouse in the vertical direction. The movement of the mouse gives the appearance that it is following the material that the user is reading.

- *Highlighting:* This behavior occurs when a user moves the mouse from one position to a new one where some sort of information must be available. The mouse remains inactive in this new area for some amount of time or rebounds off of it after a short, but noticeable, period of time. The mouse may also move back and forth very tightly in the new zone.

- *Re-scoping:* When a new page loads, the old position of the mouse may not be of use to the user, or the user may be seen moving away from the judging buttons to possibly avoid accidental clicks. Moving the mouse to the side or to a new zone of interest after loading a new page is known as re-scoping. Figure 1 shows an example of re-scoping behavior.

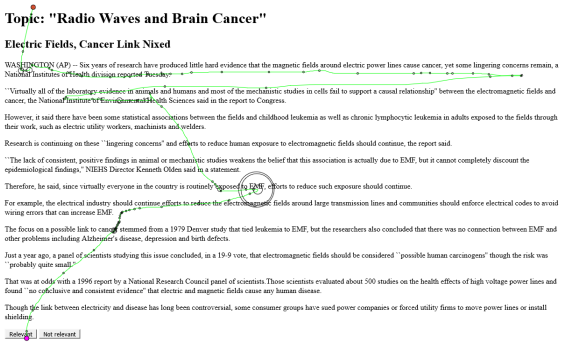

Figure 1. Example of a relevant document judged by a user

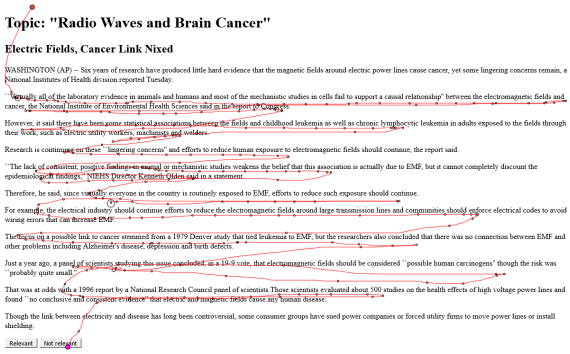

Figure 2. Example of a not relevant document judged by a user

- *Random:* Random movement can be treated simply as none of the above mouse behaviors. Quite commonly, behaviors may appear to be some form of interaction such as reading. However, if there is no clear definition for the behavior and it does not resemble any of the classifications above, then it is random movement. This category is reserved for larger, noticeable movements of the mouse that have no clear definition but given some indication of the user's attention.

- *No-Movement:* It is possible for a user to make a judgment without moving the mouse if the mouse is positioned above the correct button for judging the current document.

PRELIMINARY RESULTS

We have already implemented a functional prototype of the application. It tracks the mouse movement of the user during reading and at the end, when the user makes the judgment, our application draws the mouse movement and renders a screen shot for further analysis. Figures 1 and 2 show the results that we obtained from our prototype application. Whenever the user marks a document as relevant given a topic, the mouse movement is shown in green otherwise it is shown in red.

CONCLUSIONS

Some researches found out that there is correlation between a user's mouse movement with the user's gaze. By reproducing this experiment and by adding a couple of parameters, we hope

to validate such claims and come up with such a framework of this specific experiment that is not only scalable, but also can be used in other application of tracking the mouse movement if need be. The results that we have in this current stage, we are hopeful, will be a strong foundation to design the whole experiment soon so we can collect experimental data for further analysis.

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