Annotating Trails : A Synthesis of Sensemaking, Annotation Management, and Trail Caching during Exploratory Browsing

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ABSTRACT

We have developed a system that combines user-friendly information visualization methods with a user-driven annotation to make the sensemaking process more efficient when learning about a topic. We believe that by providing annotation tools and a trail caching knowledge graph, sensemaking of topics and articles will improve. We picked Wikipedia as the platform for the study since it represented a large body of topic compiled in a unilateral environment. We performed our study using 10 participants, who were tasked with providing brief summarizations on two different subjects while using our annotation system and not using the system. The summarizations were compared and scored by human raters, based on content, accuracy, and brevity. A semi-structured interview was performed following the trials, in order to understand the participant's experience with the system. We found that the summarizations provided with the system were more robust than those in the control condition. We now look to further improve sensemaking by bringing the design model more in line with the user model in future iterations.

Author Keywords

Annotation Trails; Knowledge Graph; Annotating Trails; Sensemaking ; Wikipedia; Knowledge Map

ACM Classification Keywords

H.5.m. Information interfaces and presentation: *human factors, documentation, experimentation, performance*

INTRODUCTION

How does one go about performing research on a topic when sources provide too much irrelevant information, especially not knowing what to look for but still finding topics that sound relevant? Students increasingly use Wikipedia as an important source for research papers, however students increasingly report feeling lost and confused while researching a topic. "Context, as we came to understand it in the sessions, is a key to understanding how students operationalize and prioritize their course-related and everyday life research activities. In our discussions, students consistently referred to "finding context," in one form or another, as the most laborious, yet requisite, part of the research process." (Head). In other words students have difficulty in sensemaking with the abundance of information available to them.

Our research hypothesizes that we can provide context to users by creating a visual map to represent the trail of breadcrumbs and browsing history which we refer to as 'Trail caching' and the tool to enable trail caching as 'knowledge graph'. A visual representation of historical browsing would be a novel way to enable retrospective sensemaking. Retrospection is a key activity in enabling sensemaking (Weick). The interface must communicate the browsing trail and the logical steps that enabled the user to arrive at any node. Our research combines trail caching with an annotation tool to further improve sensemaking. Further detail on Annotation is provided in the Prior Work Section.

Our contributions include:

1. Determine the effect of spatial organisation of Trail caching in retrospective sensemaking

2. Supporting contextual browsing using Trail caching

3. Supporting annotation of information in a spatial relationship with its contextual page

4. Creation of Knowledge graph as a way to enhance exploratory browsing

The tool provides a knowledge graph to which nodes are added every time a new page is visited. Users, while browsing through the site can get a picture of how they got to that page and navigate back and forth to a related page through the knowledge graph. The tool also lets users add annotations to text in wikipedia. By adding annotations users can navigate between pages and come back to the page to see the annotations on that page which helps in sensemaking. Our long term objective for this research is to help Wikipedia users in sensemaking by tracking content breadcrumbs and enabling annotation and putting them into context of broader research topics.

SCENARIO

Jason is a sophomore at Texas A&M, He just completed his freshman year and is considering a Psychology major. He found the topics to be very interesting and he picked up courses for this major. However he severely underestimated the amount of research he would have to read and understand to meet his course requirements. The courses he is taking on Motivation theory and Development Psychology in particular are extremely taxing and require a lot of time investment. His main problem is that he is not familiar with the topics that concern his major and he has to read a lot to start gaining an understanding the topics he is hearing about in class. He spends hours on wikipedia going through the topics that have been assigned to him for research, whenever he comes across terms that sounds relevant and unfamiliar he clicks on the link to comprehend that topic. He relies on his instinct to understand what might be important. But as he goes through with his process, he inevitably loses track of how the topic that he is reading about is relevant.

For. e.g when he was reading for his submission on Attachment theory, he came across terms like abandonment, which he clicked on to understand more about how it is related. The page for which contained details on PTSD, since his grandfather had suffered through PTSD, he wants to understand how it is relevant. He goes to the page and is suddenly lost reading about the But he quickly loses track of how this relates to his paper on Attachment Theory. All this confusion has been leading to his papers being incoherent and confusing and thus getting him bad grades.

Our Chrome Extension with it's knowledge map feature, would allow him to visualize these concepts and how they relate to each other. When he navigates away from the page for Attachment theory, A Visual map immediately pops up and helps him keep track of his mental map of his research. Anything he annotates is also adds to his knowledge repository. When he is on the page for PTSD, He can see that the chain of Attachment Theory - Abandonment - PTSD. when he navigates back to the page for Abandonment and then navigates to separation anxiety, he is able to see the fork in the browsing that shows his browsing chain.

Thanks to the Knowledge Map, Jason was able to turn in a paper that was better in quality than what he usually turns in. Thus getting a better grade.

PRIOR WORK

We found several prior work which we classified into three categories, Needs, Ingredients and Precedents

Needs: In this section we analyzed research which spoke to improving the sensemaking process, two factors clearly popped out in this section: Annotations and Knowledge maps. Annotation, especially hypertextual annotation was associated with improved sensemaking and reduced cognitive load, meanwhile Knowledge Maps were shown to improve cognition and comprehension. (Marshall)(Wallen)(Kuo-En Chang)(O'Donnel)(Reutzel)

Ingredients: This section helped us build up the evaluation and sensemaking and we will be following thes closely to set up our studies. Evolution works is a paper that also provides a graphical representation of research documents that we used. Metadata type systems for exploratory browsing introduced elements of providing contextual browsing and will be used as a guide on enabling contextual representation of information (Yin)(Russell) (Wilkins)

Precedents: There were four works WikiTrails, EvolutionWorks, Apolo and Saavy Wiki which separately worked on aspects of history management, knowledge maps and annotation.

The paper on Apolo by chau et all is the closest representation to our work but focuses on the implications of visual maps and annotations for sensemaking, but our approach is centered around the user's knowledge map and history more than mapping all available knowledge resources. We wish to evaluate if this improvement will reduce the learning curve and improve sensemaking. Our work will further the findings on these topics and further contribute to the improvement of sensemaking. (Chau)(Reinhold)(Nakanashi)(Wilkins)

DESIGN

There is information overload especially when reading about complex topics. Our motivation for this research stems from or personal frustration with the process of researching topics that are unfamiliar to us. Often, the authors ended up on unrelated pages without the ability to understand how we got there. This inspired to imagine a visual map of browsing that is a more accurate representation of trail caching than a linear breadcrumb history. Exploratory browsing is seldom linear and thus the tools that support exploratory browsing shouldn't be linear either. We designed a chrome extension that contains a combination of Knowledge graph and Annotation tool. The tool allows users keep visual track of the pages they have visited while learning about the topic and annotation to the topic.

Fig 1. Represents the system architecture of our architecture. We used the springy frame work which provided a force directed graphing algorithm that enabled the creation of individual nodes that could behave as a cohesive unit at the same time retaining their individuality. The UI was generated with springyui.js and the data architecture is supported by springyui.js. Popup.js captures content and sends it background.js on two events, on load and on save annotation. Background.js persists the graph throughout an entire session. Popup.js is further used to modify the html of the host page.

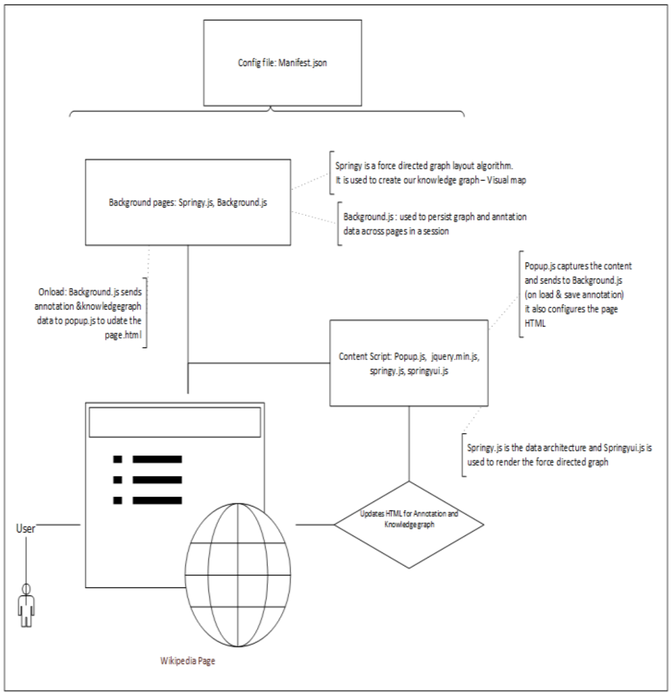


Fig 1: System Architecture Diagram

We demonstrate the evolution of design from lightweight prototype to functional prototype in figure 2-4. Throughout the process user study data that was gathered informed our design evolution. Our lightweight prototype had image nodes with connection lines between nodes. With an annotation tool that supported annotation and highlighting.

After user study 1 we found from users that adding arrows to connection lines to show the direction would give a better picture of history of nodes. Users felt that movable nodes would aid in sensemaking as they could reorganize the nodes in a manner they feet it made sense. In our light weight prototype we had decided to make the tool a sliding extension, users opined that a slide out extension hid the content in a page and they suggested a persistent extension so they can see the knowledge graph all times. They further asked for the nodes to be clickable, and we therefore made the nodes clickable on double click. Based on user findings we made changes to our design for the functional prototype with two modifications by us namely to replace the node image with just text and to remove highlight feature. The node images were replaced to improve readability, and improve real estate for the graph. The highlight feature was removed due to time constraints and because it was not a key part of our research.

During the user study 2 with the functional prototype, we found that some of our users felt the arrows were very strong and visually distracting. Based on further user feedback we changed the text to blue to represent link and made them work on single click. We further added multidirectional arrows with single lines in grey color, this reduced the number of lines and improved legibility. Based on user data , we have changed the design to aid in sensemaking. The changing of nodes to blue color represent links were from studies as users clicked the back button twice to go to a previous page but did not use the graph.

METHOD

For this study we had ten participants, all of which were college students or postgraduates, ranging between the ages of 20 and 36. Gender distribution was 7 male, 3 female. Participants were presented with a paper printout with informed consent information. Individually, the experimenter explained the consent information and asked the participants to read over the form and sign it. The participants were informed of the risks and were told that they could stop participation at any time. The participants were asked to provide verbal consent before continuing with the study. Next, the experimenter asked the participants to complete a background questionnaire to collect information such as prior experience with Wikipedia and education/occupation. The questionnaire also asked participants about their levels of familiarity with two topics: Machine Learning and Neuroscience. This was rated on a scale from 1 to 5, with 1 being completely unfamiliar and 5 being comfortably knowledgeable. We selected participants who had low familiarity with the two topics, in order to test for novelty of a subject. Participants who rated themselves from 3 to 5 were not selected for this experiment as their previous knowledge could influence their performance later on.

Our study features a within subjects experimental design, where each participant received both trial conditions. The independent variables were the research topics and the Annotations Trails tool, and the dependent variable was the summarizations of the topics. The task the participants were to perform was to provide a brief summary of the two -

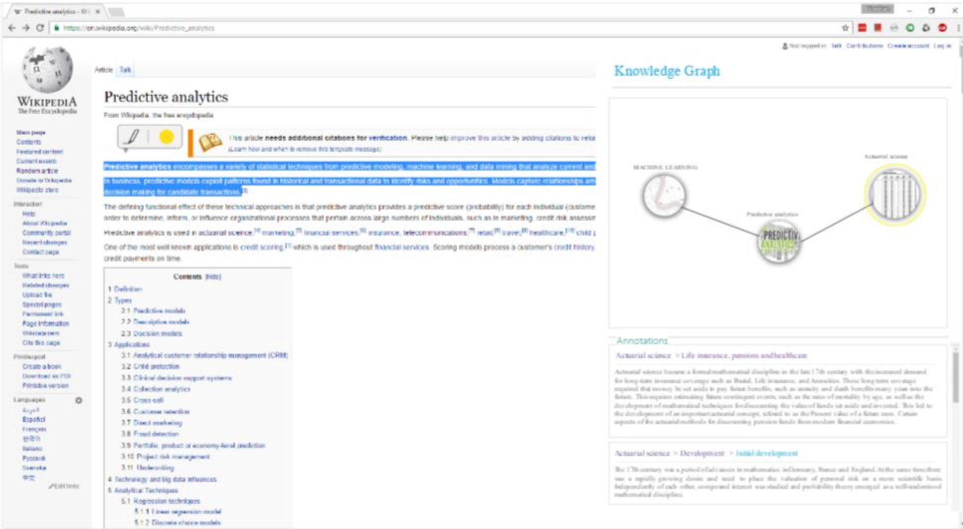
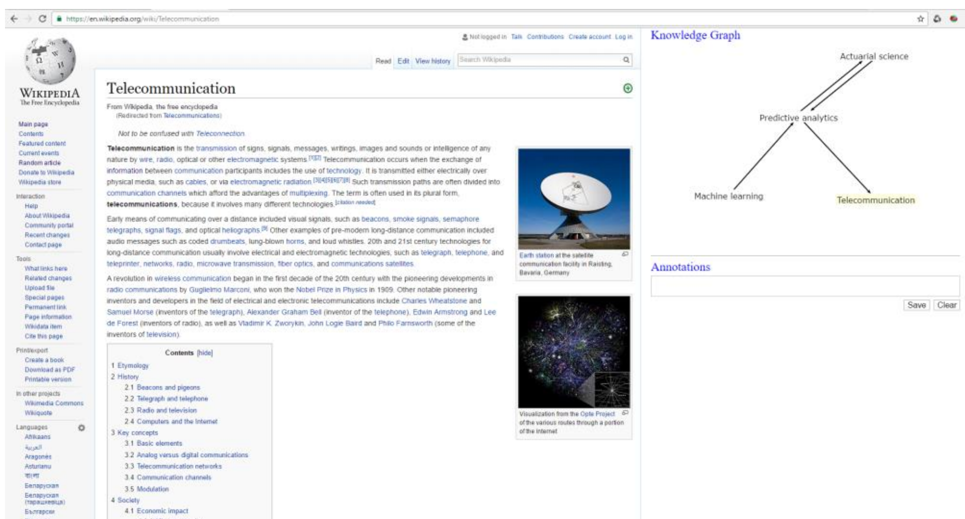


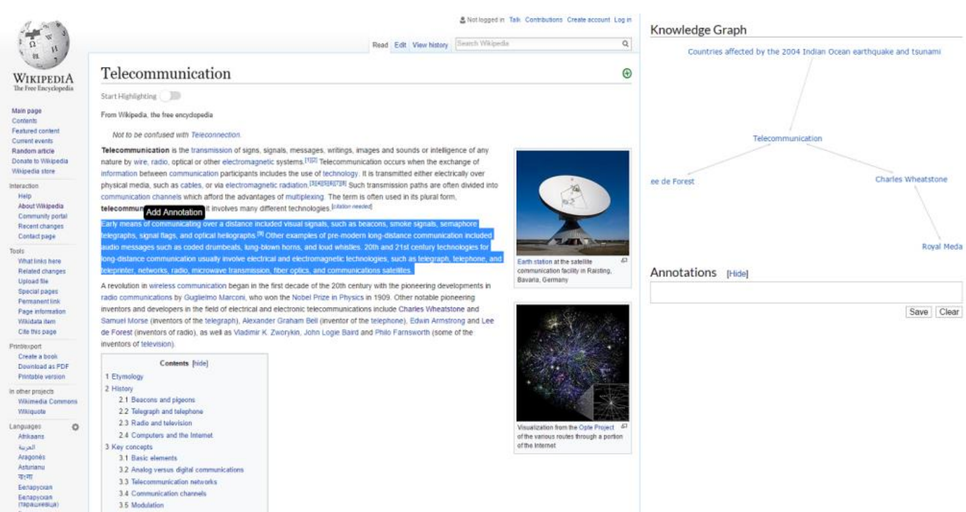
Fig 2: Lightweight Prototype
Two key areas (i) Knowledge Graph and (ii) Annotations are seen in the right side of the screen.
Some key features are:

- Each node represents a wikipedia page and represented with an image
- Annotation included highlight and user created

Fig 3: Functional Prototype - 1
Major revisions were made after the user study 1 and feasibility testing by our team

- Arrows were added between nodes to show direction. A second line was added to indicate back and forth movement
- Text was used





Design Evolution: Lightweight to Functional Prototype topics after 15 minutes of reading each the topic. Each participant was to read two topics, one topic using our Annotation Trails tool and the other topic without. The orders for the topics and use of the tool were counterbalanced in order to eliminate the presence of confounding variables. The participants were told the topic they would be reading before hand and if they would be using the tool or not before each topic. The experimenter gave a short explanation of the Annotation Trails tool before the participants used it, in order to explain it's purpose. After reading a topic for 15 minutes, participants were given 5 minutes to provide a brief summary of the topic. This was done without access to the Wikipedia page, the Annotation Trails tool, or any other form of notes the participants had taken. We collected qualitative data on the participant's actions while using the Annotation Trails tool.

After the participant's session, we used human graders to evaluate the summarizations. In order to avoid bias, the grader was unaware of which topic had which condition. In order to evaluate the summarizations, the grader had access to the Wikipedia pages for the topic, as well as prior background knowledge of the topic. In lieu of a numeric grading scale, the grader focused on several criteria: Brevity, Accuracy, and Key Content. Brevity was measured by the length that the summarizations were. Accuracy was measured by the correctness of the information provided. Key Content was measured by how well the participant understood important concepts of the topic. Overall we had 20 summaries, 5 for each topic under each condition.

After the participants had finished their topics, we conducted a semi-structured interview of their experience. We asked the participants to describe how the tool changed their ability to process and analyze data, which in turn we coded and categorized for our own analysis. Once the interview was complete, the experiment concluded. Overall, the each session took between 55 minutes to an hour, depending on the interview.

EVALUATION

We recorded the actions participants took while using the Annotation Trails tool. We avoided asking questions during the trials and recorded behaviors made during the process.

Annotation Trail Experience - Participants quickly learned that clicking on the nodes directed them to the page, although this feature was not demonstrated to them. Participants often initially tried to drag the entire Knowledge Graph around, and re-order the annotations they made.

Support for Sensemaking - When using the Knowledge Graph, participants tended to manually organize the branches and subfields of Neuroscience together. When using the Annotation tool, participants often annotated the title of each content section. Some participants copy and pasted sections of text from those sections into the notes, while others manually wrote their own notes into the annotations.

Overall, the summaries that were completed with the use of the Annotation Trails tool provided more information in a summarization and included more key content in these summaries.

Brevity - The summaries in which participants did not use the Annotation Trails tool were shorter than summaries that used the tool. Between both conditions on average, summaries on Machine Learning were shorter than those on Neuroscience. This could be due to Neuroscience being more general than Machine Learning, or Machine Learning being more complicated to explain than Neuroscience.

Accuracy - The Annotation Trails tool did not seem to have a direct impact on accuracy. What was noted is the participants who opted to manually write notes had higher levels of accuracy. Interestingly, there was a difference in accuracy for the Annotation Tools for users who either copy-pasted notes in their annotations versus those who manually typed in their notes, in which those who typed their notes had higher accuracy.

Key Content - When graded on Key Content, the summaries with Annotation Trails tool contained more content than those without the tool. Both groups tended to write summaries that included the key points of the Content section on the Wikipedia page. The content provided for those without the tool tended to come from page topic itself, but the summaries that were made with the tool often featured more detailed information about related pages to the topic.

After the trials were complete, we conducted a semi-structured interview for each participant to gather information on their experience with the Annotation Trails tool. Primarily, we wanted to know how the tool affected their ability or method of learning the topics, so we asked questions about their thought process and experience while using the tool. Once the participants began to explain, we tailored our questions to logically follow their responses.

Support for Sensemaking - Some participants who used the tool in the first trial reported that they changed the way they organized their notes in the second trial. They would create their own nodes, add notes beneath the nodes, and create links between the nodes. This mirrors the behavior of the Annotation Trails tool. Participants noted that the Annotation tool not only allowed for faster note taking, but having the notes be on the same screen as the page allowed them to cross reference without switching pages or windows. Most participants reported that the Knowledge Graph encouraged them to explore the related section pages to the topic, one participant citing that "it was fun to see how the pages were connected with each other."

DISCUSSION

Our primary goal for supporting sensemaking was achieved in this study. The summaries that participants provided while using the Annotation Trails tool contained more key content and contained more information on average than the control condition summaries. Accuracy was not directly affected by the tools, although participants who elected to write notes scored higher in accuracy than those who did not write notes or copy-pasted information into the annotations. So while our system does not promote accuracy, we do not hinder it by allowing for user-curated notation. While summaries that did not use the tools were more concise, we believe that the Annotation Trails tool allowed for a greater amount of gathered information to be provided. The main difference between the two conditions was the Knowledge Graph tool, as participants without the Annotation Trails tool could make notes in a similar fashion to the annotation tool, albeit at a slower pace.

IMPLICATIONS FOR DESIGN

We have found that spatial organization of trails supports retrospective sensemaking. Providing visual/graphical representation of history would improve reflection. Using summative assessments we found User created annotations improved accuracy of data rather than pasted snippets and spatial reordering of information enabled contextual learning.

We believe the Knowledge Graph tool to be the largest contribution provided by our system. While participants used the annotation tools, this method of note taking could be done in the control condition. Participants reported that the Knowledge Graph tool was novel to them, and we saw some participants who used the Knowledge Graph in their first trial trying to emulate it in their second trial. The Knowledge graph thus provides a novel way to improve spatial organisation of content which enables improved retrospective sensemaking

CONCLUSION

We set out to support sensemaking for users by allowing them to freely annotate selections from Wikipedia and by providing a visual knowledge graph that formed connections between pages. Through various user studies and iterative design, we arrived at a prototype that allowed users to accomplish this goal. What we found was that users were more capable of formulating relations between ideas and were able to provide more material in a summarization. We observed that our system changed the way users would spatially arrange or organize their notes, either through our knowledge graph implementation or through imitation of its design. The knowledge graph was shown to be the most novel implementation of our tool and the most informative of our results. We found evidence of the knowledge graph supporting a retrospective sensemaking, which can be more thoroughly explored. In the future, we would like to see a more explorative approach to the knowledge graph that could lead to improved user ideation and sensemaking. We believe our tool stands to contribute to the fields of human-computer interaction, cognitive psychology, and learning education.

FUTURE WORK

For future design we wish to bring the design model of our system more in line with the user model. As seen during the trials, users tried interacting with the system in ways we had not implemented, such as trying to move the Knowledge Graph around as a whole, trying to rearrange the annotations that the participants created, or deleting annotations and nodes that are not needed. Creating each component as widgets will aid the user to use the tools required at that point in time. By implementing these features, we hope to further improve sensemaking and support user mappings. As of the current iteration, our system's Knowledge Graph and annotations reset upon closing the browser. We wish to fix this in future iterations to improve consistency.

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