Introduction

Discovering and making sense of relevant literature is fundamental in any scientific field. Node-link diagram-based visualization tools can aid this process; however, existing tools have been evaluated only on small scales. This paper evaluates ARGO SCHOLAR, an open-source visualization tool designed for interactive exploration of literature and easy sharing of exploration results. A large-scale user study of 122 participants from diverse backgrounds and experiences showed that ARGO SCHOLAR is effective at helping users find related work and understand paper connections, and incremental graph-based exploration is effective across diverse disciplines. Based on the user study and user feedback, we provide design considerations and feature suggestions for future work.

Index Terms: Human-centered computing—Visualization—Visualization design and evaluation methods

1 Introduction

Discovering and making sense of relevant literature is fundamental in any scientific field. Academic search engines are common starting point; however, keyword searching does not provide users with all relevant papers, so incremental exploration, a common and effective method where users iterate from familiar (identified via search engines) to novel works while filtering based on paper attributes, is also employed [4]. Visualization can aid this process, such as node-link diagram-based tools that support the visual exploration of citation networks with a bottom-up approach that allows users to grow their own networks and understanding of its papers [1]. However, the evaluations of existing tools often only consist of a dozen or so participants for certain selected domains [1,5]. A large-scale evaluation of such node-link based literature exploration tools across diverse domains could generate different discoveries and insights.

This paper presents a follow-up, large-scale evaluation of ARGO SCHOLAR [2], open-sourced, web-based visualization tool that facilitates the incremental exploration of literature to gain insight and uncover relevant work. We were interested to see how receptive participants from diverse backgrounds were to node-link diagram representations of citation networks and what features of literature exploration tools did participants find the most helpful. To answer these questions, we recruited 122 participants from a wide range of backgrounds and research experiences.

2 Background: Visual Exploration of Literature with ARGO SCHOLAR

ARGO SCHOLAR [2] is an open-source, web-based visualization tool for interactive exploration of literature and easy sharing of exploration results developed by the authors of this poster. ARGO SCHOLAR supports the method of incremental exploration, an effective technique to discover relevant and related work [5,6], on Semantic Scholar’s live database of 200+ million papers [3].

ARGO SCHOLAR (Fig. 1) enables users to generate personalized literature exploration results in real-time. ARGO SCHOLAR’s main view displays the user’s collection of papers as a node-link diagram where papers are represented by nodes and are connected by citation edges. Users can easily expand their collection by querying for papers through keywords or adding the citations or references of existing papers based on relevance, citation count, influence, or recency [3], and nodes can be dragged to be rearranged and display attributes adjusted to help the sensemaking process. Users can save or share a snapshot of their results as a URL on the cloud for free. ARGO SCHOLAR was developed as an open-sourced web-based tool to help increase the availability and impact. Built with modern web technologies, such as Three.js WebGL rendering, ARGO SCHOLAR can smoothly render hundreds of papers and their relationships and is hosted at https://poloclub.github.io/argo-scholar. The open-sourced nature of ARGO SCHOLAR also differentiates itself from other existing tools.

3 Evaluation

To investigate how users would interact with ARGO SCHOLAR’s features to explore literature networks and find relevant work and evaluate ARGO SCHOLAR’s effectiveness and usability, we conducted a large-scale user study of 122 participants. This section describes the study’s design and findings.

3.1 Experimental Design

Participants. 122 U.S.-based participants were recruited from Prolific\(^1\), an online crowdsourcing platform designed specifically for academic research. Participants were screened to ensure they had at least one year of research experience, so they would be able to accurately gauge the effectiveness of ARGO SCHOLAR for finding related work. The resulting sample encompassed diverse knowledge backgrounds and research experiences (Table 1). 76 participants were current students, while 46 were not currently enrolled. 21 listed a Doctorate degree as the high level of education completed or currently completing, 42 Master’s, 44 Bachelor’s, 12 GED or equivalent, and 3 others (JD, MD, and DDS). Notably, three were professors and two were postdoctoral researchers.

\(^{1}\)https://www.prolific.co/
The large-scale and diversity of our study provided many different viewpoints. While many found the node-link diagram representation helpful, such as a professor participant commending “...a nice tool to visualize the literature and I could see myself using this and showing it to graduate students to help them with their literature reviews.” and a Doctor of Medicine participant proclaiming “Love the node aspect and makes showing connections to other papers super easy!” some were not as receptive; “This type of visualization is really not how my mind works, I can see that it could be very powerful for some people, though.” A learning curve for the system was also noted: “seemed a little difficult to use at first, but after a few minutes ... everything become more enjoyable”. It is encouraging the consensus found ARGO SCHOLAR useful and enjoyable; however, future work may focus on creating walk-up-and-use systems for literature exploration.

**4 Conclusion and Discussion**

This paper presents a follow-up evaluation study of ARGO SCHOLAR, an open-sourced, web-based visualization tool that allows users to interactively and incrementally explore literature to gain insight and uncover relevant work. From a large-scale observational study, we found ARGO SCHOLAR effective in helping users understand citational relationships within a field and uncover related work. We also condense lessons and suggestions from the feedback of our participants to provide inspiration for future work.

**References**

[1] D. H. Chau, A. Kittur, J. I. Hong, and C. Faloutsos. Apolo: making sense of large network data by combining rich user interaction and machine learning. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2011.

[2] K. Li, H. Yang, A. Upadhayay, Z. Zhou, J. Saad-Falcon, and D. H. Chau. Argo scholar: Interactive visual exploration of literature in browsers. *ArXiv*, abs/2110.14060, 2021.

[3] K. Lo, L. L. Wang, M. Neumann, R. M. Kinney, and D. S. Weld. S2orc: the semantic scholar open research corpus. In *ACL*, 2019.

[4] H. Snyder. Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, 2019.

[5] N. Sultanum, C. Murad, and D. J. Wigdor. Understanding and supporting academic literature review workflows with itsense. *Proceedings of the International Conference on Advanced Visual Interfaces*, 2020.

[6] C. Wohlin. Guidelines for snowballing in systematic literature studies and a replication in software engineering. In *EASE ‘14*, 2014.