SketchingRelatedWork: Finding and Organizing Papers through Inking a Node-Link Diagram

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ABSTRACT

Writing an academic paper requires significant time and effort to find, read, and organize many related papers, which is a complex knowledge task. We present a novel interactive system that allows users to perform these tasks quickly and easily on the 2D canvas with pen and multitouch inputs. Our system turns users' sketches and handwriting into a node-link diagram of papers and citations that users can iteratively expand in situ toward constructing a coherent narrative when writing Related Work sections.

CCS CONCEPTS

• **Human-centered computing** → **Interaction techniques**.

KEYWORDS

Related work, inking, node-link diagram

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1 INTRODUCTION

Researchers write "Related Work" sections to explain that their papers are based on the existing body of knowledge, differ from it, and contribute to it. To do so, they investigate hundreds of papers over several weeks or months, cite dozens of related papers, and describe their relationships in writing.

A common method of investigating related papers is to find a "seed paper" considered highly relevant to research and then conduct an exhaustive survey of the papers cited by the seed paper and those citing it [2, 3]. By doing so, researchers can collect a comprehensive list of old and new papers on the topic.

However, each paper usually cites dozens of others. Also, there may be hundreds of others that cite it. Therefore, as the above process is repeated, the number of papers to collect can increase exponentially, so it is easy for researchers to feel anxious about possibly skipping important papers, overwhelmed by the growing pile of papers to read and analyze, and frustrated by the lack of a visual representation that helps them see the big picture.

We propose a novel interactive system allowing researchers to find and organize many papers quickly and easily with pen and multitouch inputs. Our system enables users to find papers by simply sketching their citation relationships with other papers on the 2D canvas as boxes, arrows, and handwriting and, from this process, construct a node-link diagram that can help users take advantage of their spatial memory (Figure 1).

2 RELATED WORK

In writing Related Work sections, researchers find, read, extract information from, record, and review existing papers [13]. In doing so, they often use commercial tools that help them efficiently manage a large number of papers in a list [4, 12]. However, understanding complex citation relationships between papers from such a list can be difficult [10].

Node-link diagrams can visualize citation relationships of many papers [2, 3, 5, 8, 9, 14, 16, 18, 20, 22]. In a node-link diagram, nodes can be placed anywhere on a 2D canvas, and links can express any

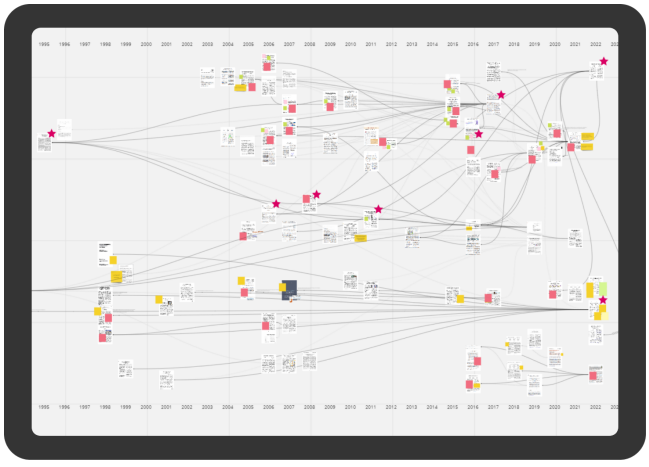

Figure 1: By utilizing this system's intuitive search method and flexible 2D workspace, researchers can find and organize papers important for writing Related Work sections. They can arrange these papers in chronological order of publication to understand the history of existing knowledge or place related papers close together, potentially discovering new areas that existing knowledge has not yet explored.

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relationship between nodes. In our system, users can take advantage of this flexibility.

People are known to remember an item's location for longer when they put it in a place that they choose [17, 23]. Therefore, our system, similar to that Chau et al. [2] proposed, lets users manually arrange papers and connect them on the 2D canvas to construct a node-link diagram. This contrasts previous works that automatically adjust node arrangements for high visibility without user intervention [3, 5, 8, 9, 14, 16, 18, 20, 22].

Xia et al. [24] proposed a system where users sketch their thoughts with the pen first, and turn them into smart objects later. Subramonyam et al. [21] proposed a system where users highlight parts of text first, and it turns them into a node-link diagram later. Similarly, in our system, users sketch papers and citation relationships with the pen, and the system infers users' intention from the sketches and completes them with actual data so that users can construct a node-link diagram from the natural journaling process.

Node-link diagrams can also be used to express search conditions: Users can add search keywords to nodes and links [7], specify node types [15], and define relationships between known and unknown entities [11]. Based on these works, our system allows users not only to create a node-link diagram from sketches [21, 24], but also to search for new information through this process.

3 INTERACTIVE SYSTEM

The design goal of this system is to help researchers quickly and easily find and organize relationships within the existing body of knowledge when writing Related Work sections. We were inspired by people's habit of creating rough sketches to capture their ideas before they fade away and designed the following workflow: When users sketch papers and relationships between papers, the system infers their intention and completes the sketches as a node-link diagram comprising actual papers and citations (Figure 2).

In our system, a node-link diagram serves three roles. First, it helps users find new related papers in situ using parts of the diagram as a graph of search conditions when organizing the papers (Figure 3). Second, it helps users create a unique layout of papers visualized as thumbnail images of the papers' first pages and memos visualized as colorful sticky notes on the 2D canvas (Figure 4b), taking advantage of their spatial memory. Third, it helps users iteratively diverge and converge their knowledge landscape through curating only those citations important for constructing a coherent narrative (Figure 4a, 4c).

4 IMPLEMENTATION

We implemented our system as a tablet application for pen and multitouch inputs using Unity. Additionally, we utilized Selvy Pen SDK [1] to recognize users' handwriting and Serp API [19] and SemanticScholar API [6] to fetch papers' data and metadata.

5 CONCLUSION & FUTURE WORK

In this study, we propose a sketch-based interactive system for inking a node-link diagram of research papers. In our system, users can search for papers through in situ graph queries, alleviating the anxiety of finding papers; utilize the infinite 2D canvas as a workspace for browsing and note-taking, alleviating feelings of being overwhelmed by reading papers; and progressively refine their knowledge graph of related work, alleviating the frustration of organizing papers. In future work, we will work with researchers who have written Related Work sections to validate our system's usefulness and usability against existing tools and workflows.

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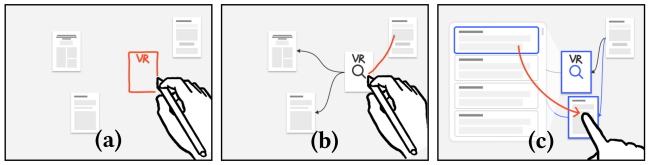

Figure 2: Users can sketch papers on the 2D canvas by (a) drawing boxes and writing keywords and/or (b) drawing citation relationships. Then, (c) the sketches are used as search conditions to find papers in situ, which can be collected at locations where they wish to be placed.

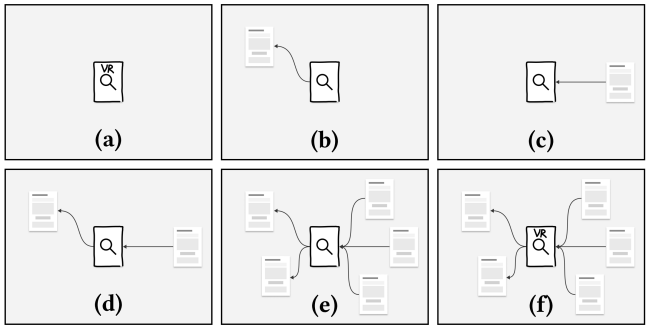

Figure 3: By drawing various node-link diagrams, users can query (a) all papers containing specific words, (b) all papers citing one paper, (c) all papers cited by one paper, (d) all papers citing one paper and cited by another paper, (e) all papers citing multiple papers and cited by other multiple papers, and (f) all papers containing specific words, citing multiple papers, and cited by other multiple papers.

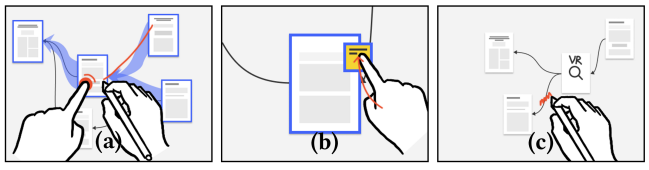

Figure 4: Users can (a) long-press a collected paper with one finger to view all citation relationships among other collected papers, allowing them to selectively visualize only the relationships they wish. (b) They can create sticky notes by sketching small squares and attaching them to papers. (c) They can erase unnecessary information by scribbling over the corresponding objects.

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