Abstract

Starting research requires understanding field trends through lectures, seminars, and paper surveys. However, novice researchers often struggle to apply this knowledge practically, especially in connecting concepts logically and analyzing them from multiple perspectives. The rapid advancement of information science has increased the need for self-study, but extracting key information from numerous papers remains challenging for newcomers lacking experience. To address this, novice researchers need a top-down approach that guides them from broad overview to detailed exploration. This study develops a research survey assistant interface that provides both broad perspective and detailed insights, helping novice researchers explore topics more systematically. The system consists of five main components spanning from data construction to interface development:

Phase 1 - Object Recognition from Scientific Document based on Compartment & Text Blocks Refinement Framework (CTBR) for infrastructure data generation: Efficient information extraction from scientific documents is crucial for digital ecosystems, especially in research surveys. While current methods use either rule-based (**RB**) or machine learning (**ML**) approaches, both have limitations - **RB** methods require extensive coding for complex layouts, while **ML** methods need costly annotations. Popular datasets like *S2orc* and *Unarxiv* often contain mixed content that disrupts text continuity, affecting semantic analysis accuracy. From the perspective of analyzing the standard layout and typesetting used in the specified publication, we propose **CTBR**, a framework that classifies text blocks and uses rule-based compartment segmentation for generating high-purity infrastructure data. These results automatically feed into further processing as foundational of research survey assistant interface.

Phase 2 - Gain a bird-eyes view on a specific research topic: Novice researchers struggle with understanding multiple academic papers and grasping research fundamentals. Traditional keyword-based knowledge graphs and **ChatGPT** have limitations for novice researchers who lack field expertise to formulate effective queries. This subsystem addresses these challenges by providing a ***fish-bone*** diagram with causal relationships, offering a research topic overview. Built using issue ontology from academic papers, it presents a broad perspective based on relevance and logical factors. The system guides researchers through a structured route (research topic → task → issue ontology → corresponding articles) that forms the basis for detailed data mining. These components then feed into subsequent research insight phases.

Phase 3 - Hierarchical Tree-structured Knowledge Graph for Academic Insight Survey: The ***fish-bone*** diagram alone cannot effectively track temporal patterns across multiple articles. Novice researchers, particularly those inexperienced with longitudinal research, struggle to quickly understand logical connections between research tasks. While knowledge graphs (**KG**) and paper recommendations could help this processing, current solutions have limitations such as navigation knowledge graphs rely too heavily on keywords, making hierarchical relationships of inheritance and relevance unclear, while recommendation systems based on text similarity don't explain why articles are related. This subsystem addresses these challenges by creating a hierarchical ***tree-structured knowledge graph*** that shows longitudinal inheritance and relevance relationships between academic papers on specific research topics.

Phase 4 - A Viewpoints Refinement diff-table System for Cross-sectional Insight Surveys: While longitudinal insights are valuable, they may not fully capture similarities and differences across articles. Our cross-sectional insight survey addresses this by comparing article groups based on expert-defined attributes. Current systems rarely highlight such comparisons effectively, making it challenging for beginners to grasp the logical connections between research concepts. Therefore, this subsystem enhances difference extraction between related articles through Cross-sectional Insight Surveys, expanding the ***tree-structured knowledge graph***. It generates a concise ***diff-table*** based on expert consensus viewpoints, using templated prompts to create abstractive summaries for each table cell.

Phase5 - Research Survey Supporting Interface: We integrate knowledge graph outputs from **Phases 2-4** into an intuitive **UI** display that helps researchers better understand survey logistics and navigate information. The interface lets users explore different survey routes aligned with their interests and objectives. By presenting a clear survey overview to novice researchers, it serves as a 'learn how to learn' module and research support tool for graduate students.

Keywords: Top-down, Research survey, Infrastructure data, Academic articles, Automatic summarization, Knowledge graph, Bird-eyes view, Longitudinal insight, Cross-sectional insight, Interface.