LLM-Based Research Paper Summarizer for Academic Knowledge Extraction

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Abstract — The exponential increase in the number of scientific publications presents a major challenge for researchers attempting to stay up to date with emerging knowledge. Traditional extractive summarization techniques are often inadequate for capturing contextual and semantic details from academic literature. This paper proposes an advanced framework utilizing Large Language Models (LLMs) combined with retrieval-based techniques to automatically summarize and analyze research papers. The proposed architecture parses scientific PDFs, extracts structured sections, generates concise summaries, enables retrieval-augmented question answering (RAG), and visualizes inter-paper relationships. Evaluation metrics such as ROUGE and BERTScore validate the generated summaries, while clustering visualizations assist researchers in conducting literature reviews efficiently.

Keywords — Large Language Models, Summarization, Retrieval-Augmented Generation, Research Papers, NLP, Vector Databases

I. INTRODUCTION

In recent years, the volume of scientific literature has grown exponentially across multiple disciplines. Researchers face difficulties in efficiently digesting the increasing number of publications. Manual review of these papers consumes considerable time and effort, hindering innovation and slowing the pace of research. Traditional extractive summarization methods, such as TF-IDF and TextRank, primarily rely on frequency-based heuristics that often fail to retain semantic meaning or logical flow. Recent advancements in Natural Language Processing (NLP), particularly Large Language Models (LLMs) such as GPT-4 and Llama-3, have demonstrated remarkable capabilities in understanding, summarizing, and reasoning over textual content. This work introduces an intelligent system leveraging LLMs for summarizing academic papers, enabling researchers to quickly grasp the problem, methodology, and findings without exhaustive manual reading.

II. METHODOLOGY

The proposed model architecture consists of multiple integrated modules designed for seamless academic summarization and exploration.

A. PDF Parsing and Preprocessing: Research papers in PDF format are parsed using PyMuPDF or Grobid to extract structured content, including the title, abstract, introduction, methodology, and conclusion. The text is then cleaned and normalized to remove artifacts such as citations and mathematical notations.

B. Embedding Generation and Vector Storage: Sentence embeddings are generated using OpenAI embeddings or Sentence-Transformers and stored in FAISS or Chroma vector databases to facilitate semantic retrieval.

C. Summarization Engine: LLMs (e.g., GPT-4, Llama-3, Mistral) are prompted to generate section-level summaries, which are then hierarchically merged to form a complete paper summary. The summarization emphasizes key aspects such as problem definition, methods, and findings.

D. Retrieval-Augmented Question Answering (RAG): A RAG pipeline retrieves relevant context from the embedded database and provides natural language answers to user queries, allowing interactive exploration of research content.

E. Visualization and Evaluation: Topic clusters and citation networks are visualized using Plotly or NetworkX. Summaries are evaluated quantitatively using ROUGE and BERTScore metrics.

III. RESULTS AND DISCUSSION

The LLM-based summarization pipeline produces concise and coherent summaries that retain key semantic relationships. Compared to traditional extractive summarization methods, the proposed system generates summaries that are more readable, contextually relevant, and logically structured. Qualitative evaluations highlight the model’s ability to capture experimental details and results effectively. Furthermore, the RAG component significantly enhances the usability of the system, enabling interactive and context-aware question answering. Visualizations of clustered papers demonstrate meaningful groupings by topic, proving valuable for literature review and meta-analysis tasks.

IV. CONCLUSION

This paper presents a comprehensive system for summarizing and analyzing academic research papers using Large Language Models. The integration of LLM-based summarization, retrieval mechanisms, and visualization tools provides an end-to-end platform for efficient academic exploration. The results indicate that LLMs, combined with semantic embeddings, can substantially enhance literature understanding and synthesis. Future directions include fine-tuning on domain-specific datasets, developing citation-aware summarization, and integrating multi-document summarization for broader literature synthesis.

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