

Evaluation of Intermediate Steps in Retrieval Augmented Generation

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This work investigates the research question: Does a RAG pipeline that expands the initial prompt into an LLM-generated query pool produce answers that humans prefer (on correctness, conciseness, and relevance) over a baseline that directly queries Elasticsearch once? To explore this, we implement two retrieval-augmented generation (RAG) pipelines that operate exclusively on search engine result page (SERP) snippets, which are often incomplete and inconsistent. The baseline pipeline (P1) retrieves snippets from a single query and directly conditions an LLM on this evidence. The advanced pipeline (P4), in contrast, employs LLM-based query expansion to generate a pool of reformulated queries, filters the resulting snippets, and integrates them for answer inference. Human evaluation indicates that P4 produces answers that are slightly more coherent, contextually appropriate, and preferred overall, though the improvements remain moderate. However, these gains come at the cost of significantly longer execution time, highlighting a trade-off between answer quality and system efficiency. These findings demonstrate the potential of query-expansion-based RAG pipelines for enhancing answer quality from fragmented snippet collections, while also pointing to open challenges in efficiency, evidence integration, and domain adaptation.

CCS Concepts: • **Information systems** → **Retrieval models and ranking; Evaluation of retrieval results;** • **Computing methodologies** → *Natural language processing*.

Additional Key Words and Phrases: RAG, Summary, Pooling, Query, LLM, Pipeline

ACM Reference Format:

Aram Aytekin, Moritz Dietrich, Maximilian Bennedik, and Domenic Bremmer. 2025. Evaluation of Intermediate Steps in Retrieval Augmented Generation. 1, 1 (August 2025), 6 pages. <https://doi.org/10.1145/nnnnnnn.nnnnnnn>

1 Introduction

Information retrieval and answer generation have been transformed in recent years by large language models (LLMs) and retrieval-augmented generation (RAG). While these approaches typically rely on access to the full underlying documents, many real-world scenarios such as search engines only provide access to fragmented snippets contained in search engine result pages (SERPs). These snippets are often incomplete, inconsistent, and heterogeneous in style, making coherent answer generation particularly challenging. Nevertheless, being able to synthesize high-quality answers from such fragments is of both practical and theoretical interest.

A central obstacle in this setting lies in how queries are handled. Traditional retrieval methods issue a single query and directly return associated results, which often fails to capture the full breadth of relevant information. Recent advances in LLM prompting, however, allow for automatic query reformulation and expansion, potentially improving coverage and evidence diversity. Whether such query pooling strategies can indeed enhance answer generation quality from SERP snippets remains an open question.

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2025. Manuscript submitted to ACM

1.1 Research Question

Against this background, our study investigates the following research question: *Does a RAG pipeline that expands the initial prompt into an LLM-generated query pool produce answers that humans prefer (on correctness, conciseness, and relevance) over a baseline that directly queries Elasticsearch once?*

1.2 Contribution

To answer this question, we implement and evaluate two RAG pipelines that operate solely on SERP snippets. The baseline pipeline (P1) issues a single query and generates answers from the retrieved snippets without further reformulation. The advanced pipeline (P4), in contrast, expands the initial query into a pool of reformulated queries using an LLM, retrieves and filters a broader snippet set, and conditions answer generation on this richer evidence. We evaluate both pipelines through human preference judgments along correctness, conciseness, and relevance, and further measure computational cost. Our findings show that while P4 produces answers that are slightly more coherent and preferred overall, it incurs substantially higher runtime costs, highlighting a trade-off between answer quality and efficiency. This contribution provides insight into the potential and the limitations of query-expansion-based RAG pipelines when applied to fragmented snippet data.

2 Background & Related Work

2.1 Retrieval Augmented Generation

Retrieval-Augmented Generation (RAG) has emerged as a powerful paradigm for combining the generative capabilities of large language models (LLMs) with external retrieval mechanisms to produce factually grounded answers. In typical RAG setups, queries are used to retrieve relevant documents or passages from a large corpus, which are then used to condition the LLM’s response [? ?]. This approach mitigates hallucinations often observed in standalone LLMs and enhances factual accuracy. Previous studies have demonstrated the effectiveness of RAG in settings such as open-domain question answering, summarization, and knowledge-intensive tasks [? ?]. However, most prior work assumes access to complete and well-structured documents. In contrast, the present study operates under the more constrained setting of search engine result page (SERP) snippets, which are often fragmented, inconsistent, and incomplete. This constraint introduces unique challenges for coherent answer generation, motivating the exploration of advanced retrieval strategies.

2.2 Query Expansion vs. Single-Query Baselines

Traditional information retrieval systems often rely on a single-query approach, issuing one query to retrieve the top-k documents or passages. While computationally efficient, this strategy may fail to capture the full spectrum of relevant evidence, particularly in domains with heterogeneous or incomplete sources. Query expansion techniques aim to address this limitation by reformulating the initial query or generating multiple variant queries to improve coverage. Classical methods include pseudo-relevance feedback and relevance-based models, whereas more recent approaches leverage LLMs to generate paraphrases, sub-questions, or expanded queries tailored to the information need [? ?]. The trade-off is evident: query expansion can increase evidence diversity and retrieval effectiveness, but at the cost of additional computation and potential introduction of irrelevant information. In our study, the baseline pipeline (P1) represents the single-query approach, while the advanced pipeline (P4) operationalizes LLM-driven query expansion within a RAG framework, allowing for a systematic evaluation of this trade-off.

2.3 Human Preference Evaluation

Automatic evaluation metrics such as BLEU [?], ROUGE [?], and BERTScore [?] are limited in their ability to capture the quality of open-ended answers, especially in terms of correctness, conciseness, and relevance [?]. Human evaluation remains the gold standard for assessing answer quality in generative tasks [?]. Pairwise preference judgments, where annotators compare outputs from different systems, have been widely adopted to obtain robust insights into model performance [?].

Recent work has shown that crowdsourcing can be a viable approach for evaluating RAG systems, enabling structured assessments while controlling for annotator variability [?]. Despite the advantages, human evaluation remains resource-intensive. In our study, we conduct a structured human preference evaluation comparing answers generated by P1 and P4 along three dimensions: correctness, conciseness, and relevance. This provides direct evidence of the practical impact of query pooling on perceived answer quality, complementing quantitative retrieval metrics and highlighting the cost-quality trade-offs inherent in LLM-driven RAG pipelines.

3 Methods

3.1 Pipelines

In this project, we compare two retrieval-augmented generation pipelines that differ in how they formulate and execute search queries before producing an LLM-based answer.

Pipeline 1: Direct Retrieval and Answering. In this baseline approach, the system directly takes the user’s input prompt and submits it as a query to the Elasticsearch retriever (SourceRetriever.py). The retriever returns the top- k relevant text snippets, which are then provided to the LLM (LLM.py) together with a strict system instruction: the model must formulate its answer *only based on the retrieved snippets*. This ensures that the output is grounded in the search results without additional query expansion or prompt reformulation.

Pipeline 4: Query Pool Expansion. This enhanced approach adds an intermediate reasoning step before retrieval. The LLM is first asked to generate a *query pool*, i.e. a set of reformulated or semantically related search queries derived from the original user prompt. These multiple queries are then executed against Elasticsearch, leading to a richer and more diverse set of retrieved snippets. The snippets are aggregated and passed to the LLM, which produces the final answer. By broadening the retrieval space, Pipeline 4 aims to increase coverage and relevance compared to the single-query baseline.

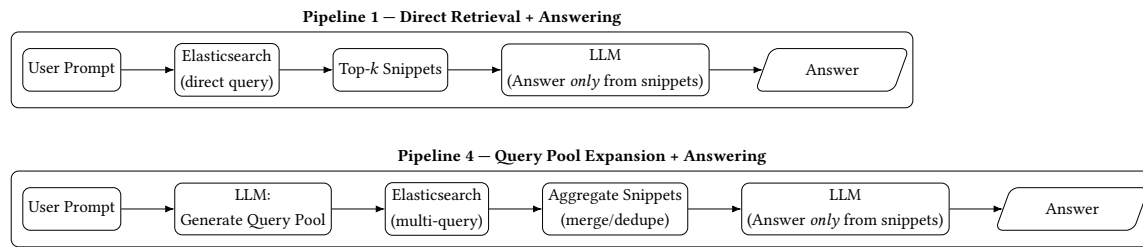


Fig. 1. Method overview. Pipeline 1 queries Elasticsearch once and answers strictly from the retrieved snippets. Pipeline 4 first asks the LLM to generate a pool of queries, retrieves with multiple queries, aggregates snippets, and then answers grounded in those snippets.

3.2 Data & Task Setup

xxx

3.3 Retrieval & LLM Configuration

xxx

3.4 Evaluation Protocol

xxx

3.5 Metrics & Hypotheses

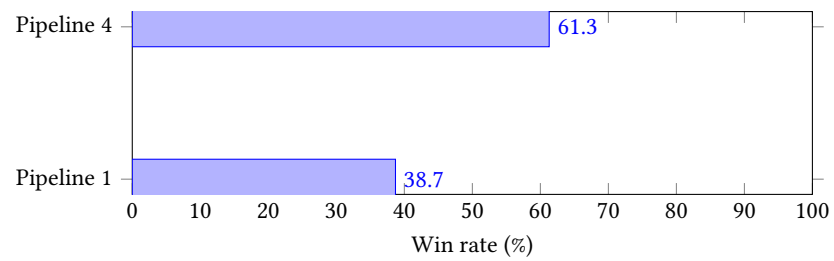


Fig. 2. Win rate comparison between Pipeline 1 and Pipeline 4.

3.6 Cost Measurement

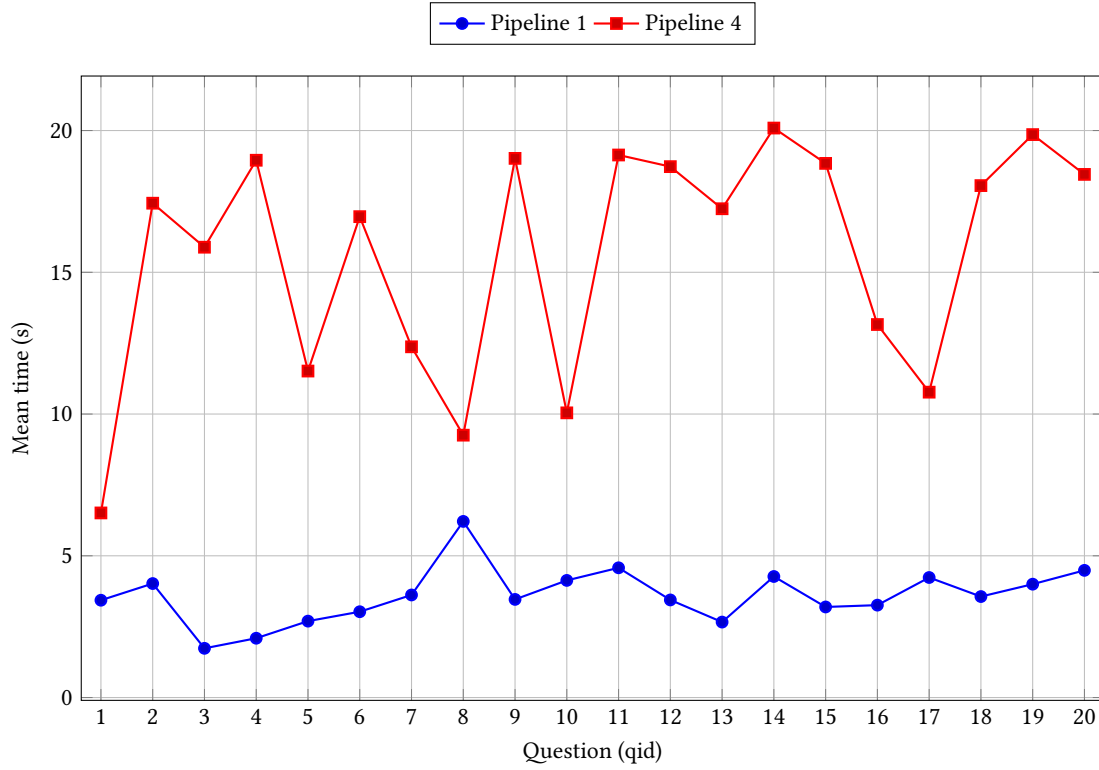


Fig. 3. Mean LLM response times per question (s) for the two pipelines.

4 Results

4.1 Overall Preference

xxx

4.2 Annotator Remarks

xxx

4.3 Cost-Quality Tradeoff

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5 Conclusion

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Acknowledgments

To Robert, for the bagels and explaining CMYK and color spaces.

References

A Research Methods

A.1 Part One

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B Online Resources

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