Hochschule
Bonn-Rhein-Sieg
University of Applied Sciences

Fachbereich Informatik
Department of Computer Science

Master Project

Computer Science

LitQEval: Measuring the Effectiveness of Litreature Search Queries

Computer Science

Mohammad Sakinini

Supervisor	Philipp Baaden Fraunhofer INT
Examiner 1	Prof. Dr. Jörn Hees
Examiner 2	Dr. Milos Jovanovic
Draft as of	2024-11-10 15:43:33+01:00 (For submission: set `final` option in thesis.tex!)
To be submitted on	2024-07-26

Abstract

This work is based on a larger initiative known as the Search Query Writer (SQW), an internal tool developed at Fraunhofer INT to aid scientific researchers in creating comprehensive literature search queries. These queries are intended to provide researchers with a strong starting point in a topic area they may have limited knowledge about.

The current state of the SQW tool presents a key challenge: the absence of a mechanism to evaluate the quality of the generated queries. As a result, the evaluation has so far been conducted subjectively. This project aims to address this issue by introducing a dataset that contains publications deemed relevant to specific topics. Additionally, it introduces several metrics to account for different aspects of query evaluation, given the complexity of the task.

(Explain performed experiments after completing them)

Contents

1. Introduction

The Fraunhofer Institute for Technological Trend Analysis (INT)[1] is a research institute that frequently undertakes new tasks and research questions across various fields. Often, these inquiries require systematic and robust scientific responses, even when the initial knowledge in the area may be limited at the time. Given the recurring nature of this challenge, a tool that can support researchers by providing a head start and entry point into unfamiliar fields is essential.

To address this, several internal tools have been developed to analyze large volumes of scientific data from sources like Dimensions.ai[2] and Web of Science[3]. The rise of large language models (LLMs) has further enhanced the appeal and accessibility of automation across numerous domains, including scientific research, spanning from idea generation and experimental iteration to paper composition[6].

In the realm of search queries, the main focus has been on text-to-SQL[2], where an LLM is prompted via natural language to generate a precise and valid SQL query. However, to our knowledge, there has been limited and non-diverse effort dedicated to the development of text-to-literature search queries. Thus this work introduces a pipeline and curates a dataset designed to address this gap, with a particular focus on enhancing the Fraunhofer Search Query Writer tool.

1.1. Motivation

The SQW tool is currently under development by the company and has generated significant interest among researchers. However, a primary challenge we face after testing earlier versions is evaluating the quality of the generated queries. Initially, we considered gathering human feedback from users by requesting them to rate the generated query on a scale of 0 to 5. While this approach could be useful for fine-tuning the underlying model, the quantity of feedback has so far been limited and remains subjective. This is especially problematic because the tool's purpose is to generate queries for researchers who are new to a given topic. Consequently, if the query quality is poor, the researcher may not immediately recognize this.

Identifying suitable evaluation metrics and datasets to assess the quality of the generated queries is a complex task, which forms the basis of this master's project. The project's objective is to find a robust solution for assessing the quality of literature search queries, enabling the further development of the SQW tool to

[1]https://www.int.fraunhofer.de/
[2]https://www.dimensions.ai/
[3]https://clarivate.com/

provide more accurate results and improve productivity through the integration of large language models.

1.2. Research Questions

There are three main research questions that we aim to address while curating the dataset and formulating the metrics to evaluate the generated queries. These questions are based on the following hypothesis: Given that we know which publications are the most important for a given field, which we will refer to as **Core Publications** (CP).

- **RQ1:** How many of the core publications can the generated search query recall?
- **RQ2:** How many of the non-core publications are relevant?
- **RQ3:** Which metric can we use to penalize the model for exploiting the ability to generate large queries to achieve high recall?

1.3. Structure of this Work

The remainder of this work is structured as follows:

After this introduction, we will first focus on the foundations in Chapter 2, where we will briefly explain the SQW tool, primarily focusing on the format of the input and output. We will also cover the necessary basics and information about the main data source, Dimensions.ai, which will be used to curate the dataset **??**, as well as common metrics **??** used for evaluation in the community, before discussing related works in Section 2.2.

Next, in Chapter 3, we will detail our approach and its components, which involve curating a dataset that contains core publications and establishing a pipeline to streamline the evaluation process, thereby accelerating the development of the SQW tool.

We will evaluate our approach in Chapter 4, beginning with a description of our experimental setup, where we acquire the generated query via the SQW tool and explain the reasoning behind the selection of topics for which the queries are generated.

Finally, we will conclude this work with a summary of our main contributions and an outlook in Chapter 5.

2. Foundations

In this section, we will begin by briefly introducing the SQW tool to provide a foundational understanding of how its settings may influence the overall results. This introduction will also establish the groundwork for designing an evaluation process that ensures a fair and accurate assessment.

Next, we will review prior works that tackle the challenge of using large language models (LLMs) to generate literature search queries, examining their potential in this domain.

Following this, we will describe the dataset curation process, including relevant statistics and exploratory data analysis. This analysis will help us evaluate the dataset's quality and determine the topics suitable for evaluation.

Then, we will introduce new metrics designed to assess the quality of generated search queries. These metrics are intended not only to identify true positives from core publications but also to account for other potentially relevant publications. Once the evaluation pipeline is established, we will conduct a comparative analysis between a baseline and the queries generated by the SQW tool.

Finally, we will provide an outlook on the next steps and potential optimization options for the SQW tool. Additionally, we will discuss other tools that could be developed to build upon these advancements.

2.1. Search Query Writer

The Search Query Writer is a tool based on a large language model (LLM), specifically using GPT-4o, to systematically generate literature search queries. The only required input for this tool, which is the main focus of this work, is the **Topic**. Users are required to provide a topic for generating a search query, irrespective of the scientific field—for example, *Synthetic Biology*.

Several optional inputs are available to enhance the quality of the generated query, including:

- **Negative Keywords:** Terms that should be excluded to avoid unwanted results.
- **Description:** A description that serves as an alignment mechanism to clarify the task's intent.
- **Modes:** Three selectable modes (Strict, Moderate, Creative) that control the temperature of the LLM to manage the level of randomness in responses.

Hochschule
Bonn-Rhein-Sieg
University of Applied Sciences

Figure 2.1.: Nice long caption

- **Depth:** A parameter that specifies how comprehensively the topic should be analyzed.

- **Supporting Documents:** Users can upload a PDF, ideally a survey or overview document on the topic, which helps the tool acquire knowledge about the scientific field and better align with the research intent.

These additional inputs are intended to refine and tailor the search query to more closely match the user's research goals, but will not be extensively tested in this work.

To generate a literature search query, we designed the SQW to take a human-like approach, divided into two main steps: **Knowledge Enrichment** and **Iterative Scientific Fine-Tuning**.

The objective of the Knowledge Enrichment step is to provide the LLM with contextual information about the research topic. This is achieved by first retrieving information from Wikipedia based on the given topic. Specifically, the first 4,000 characters from the top-k pages are collected and summarized before being passed into the LLM's memory. ArXiv is queried in a similar manner to gather relevant research content. Additionally, we perform an online search using DuckDuckGo[1], aggregating results to offer a broader understanding of the topic.

Notably, each of the steps is conducted within a separate memory session, with results stored independently for future use. This setup allows the model to explore the topic using various sources, helping to mitigate any potential recency bias and ensure a well-rounded context.

The output of this first stage will be a list of keywords that are usually presented in a transfer-list as shown in Figure 2.2, that contains two lists; specific and general keywords, along side some additional information such as the number of publications found per keyword. The goal is to let the user decide weather a keyword is too broad in which he is supposed to move it to the general list, and if it targets the specified topic quite well then it should stay in the specific list, and at the end they user should also provide an overarching topic for which the scope of the general keywords is limited to be more focused to words the research intent. The output of this step will be the queries that will be used for the evaluation at the end.

The iterative scientific fine-tuning on the other hand approaches more scientific sources, namely dimensions.ai, which is a literature database that offers quick

[1] `https://duckduckgo.com/`

Hochschule
Bonn-Rhein-Sieg
University of Applied Sciences

Figure 2.2.: Nice long caption

access to publications across a wide range of journals. The query generated in the earlier stage is then used to prompt dimensions three times, once to retrieve the most cited 1k literature, a second time to retrieve the newest 1k literature, and one last 1k to retrieve the most relevant documents based on their **DOUBLE CHECK THIS INFO** internal rating metric. This leaves us with a total of 3k publications in which we extract the title and abstract for, and use an Openai's embedding model, and apply a simple RAG pipeline to retrieve the most relevant keywords based on the extracted passages.

2.2. Related Work

Systematic literature reviews are widely used across various fields, allowing researchers to conduct a comprehensive manual review of scientific topics and identify publications that answer a set of important research questions. However, one significant challenge with this approach has been the exponential growth in the number of publications, which makes conducting unbiased reviews increasingly difficult. In the age of technological advancements, we can now leverage these technologies to assist in investigating topics without the need to manually sift through extensive lists of publications. To address this issue, a series of works have been proposed within the Conference and Labs of the Evaluation Forum (CLEF) [3–5]. These works focus on the evaluation of empirical medical research, utilizing a dataset of medical literature. They introduce two primary tasks: Task 1, which involves identifying relevant studies from the PubMed medical database, and Task 2, which assesses the ranking of studies following title and abstract screening. Notably, the evaluation pipeline, along with the dataset and descriptions of these tasks, are publicly accessible on GitHub[2].

Large Language Models (LLMs) have had a significant impact on modern technology, including in scientific research, where they have provided remarkable improvements in speed. While the processing speed of LLMs is unprecedented, the quality of their output in various domains is still being explored. The work by Wang [8] investigated the performance of ChatGPT in generating Boolean search queries for literature reviews. Specifically, it evaluated the effectiveness of ChatGPT in constructing queries for systematic literature reviews using different prompting techniques, including zero-shot, few-shot and iterative guided approaches. The evaluation used the CLEF datasets [3–5] and an additional med-

[2] `https://github.com/CLEF-TAR/tar/tree/master`

ical dataset containing a collection of seeds [7]. Although the results highlight the limitations of ChatGPT's performance, this work underscores the potential of LLMs to aid literature review, especially when supported by examples or more advanced, structured pipelines.

A broader and more diverse evaluation of the quality of automatically generated literature search queries for systematic literature reviews was conducted by Badami [1]. In this work, they introduced a pipeline that generates literature search queries based on a given research question and abstracts from previously identified relevant publications. The evaluation was performed against a dataset they constructed, which contains the results of 10 systematic literature reviews, including candidate papers, queries used, and relevant papers identified in each review. For example, in the review SLR_1, a total of 7,002 candidate papers were retrieved using search query S, from which a subset of 59 relevant papers RP was identified. To assess their proposed approach, they compared the generated queries in various settings using recall and precision metrics, benchmarking them against the original search query S. The dataset is made public ally available on Zenodo[3].

[3] https://tinyurl.com/496zuar3

3. Own Approach

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

3.1. Idea / Overview

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi

blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

3.2. Component 1

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

3.3. Component 2

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

3.4. Optionals

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

4. Evaluation

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

4.1. Experimental Setup

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi

blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

4.2. Results

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

4.3. Discussion

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

5. Conclusion

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

5.1. Summary and Contributions

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi

blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

5.2. Outlook

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

A. Appendix

A.1. Further Details on Something

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque, augue quis sagittis posuere, turpis lacus congue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilisi. Sed a turpis eu lacus commodo facilisis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, et vehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla. Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetuer.

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

Bibliography

[1] M. Badami, B. Benatallah, and M. Baez. "Adaptive search query generation and refinement in systematic literature review". In: *Information Systems* 117 (2023), p. 102231 (cit. on p. 6).

[2] X. Dong, C. Zhang, Y. Ge, Y. Mao, Y. Gao, J. Lin, D. Lou, et al. "C3: Zero-shot text-to-sql with chatgpt". In: *arXiv preprint arXiv:2307.07306* (2023) (cit. on p. 1).

[3] E. Kanoulas, D. Li, L. Azzopardi, and R. Spijker. "CLEF 2017 Technologically Assisted Reviews in Empirical Medicine Overview". In: Jan. 2017 (cit. on p. 5).

[4] E. Kanoulas, D. Li, L. Azzopardi, and R. Spijker. "CLEF 2018 technologically assisted reviews in empirical medicine overview". In: *CEUR workshop proceedings*. Vol. 2125. 2018 (cit. on p. 5).

[5] E. Kanoulas, D. Li, L. Azzopardi, and R. Spijker. "CLEF 2019 technology assisted reviews in empirical medicine overview". In: *CEUR workshop proceedings*. Vol. 2380. 2019, p. 250 (cit. on p. 5).

[6] C. Lu, C. Lu, R. T. Lange, J. Foerster, J. Clune, and D. Ha. *The AI Scientist: Towards Fully Automated Open-Ended Scientific Discovery*. 2024. arXiv: 2408.06292 [cs.AI]. URL: https://arxiv.org/abs/2408.06292 (cit. on p. 1).

[7] S. Wang, H. Scells, J. Clark, B. Koopman, and G. Zuccon. "From Little Things Big Things Grow: A Collection with Seed Studies for Medical Systematic Review Literature Search". In: *Proceedings of the 45th International ACM SIGIR Conference on Research and Development in Information Retrieval*. SIGIR '22. ACM, July 2022, pp. 3176–3186. DOI: 10.1145/3477495.3531748. URL: http://dx.doi.org/10.1145/3477495.3531748 (cit. on p. 6).

[8] S. Wang, H. Scells, B. Koopman, and G. Zuccon. "Can ChatGPT write a good boolean query for systematic review literature search?" In: *Proceedings of the 46th International ACM SIGIR Conference on Research and Development in Information Retrieval*. 2023, pp. 1426–1436 (cit. on p. 5).

Declaration

I declare that I have written this work by myself. I have identified as such all passages taken verbatim or in meaning from published or unpublished works by third parties. All sources and aids that I have used for the work are indicated.

(Example formulations follow, which you must adapt to your work for the sake of transparency. Of course, you should have discussed about the acceptability of such aids with your supervisor in advance.) In particular, the following AI systems were also used to create this work:

- ChatGPT in version ... was used for the initial text drafting based on bullet points given by me in the chapters ... / of the entire work.
- ChatGPT was consulted on the following topics: ... / was used to generate ideas regarding ... / for the structuring of ... / for the conception of the system ... .

  The wording of the dialogs and the version used were documented in the appendix of this work. Passages used are marked as such in the text.
- ChatGPT was used to create source code for ... . The wording of the dialogs and the version used were documented in the appendix of this work. The use is indicated in the header of the respective source file / class / method / parts.
- Copilot in version ... was used to create source code / auto-complete for ... . The use is documented in the header of the respective source file / class / method / parts.

I am aware that content generated by AI systems is no substitute for careful scientific work, which is why all such generated content has been critically reviewed and finalized by me.

This work has neither been submitted with the same content nor in essential parts to any other examination authority.

Your City, 2024-07-26

Mohammad Sakinini