Imperial College London
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Independent Research Project
Project Plan

Current Content Discovery for Module Teaching

by

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Abstract

TBD.

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1 Introduction

1.1 Problem background

Since the emergence of Business schools in the late 19th century [41, 34], several distinct pedagogical teaching strategies have been used. First institutionalized at Harvard Business School [16, 4], a method about teaching students with real world business cases (will be called *case method* in the rest of the document) has been found more effective and engaging [43, 2, 25] than traditional big lecture methods, and gained wide adoption across the world [42, 10].

However, the case method is constrained by the availability and collection of timely and relevant case material [37, 29]. In particular, Christensen has identified in his classical article that instructors would have to conduct "extensive preparation" [7] for case method, and some others emphasise the importance of up-to-date material [8, 26].

1.2 Past advancements in information retrieval

In the early 19th century, the transmission of information was still traditional — carried by person on paper or simply remembered. The invention of telegraph in the 1840s by Morse, Cornell, and Henry [35, 24], was perhaps the first big advancement in history. This technological innovation was considerably improved by the invention of the telephone by Bell in 1876 [45, 12].

Wired communication is critically limited by geographical features on where the wires were laid. Around the late 19th century, Marconi's experiments with wireless telegraphy [11] introduced electromagnetic wave-based wireless communication, eventually accumulating into the world's first voice broadcast by radio in 1906 [40].

The next many decades have seen people improving on the serious limitations of the communication methods. [15, 46, 1]. Theoretically, Hartley observed a logritham pattern of information capacity [17] and then Shannon expanded on it to first define *bits* and *entropy*, giving a formal mathematical theory of information [38] in 1948. Another notable discovery was modulation techniques [18].

As the theoretical understanding of information progressed, people began to have the idea of *searching* for information based on content and by relevance, instead of by unique identifier [32]. The term *information retrieval* was coined by Mooers in 1950 [27]. Since then, information retrieval systems have quickly evolved, and Griffiths and King identified four phases of its evolvement: "(1) manual and mechanical devices; (2) offline computing; (3) online computing, vendor access; (4) distributed, networked, and mass computing." [14], with the last three substantially contributed to by the invention of the Internet [23], and consequently the emergence of search engines in the 1990s [36, 28]. Henceforth, search engines greatly expanded in speed and coverage and has been significantly impacting the society's information for at least a decade [6, 20].

Recently, LLMs have had a huge impact on various areas [9]. One strong appeal of LLMs is that they could easily work with natural language input & output [48, 22]. However, some argue that they could not inherently reason about what they output [33, 21, 31]. Indeed, hallucination [19, 30] and other forms of distortion of facts, is a big problem of LLMs. On the other hand, although search engines rely on determinstic algorithms that give precise reference to searched result, they could not compare with LLMs' NLP abilities.

Therefore, it is a current research direction to integrate LLMs with search engines [47, 39, 44]. Specifically, Xiong et al. proposes to categorize them into "LLM4Search" and "Search4LLM", where "A4B" means using A to improve B [47]. Here is where my thesis will build upon.

1.3 Goals

In this project, I will attempt to improve the current state of information retrieval further by designing and developing a software system. More precisely, these are the goals:

1. By combining LLMs and search engines, compensate each other's weakeness in information retrieval.
   (a) The system shall be able to take unstructured data describing the desired kinds of information.
   (b) The system shall improve LLMs on result credibility and interpretibility.
2. Enhance the automation of the current general public information retrieval tools so that user would only need to occasionally configure the system to run them.
3. Specially tailor the system to business teaching related information, aiming to gather information from authentic and reliable sources.
4. The system shall support up-to-date information retrieval. More precisely, the system shall support a specification of desired time range.
5. The system could support user feedback and learning from it to provide information more close to one's need.

2 Methods

2.1 Architecture

Based on the goals, the system is designed to be a chain of tools invoking each other.

What directs the system is the user's configuration, which is expected to include

1. A time range of information to retrieve.
2. A description of the types of information to retrieve.
3. How the retrieved information is sent to the user.
4. A frequency of running the tool.

Based on the configured running frequency, the tool will

1. Use LLMs to translate the configured description and generate a list of search engine prompts.
2. The prompts are fed to search engines, with the configured time constraint.
3. The search results are gathered and processed. How the information is processed and filtered may rely on other AI systems like a rule-based expert system.
4. The processed results may be summarized by LLMs.

5. The results are sent to the users via the configured ways.
6. Optionally, the user gives feedback to the results. The tool can thus improve on feedback

Figure 1 demonstrates my architecture design and the workflow of the system.

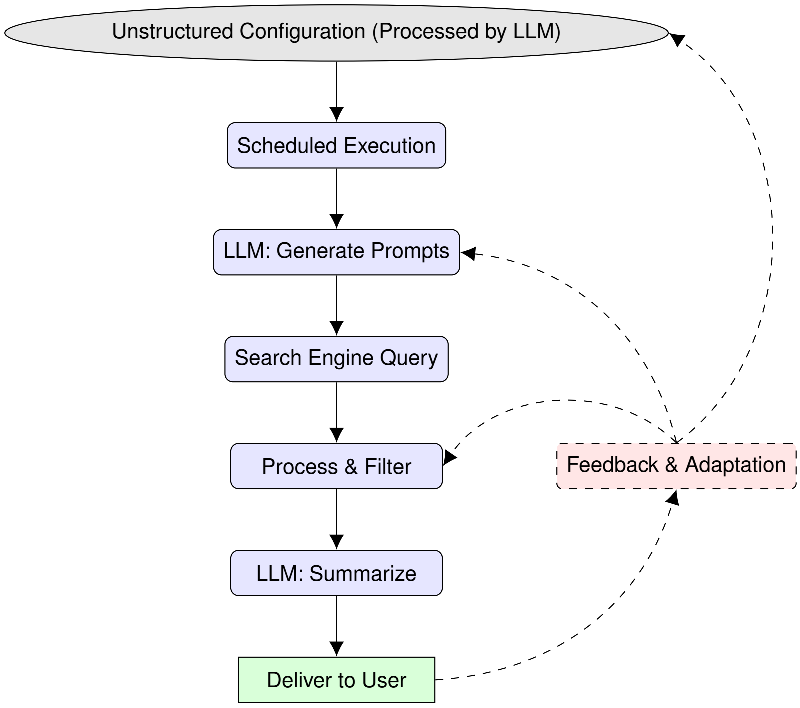

Figure 1: Architecture and operational flow of the software system

2.2 Implementation plan

In this section, I give the plan of my implementation. It is only meaningful for the project plan, as it will be replaced by the specifics in the final report.

2.2.1 Configuration format

LLMs have demonstrated unprecedented ability to process unstructured data [5, 3]. Thus, it is desirable for the system to accept unstructured configuration from the user. The user may give a natural language description of the wanted information, some examples, e.g., URLs, or simply the teaching slides and videos from previous classes.

Nevertheless, there are a few configurations that must be formatted.

1. A range of time for the information retrieved.
2. (Optional) A list of sources (e.g. websites) to always include or exclude.
3. The destination of the collected information (e.g. email addresses of teaching staff).

Of course, LLMs can still try to infer them from the given unstructured data, but they must be presented to the user for her to decide and correct, because these configurations are strict and a little error will have great effects.

Another important output from unstructured configuration is the search prompts or insturctions generated by the LLMs. As this output direct controls the information retrieved. LLMs for this task will be specifically tuned to ensure

- Diversity of results.
- A specific distribution of results. E.g., a more authentic website will contribute relatively more information.

2.2.2 Multi-Source Search Integration

One problem of search engine APIs is that they have ungenerous search limits [13], allowing about 1000 queries per month, which is not enough for frequent testing and prototyping.

As a result, I plan to use some other self-developed system in parallel with search engines, which do only a small amount of tasks that truly require whole Internet searching. The majority of the searching will be handled by scraping a limited sets of websites, most likely.

2.2.3 Content Processing and Filtering

The filtering system could utilize content deduplication, relevance scoring, and source credibility assessment. The processing pipeline will need to handle various content formats including urls, texts, images, and videos.

2.2.4 Summarization tuning

Processed results will be summarized with business-focused prompting strategies. It is where the system will be seriously tuned to avoid hallucination and ensure the completeness of the summary.

2.2.5 Delivery and User Interface

Results shall be sent to users via configured methods, which may include email addresses or educational/collaboration online platforms. The delivery component shall handle different user preferences and ensure information is presented in a format suitable for educational use.

2.2.6 Feedback and Adaptation System

The system shall collect user feedback to improve future searches. This involves designing feedback mechanisms that capture both explicit user ratings and implicit behavioral signals. Possible algorithms include recommendation algorithms and other machine learning models.

2.3 Technical Considerations

The system will be a high-level program, which benefits from simple programming languages like Python. On the other hand, the system may have specific performance requirements, especially for LLMs and other machine learning algorithms. The likely result is then a combination of different programming languages and technical frameworks.

2.4 Evaluation and Validation

It may be desirable to develop an external evaluation framework for the system, if I have enough time in the end.

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