PDF Retrieval Assistant - NLP Project

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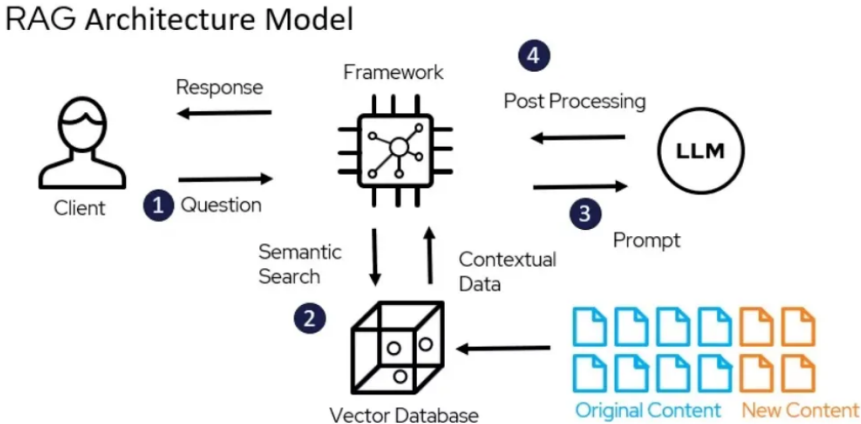
Introduction

Problem: Students often struggle to quickly retrieve relevant information from lecture presentations, leading to inefficient learning and preparation.
Solution: Develop a Retrieval-Augmented Generation (RAG) system based on lecture presentations from Warsaw University of Technology. This system will provide a fast, accurate, and user-friendly way to access key information from academic lectures.

RAG



RAG architecture [Source: medium.com/@bijit211987/designing-high-performing-rag-systems-464260b76815]

Methodology: Vector Store

- We implemented a Vector Store based on the FAISS (Facebook AI Similarity Search)
  - Efficient storing and retrieving high-dimensional vectors.
  - Handling large scale data retrieval at high speed.
- For the embedding we use **BAAI/bge-base-en** model with 768-dimensional embeddings.

Retrieval

- We retrieve documents using only dense approach.
- We use **IndexFlatL2** indexing, which measures the Euclidean distance between the query vector and all vectors loaded into the index.
- We retrieve two most relevant chunks (chunks with the lowest Euclidean distance).

Generator

- For answer generation we use **meta-llama/Llama-3.2-3B-Instruct** model with context window set to 4096.
- As context we provide the whole slide, related to the retrieved chunk.
- We set the max output length to 8192 tokens.
- We also set low temperature, to ensure higher predictability.

Dataset

Overview:

- Lecture materials in PDF format from Warsaw University of Technology.
- Represents domain-specific scenarios for academic and professional use.

Courses Covered:

- Big Data Analytics
- Fuzzy Reasoning
- Social Networks and Recommendation Systems
- Optimization in Data Analytics
- Deep Learning
- Data Storage in Big Data Systems
- Data Warehouses and BI Systems
- Data Transmission
- Databases
- Introduction to Machine Learning
- IT Systems Engineering
- Operating Systems in Data Engineering

Dataset: EDA

- 155 PDF files from courses at the WUT
- For each course about 13 lectures
- The number of pages vary from 6 to 98 pages
- On average 38 pages

Data Preprocessing

- Each PDF is **sliced into 1-page segments**:
  - Ensures efficient retrieval.
  - Allows granular control over data processing.
- Text is extracted from PDFs using python libraries.
- Extracted text is split into chunks of maximum size of 256 tokens. For chunking we use sentence splitter with 10% chunk overlap.

Model Evaluation

Evaluation Approach:

- We used **RAGAs** (Retrieval-Augmented Generation Assessment Suite) to guide the evaluation process.
- Key evaluation metrics include:
  - **Context Precision:** Measures the proportion of retrieved context that is relevant to the input query.
  - **Faithfulness:** Assesses whether the generated response is faithful to the retrieved context, i.e., whether the answer aligns with the provided evidence without introducing unsupported claims.
  - **Answer Relevancy:** Measures the relevance of the generated answer to the user's query, independent of the retrieved context.
  - **Context Recall:** Evaluates the extent to which the system retrieves all necessary information to generate a complete and accurate response.

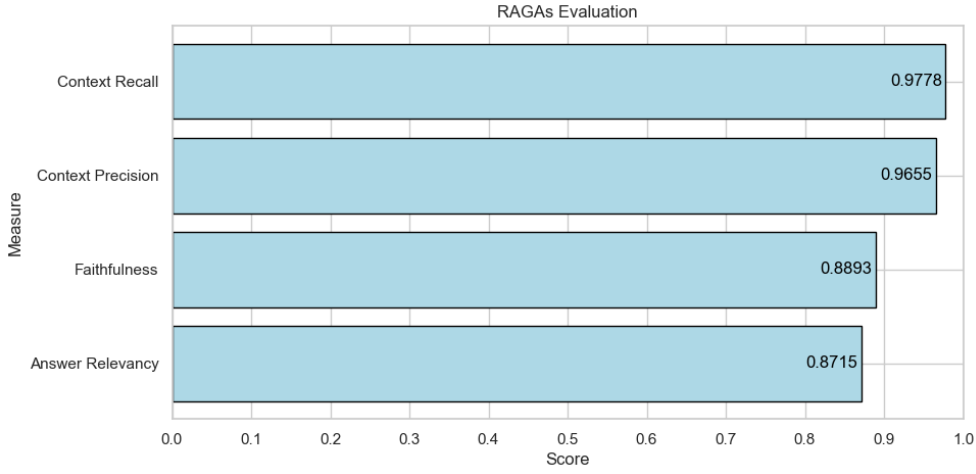
RAG Evaluation Dataset

Overview:

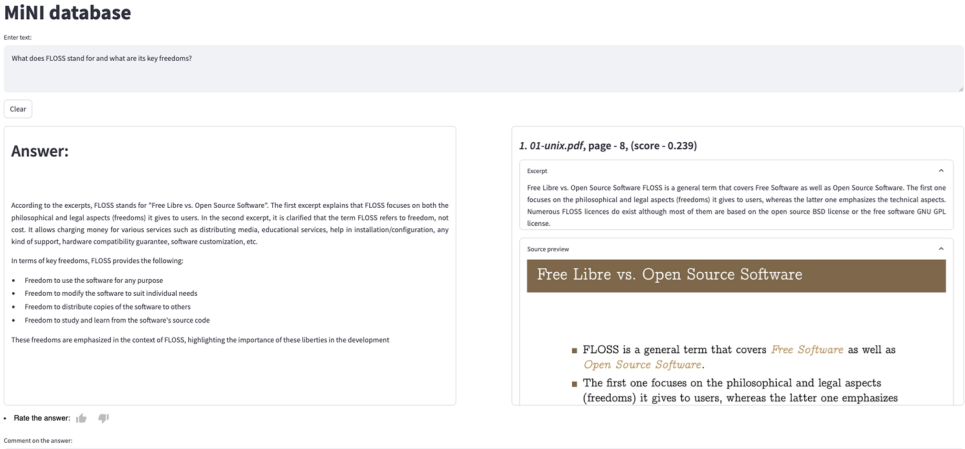
- The dataset consists of **125 questions** based on lecture content.
- Each question is paired with:
  - **Ground Truth:** Answers to asked questions obtained through ChatGPT and supervised by humans for high-quality reference.
  - **RAG System Responses:** Answers generated by the RAG system using the lecture data. These included the generated answers to users' queries and the retrieved content.
- The questions cover a wide range of topics from the lecture materials, ensuring diversity and thorough evaluation.

Evaluation results

For evaluating the RAGAs score we used the **llama3** model.



User Interface



Streamlit app view.

Conclusion

- Our system aims to efficiently help students query and navigate lecture materials.
- The system utilizes advanced Natural Language Processing techniques for semantic querying, embedding generation, and context-aware search.
- By integrating large language models (LLMs), such as `Llama 3.2`, the assistant can handle complex queries and provide relevant, targeted responses.
- We created a dataset, that might be useful for evaluating other NLP implementations on MINI lectures.
- The system has been evaluated using RAGAs to ensure its effectiveness in handling different lecture contexts and queries.
- The user interface has been built using Streamlit for easy and smooth interaction with the system.

Future works

- Fine-tune model based on users' feedback.
- Expand the dataset to include more diverse academic topics for broader applicability.
- Explore the integration of multimedia such as images in the retrieval system to provide richer responses.

Bibliography

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