

```
!pip install colab-xterm
```

```
Requirement already satisfied: colab-xterm in /usr/local/lib/python3.12/dist-packages (0.2.0)  
Requirement already satisfied: ptyprocess~=0.7.0 in /usr/local/lib/python3.12/dist-packages (from colab-xterm) (0.7.0)  
Requirement already satisfied: tornado>5.1 in /usr/local/lib/python3.12/dist-packages (from colab-xterm) (6.4.2)
```

```
%load_ext colabxterm
```

```
#curl https://ollama.ai/install.sh | sh  
#ollama serve  
#ollama run deepseek-r1:1.5b
```

```
The colabxterm extension is already loaded. To reload it, use:  
%reload_ext colabxterm
```

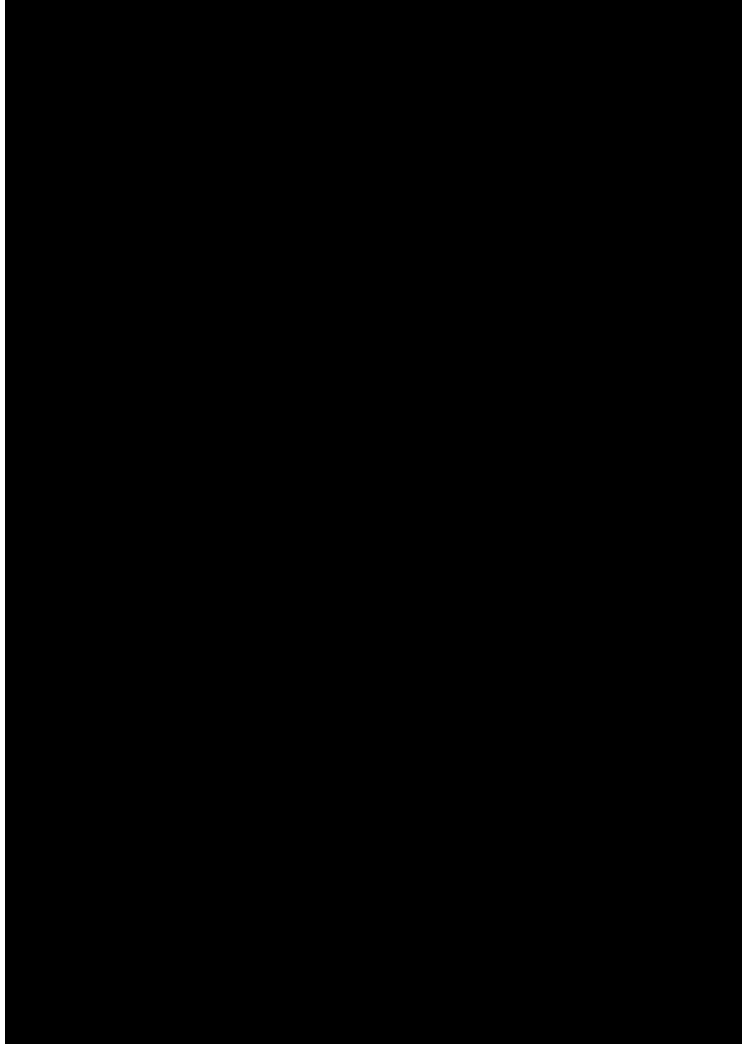
```
%xterm
```

```
Launching Xterm...
```



```
%xterm
```

Launching Xterm...



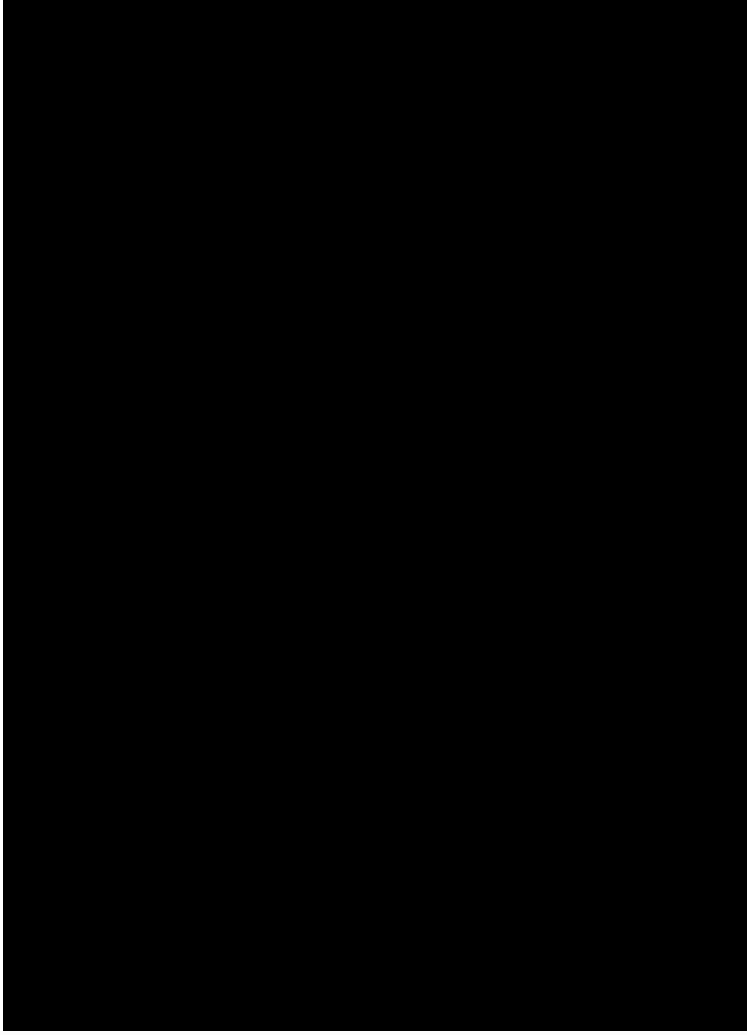
```
%xterm
```

Launching Xterm...



%xterm

Launching Xterm...



Double-click (or enter) to edit

```
! pip install langchain_community tiktoken langchain-openai langchainhub chromadb langchain
```

```
Requirement already satisfied: greenlet>=1 in /usr/local/lib/python3.12/dist-packages (from SQLAlchemy<3.0.0,>=1.4.0->langchain)
Requirement already satisfied: huggingface-hub<2.0,>=0.16.4 in /usr/local/lib/python3.12/dist-packages (from tokenizers>=0.13)
Requirement already satisfied: click>=8.0.0 in /usr/local/lib/python3.12/dist-packages (from typer>=0.9.0->chromadb) (8.3.0)
Requirement already satisfied: shellingham>=1.3.0 in /usr/local/lib/python3.12/dist-packages (from typer>=0.9.0->chromadb) (1)
Requirement already satisfied: httptools>=0.6.3 in /usr/local/lib/python3.12/dist-packages (from uvicorn[standard]>=0.18.3->chromadb)
Requirement already satisfied: uvloop>=0.15.1 in /usr/local/lib/python3.12/dist-packages (from uvicorn[standard]>=0.18.3->chromadb)
Requirement already satisfied: watchfiles>=0.13 in /usr/local/lib/python3.12/dist-packages (from uvicorn[standard]>=0.18.3->chromadb)
Requirement already satisfied: websockets>=10.4 in /usr/local/lib/python3.12/dist-packages (from uvicorn[standard]>=0.18.3->chromadb)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in /usr/local/lib/python3.12/dist-packages (from google-auth>=1.0.1->kubernetes)
Requirement already satisfied: pyasn1-modules>=0.2.1 in /usr/local/lib/python3.12/dist-packages (from google-auth>=1.0.1->kubernetes)
Requirement already satisfied: rsa<5,>=3.1.4 in /usr/local/lib/python3.12/dist-packages (from google-auth>=1.0.1->kubernetes)
Requirement already satisfied: filelock in /usr/local/lib/python3.12/dist-packages (from huggingface-hub<2.0,>=0.16.4->tokenizers)
Requirement already satisfied: fsspec>=2023.5.0 in /usr/local/lib/python3.12/dist-packages (from huggingface-hub<2.0,>=0.16.4->tokenizers)
Requirement already satisfied: hf-xet<2.0.0,>=1.1.3 in /usr/local/lib/python3.12/dist-packages (from huggingface-hub<2.0,>=0.16.4->tokenizers)
Requirement already satisfied: zipp>=3.20 in /usr/local/lib/python3.12/dist-packages (from importlib-metadata<8.0,>=6.0->opentelemetry)
Requirement already satisfied: jsonpointer>=1.9 in /usr/local/lib/python3.12/dist-packages (from jsonpatch<2.0.0,>=1.33.0->langchain)
Requirement already satisfied: mdurl<=0.1 in /usr/local/lib/python3.12/dist-packages (from markdown-it-py>=2.2.0->rich>=10.11)
Requirement already satisfied: mypy-extensions>=0.3.0 in /usr/local/lib/python3.12/dist-packages (from typing-inspect<1,>=0.4)
Requirement already satisfied: humanfriendly>=9.1 in /usr/local/lib/python3.12/dist-packages (from coloredlogs->onnxruntime)
Requirement already satisfied: oauthlib>=3.0.0 in /usr/local/lib/python3.12/dist-packages (from requests-oauthlib->kubernetes)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in /usr/local/lib/python3.12/dist-packages (from sympy->onnxruntime>=1.14.1)
Requirement already satisfied: pyasn1<0.7.0,>=0.6.1 in /usr/local/lib/python3.12/dist-packages (from pyasn1-modules>=0.2.1->google-auth)
```

```
!pip install rank_bm25 langchain_huggingface langchain_ollama
```

```
Requirement already satisfied: rank_bm25 in /usr/local/lib/python3.12/dist-packages (0.2.2)
Requirement already satisfied: langchain_huggingface in /usr/local/lib/python3.12/dist-packages (0.3.1)
Requirement already satisfied: langchain_ollama in /usr/local/lib/python3.12/dist-packages (0.3.10)
Requirement already satisfied: numpy in /usr/local/lib/python3.12/dist-packages (from rank_bm25) (2.0.2)
Requirement already satisfied: langchain-core<1.0.0,>=0.3.70 in /usr/local/lib/python3.12/dist-packages (from langchain_huggingface)
Requirement already satisfied: tokenizers>=0.19.1 in /usr/local/lib/python3.12/dist-packages (from langchain_huggingface) (0.20.1)
Requirement already satisfied: huggingface-hub>=0.33.4 in /usr/local/lib/python3.12/dist-packages (from langchain_huggingface)
Requirement already satisfied: ollama<1.0.0,>=0.5.3 in /usr/local/lib/python3.12/dist-packages (from langchain_ollama) (0.6.0)
Requirement already satisfied: filelock in /usr/local/lib/python3.12/dist-packages (from huggingface-hub>=0.33.4->langchain_huggingface)
Requirement already satisfied: fsspec>=2023.5.0 in /usr/local/lib/python3.12/dist-packages (from huggingface-hub>=0.33.4->langchain_huggingface)
Requirement already satisfied: packaging>=20.9 in /usr/local/lib/python3.12/dist-packages (from huggingface-hub>=0.33.4->langchain_huggingface)
Requirement already satisfied: pyyaml>=5.1 in /usr/local/lib/python3.12/dist-packages (from huggingface-hub>=0.33.4->langchain_huggingface)
Requirement already satisfied: requests in /usr/local/lib/python3.12/dist-packages (from huggingface-hub>=0.33.4->langchain_huggingface)
Requirement already satisfied: tqdm>=4.42.1 in /usr/local/lib/python3.12/dist-packages (from huggingface-hub>=0.33.4->langchain_huggingface)
Requirement already satisfied: typing-extensions>=3.7.4.3 in /usr/local/lib/python3.12/dist-packages (from huggingface-hub>=0.33.4->langchain_huggingface)
Requirement already satisfied: hf-xet<2.0.0,>=1.1.3 in /usr/local/lib/python3.12/dist-packages (from huggingface-hub>=0.33.4->langchain_huggingface)
Requirement already satisfied: langsmith<1.0.0,>=0.3.45 in /usr/local/lib/python3.12/dist-packages (from langchain-core<1.0.0,>=0.3.70->langchain_huggingface)
Requirement already satisfied: tenacity!=8.4.0,<10.0.0,>=8.1.0 in /usr/local/lib/python3.12/dist-packages (from langchain-core<1.0.0,>=0.3.70->langchain_huggingface)
Requirement already satisfied: jsonpatch<2.0.0,>=1.33.0 in /usr/local/lib/python3.12/dist-packages (from langchain-core<1.0.0,>=0.3.70->langchain_huggingface)
Requirement already satisfied: pydantic<3.0.0,>=2.7.4 in /usr/local/lib/python3.12/dist-packages (from langchain-core<1.0.0,>=0.3.70->langchain_huggingface)
Requirement already satisfied: httpx>=0.27 in /usr/local/lib/python3.12/dist-packages (from ollama<1.0.0,>=0.5.3->langchain_ollama)
Requirement already satisfied: anyio in /usr/local/lib/python3.12/dist-packages (from httpx>=0.27->ollama<1.0.0,>=0.5.3->langchain_ollama)
Requirement already satisfied: certifi in /usr/local/lib/python3.12/dist-packages (from httpx>=0.27->ollama<1.0.0,>=0.5.3->langchain_ollama)
Requirement already satisfied: httpcore==1.* in /usr/local/lib/python3.12/dist-packages (from httpx>=0.27->ollama<1.0.0,>=0.5.3->langchain_ollama)
Requirement already satisfied: idna in /usr/local/lib/python3.12/dist-packages (from httpx>=0.27->ollama<1.0.0,>=0.5.3->langchain_ollama)
Requirement already satisfied: h11>=0.16 in /usr/local/lib/python3.12/dist-packages (from httpcore==1.*->httpx>=0.27->ollama<1.0.0,>=0.5.3->langchain_ollama)
Requirement already satisfied: jsonpointer>=1.9 in /usr/local/lib/python3.12/dist-packages (from jsonpatch<2.0.0,>=1.33.0->langchain_huggingface)
Requirement already satisfied: orjson>=3.9.14 in /usr/local/lib/python3.12/dist-packages (from langsmith<1.0.0,>=0.3.45->langchain_huggingface)
Requirement already satisfied: requests-toolbelt>=1.0.0 in /usr/local/lib/python3.12/dist-packages (from langsmith<1.0.0,>=0.3.45->langchain_huggingface)
Requirement already satisfied: zstandard>=0.23.0 in /usr/local/lib/python3.12/dist-packages (from langsmith<1.0.0,>=0.3.45->langchain_huggingface)
Requirement already satisfied: annotated-types>=0.6.0 in /usr/local/lib/python3.12/dist-packages (from pydantic<3.0.0,>=2.7.4->langchain_huggingface)
Requirement already satisfied: pydantic-core==2.33.2 in /usr/local/lib/python3.12/dist-packages (from pydantic<3.0.0,>=2.7.4->langchain_huggingface)
Requirement already satisfied: typing-inspection>=0.4.0 in /usr/local/lib/python3.12/dist-packages (from pydantic<3.0.0,>=2.7.4->langchain_huggingface)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.12/dist-packages (from requests->huggingface-hub>=0.33.4->langchain_huggingface)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.12/dist-packages (from requests->huggingface-hub>=0.33.4->langchain_huggingface)
Requirement already satisfied: sniffio>=1.1 in /usr/local/lib/python3.12/dist-packages (from anyio->httpx>=0.27->ollama<1.0.0,>=0.5.3->langchain_ollama)
```

```
!apt-get update -q
!apt-get install -y mysql-server
!pip install mysql-connector-python
```

```
Hit:1 https://cloud.r-project.org/bin/linux/ubuntu jammy-cran40/ InRelease
Hit:2 https://cli.github.com/packages stable InRelease
Hit:3 https://developer.download.nvidia.com/compute/cuda/repos/ubuntu2204/x86\_64 InRelease
Hit:4 http://security.ubuntu.com/ubuntu jammy-security InRelease
Hit:5 http://archive.ubuntu.com/ubuntu jammy InRelease
Hit:6 https://r2u.stat.illinois.edu/ubuntu jammy InRelease
Hit:7 http://archive.ubuntu.com/ubuntu jammy-updates InRelease
Hit:8 http://archive.ubuntu.com/ubuntu jammy-backports InRelease
Hit:9 https://ppa.launchpadcontent.net/deadsnakes/ppa/ubuntu jammy InRelease
Hit:10 https://ppa.launchpadcontent.net/graphics-drivers/ppa/ubuntu jammy InRelease
Hit:11 https://ppa.launchpadcontent.net/ubuntugis/ppa/ubuntu jammy InRelease
Reading package lists...
W: Skipping acquire of configured file 'main/source/Sources' as repository 'https://r2u.stat.illinois.edu/ubuntu jammy InRelease' is not a file
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
mysql-server is already the newest version (8.0.43-0ubuntu0.22.04.2).
0 upgraded, 0 newly installed, 0 to remove and 40 not upgraded.
Requirement already satisfied: mysql-connector-python in /usr/local/lib/python3.12/dist-packages (9.4.0)
```

```
!pip install langchain_community
```

```
Requirement already satisfied: langchain_community in /usr/local/lib/python3.12/dist-packages (0.3.30)
Requirement already satisfied: langchain-core<2.0.0,>=0.3.75 in /usr/local/lib/python3.12/dist-packages (from langchain_community) (0.3.75)
Requirement already satisfied: langchain<2.0.0,>=0.3.27 in /usr/local/lib/python3.12/dist-packages (from langchain_community) (0.3.27)
Requirement already satisfied: SQLAlchemy<3.0.0,>=1.4.0 in /usr/local/lib/python3.12/dist-packages (from langchain_community) (2.0.36)
Requirement already satisfied: requests<3.0.0,>=2.32.5 in /usr/local/lib/python3.12/dist-packages (from langchain_community) (2.32.5)
Requirement already satisfied: PyYAML<7.0.0,>=5.3.0 in /usr/local/lib/python3.12/dist-packages (from langchain_community) (6.0.2)
Requirement already satisfied: aiohttp<4.0.0,>=3.8.3 in /usr/local/lib/python3.12/dist-packages (from langchain_community) (3.10.10)
Requirement already satisfied: tenacity!=8.4.0,<10.0.0,>=8.1.0 in /usr/local/lib/python3.12/dist-packages (from langchain_community) (9.0.0)
Requirement already satisfied: dataclasses-json<0.7.0,>=0.6.7 in /usr/local/lib/python3.12/dist-packages (from langchain_community) (0.6.7)
Requirement already satisfied: pydantic-settings<3.0.0,>=2.10.1 in /usr/local/lib/python3.12/dist-packages (from langchain_community) (2.10.1)
Requirement already satisfied: langsmith<1.0.0,>=0.1.125 in /usr/local/lib/python3.12/dist-packages (from langchain_community) (0.1.125)
Requirement already satisfied: httpx-sse<1.0.0,>=0.4.0 in /usr/local/lib/python3.12/dist-packages (from langchain_community) (0.4.0)
Requirement already satisfied: numpy>=1.26.2 in /usr/local/lib/python3.12/dist-packages (from langchain_community) (2.0.2)
Requirement already satisfied: aiohappyeyeballs>=2.5.0 in /usr/local/lib/python3.12/dist-packages (from aiohttp<4.0.0,>=3.8.3->langchain_community) (2.5.0)
Requirement already satisfied: aiosignal>=1.4.0 in /usr/local/lib/python3.12/dist-packages (from aiohttp<4.0.0,>=3.8.3->langchain_community) (1.4.0)
Requirement already satisfied: attrs>=17.3.0 in /usr/local/lib/python3.12/dist-packages (from aiohttp<4.0.0,>=3.8.3->langchain_community) (25.1.0)
Requirement already satisfied: frozenlist>=1.1.1 in /usr/local/lib/python3.12/dist-packages (from aiohttp<4.0.0,>=3.8.3->langchain_community) (1.5.0)
Requirement already satisfied: multidict<7.0,>=4.5 in /usr/local/lib/python3.12/dist-packages (from aiohttp<4.0.0,>=3.8.3->langchain_community) (6.4.0)
Requirement already satisfied: propcache>=0.2.0 in /usr/local/lib/python3.12/dist-packages (from aiohttp<4.0.0,>=3.8.3->langchain_community) (0.2.0)
Requirement already satisfied: yarl<2.0,>=1.17.0 in /usr/local/lib/python3.12/dist-packages (from aiohttp<4.0.0,>=3.8.3->langchain_community) (1.17.0)
Requirement already satisfied: marshmallow<4.0.0,>=3.18.0 in /usr/local/lib/python3.12/dist-packages (from dataclasses-json<0.7.0,>=0.6.7->langchain_community) (3.22.0)
Requirement already satisfied: typing-inspect<1,>=0.4.0 in /usr/local/lib/python3.12/dist-packages (from dataclasses-json<0.7.0,>=0.6.7->langchain_community) (0.9.0)
Requirement already satisfied: langchain-text-splitters<1.0.0,>=0.3.9 in /usr/local/lib/python3.12/dist-packages (from langchain_community) (0.3.9)
Requirement already satisfied: pydantic<3.0.0,>=2.7.4 in /usr/local/lib/python3.12/dist-packages (from langchain-core<2.0.0,>=0.3.75->langchain_community) (2.10.1)
Requirement already satisfied: jsonpatch<2.0.0,>=1.33.0 in /usr/local/lib/python3.12/dist-packages (from langchain-core<2.0.0,>=0.3.75->langchain_community) (1.33.0)
Requirement already satisfied: typing-extensions<5.0.0,>=4.7.0 in /usr/local/lib/python3.12/dist-packages (from langchain-core<2.0.0,>=0.3.75->langchain_community) (4.12.0)
Requirement already satisfied: packaging<26.0.0,>=23.2.0 in /usr/local/lib/python3.12/dist-packages (from langchain-core<2.0.0,>=0.3.75->langchain_community) (25.0)
Requirement already satisfied: httpx<1,>=0.23.0 in /usr/local/lib/python3.12/dist-packages (from langsmith<1.0.0,>=0.1.125->langchain_community) (0.27.0)
Requirement already satisfied: orjson>=3.9.14 in /usr/local/lib/python3.12/dist-packages (from langsmith<1.0.0,>=0.1.125->langchain_community) (3.10.14)
Requirement already satisfied: requests-toolbelt>=1.0.0 in /usr/local/lib/python3.12/dist-packages (from langsmith<1.0.0,>=0.1.125->langchain_community) (1.0.0)
Requirement already satisfied: zstandard>=0.23.0 in /usr/local/lib/python3.12/dist-packages (from langsmith<1.0.0,>=0.1.125->langchain_community) (0.23.0)
Requirement already satisfied: python-dotenv>=0.21.0 in /usr/local/lib/python3.12/dist-packages (from pydantic-settings<3.0.0,>=2.10.1->langchain_community) (0.21.0)
Requirement already satisfied: typing-inspection>=0.4.0 in /usr/local/lib/python3.12/dist-packages (from pydantic-settings<3.0.0,>=2.10.1->langchain_community) (0.4.0)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.12/dist-packages (from requests<3.0.0,>=2.32.5->langchain_community) (3.4.0)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.12/dist-packages (from requests<3.0.0,>=2.32.5->langchain_community) (3.10.1)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.12/dist-packages (from requests<3.0.0,>=2.32.5->langchain_community) (2.3.0)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.12/dist-packages (from requests<3.0.0,>=2.32.5->langchain_community) (2025.10.1)
Requirement already satisfied: greenlet>=1 in /usr/local/lib/python3.12/dist-packages (from SQLAlchemy<3.0.0,>=1.4.0->langchain_community) (3.1.1)
Requirement already satisfied: anyio in /usr/local/lib/python3.12/dist-packages (from httpx<1,>=0.23.0->langsmith<1.0.0,>=0.1.125->langchain_community) (4.7.0)
Requirement already satisfied: httpcore==1.* in /usr/local/lib/python3.12/dist-packages (from httpx<1,>=0.23.0->langsmith<1.0.0,>=0.1.125->langchain_community) (1.0.7)
Requirement already satisfied: h11>=0.16 in /usr/local/lib/python3.12/dist-packages (from httpcore==1.*->httpx<1,>=0.23.0->langsmith<1.0.0,>=0.1.125->langchain_community) (0.14.0)
Requirement already satisfied: jsonpointer>=1.9 in /usr/local/lib/python3.12/dist-packages (from jsonpatch<2.0.0,>=1.33.0->langchain_community) (3.0.0)
Requirement already satisfied: annotated-types>=0.6.0 in /usr/local/lib/python3.12/dist-packages (from pydantic<3.0.0,>=2.7.4->langchain_community) (0.7.0)
Requirement already satisfied: pydantic-core==2.33.2 in /usr/local/lib/python3.12/dist-packages (from pydantic<3.0.0,>=2.7.4->langchain_community) (2.33.2)
Requirement already satisfied: mypy-extensions>=0.3.0 in /usr/local/lib/python3.12/dist-packages (from typing-inspect<1,>=0.4.0->langchain_community) (1.0.0)
Requirement already satisfied: sniffio>=1.1 in /usr/local/lib/python3.12/dist-packages (from anyio->httpx<1,>=0.23.0->langsmith<1.0.0,>=0.1.125->langchain_community) (1.3.1)
```

```
!pip install faiss-cpu
```

```
Requirement already satisfied: faiss-cpu in /usr/local/lib/python3.12/dist-packages (1.12.0)
Requirement already satisfied: numpy<3.0,>=1.25.0 in /usr/local/lib/python3.12/dist-packages (from faiss-cpu) (2.0.2)
Requirement already satisfied: packaging in /usr/local/lib/python3.12/dist-packages (from faiss-cpu) (24.2)
```

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True)
```

```
!service mysql start
```

```
* Starting MySQL database server mysqld
...done.
```

```
!mysql -e "ALTER USER 'root'@'localhost' IDENTIFIED WITH mysql_native_password BY ''; FLUSH PRIVILEGES;"
```

```
!mysql -uroot -e "CREATE DATABASE coe_pdfs_1;"
```

```
ERROR 1007 (HY000) at line 1: Can't create database 'coe_pdfs_1'; database exists
```

```
!mysql -uroot coe_pdfs_1 < /content/drive/MyDrive/coe_pdfs_1_dump.sql
```

```
import mysql.connector
from langchain_core.documents import Document

# Fetch all Document Chunks from MySQL DB
def fetch_pdf_chunks(source="All"):
    all_documents = []

    conn = mysql.connector.connect(
        host="localhost"
```

```

conn = pymysql.connect(
    user="root",
    password="",
    auth_plugin='mysql_native_password',
    database="coe_pdfs_1"
)
cursor = conn.cursor(dictionary=True)

cursor.execute(
    "SELECT * FROM pdf_chunks WHERE source = %s OR %s = 'ALL' ORDER BY id",
    (source, source)
)
rows = cursor.fetchall()

for idx, row in enumerate(rows, start=1):
    content = row.pop("content", "")
    metadata = {**row, "chunk_order": idx}

    doc = Document(
        page_content=content,
        metadata=metadata
    )
    all_documents.append(doc)

cursor.close()
conn.close()
return all_documents

```

```

from langchain.docstore.document import Document
from typing import List
from rank_bm25 import BM25Okapi
import numpy as np
from langchain_community.vectorstores import FAISS
from langchain_huggingface import HuggingFaceEmbeddings
from langchain.schema.runnable import RunnableLambda

embedding_model = HuggingFaceEmbeddings(model_name="FacebookAI/xlm-roberta-base")
vectorstore = FAISS.load_local("/content/drive/MyDrive/faiss_index", embeddings=embedding_model, allow_dangerous_deserializat:

#Combines Semantic Search and Keyword Based search
def hybrid_retrieval(params, vectorstore=vectorstore, k=5, alpha=0.5):
    query = params["query"]
    source = params["source"]
    epsilon = 1e-8

    #Creates a BM25 index for key word based search
    documents = fetch_pdf_chunks(source)
    tokenized_docs = [doc.page_content.split() for doc in documents]
    bm25 = BM25Okapi(tokenized_docs)
    bm25_scores = bm25.get_scores(query.split())

    #Return semantic search with similarity search score and filter according to source
    all_docs = vectorstore.similarity_search("", k=vectorstore.index.ntotal)
    vector_results = vectorstore.similarity_search_with_score(
        query,
        k=len(all_docs),
        filter={"source": source} if source != "ALL" else None
    )

    doc_to_index = {doc.page_content: idx for idx, doc in enumerate(all_docs)}

    vector_indices = []
    vector_scores = []

    for doc, score in vector_results:
        if doc.page_content in doc_to_index:
            idx = doc_to_index[doc.page_content]
            vector_indices.append(idx)
            vector_scores.append(score)

    if len(vector_indices) == 0 and np.all(bm25_scores == 0):
        return []

    if len(vector_indices) == 0:
        top_bm25_indices = np.argsort(bm25_scores)[::-1][:k]
        return [all_docs[i] for i in top_bm25_indices]

    if np.all(bm25_scores == 0):
        return [all_docs[idx] for idx in vector_indices[:k]]

```

```

#Min-Max Normalization of both scores
vector_scores = np.array(vector_scores)
vector_scores = 1 - (vector_scores - np.min(vector_scores)) / (np.max(vector_scores) - np.min(vector_scores) + epsilon)
bm25_subset_scores = np.array([bm25_scores[i] for i in vector_indices])
bm25_subset_scores = (bm25_subset_scores - np.min(bm25_subset_scores)) / (np.max(bm25_subset_scores) - np.min(bm25_subset_scores))

#Combine the score and sort docs according to it
combined_scores = alpha * vector_scores + (1 - alpha) * bm25_subset_scores
sorted_indices = np.argsort(combined_scores)[::-1]
return [all_docs[vector_indices[i]] for i in sorted_indices[:k]]

hybrid_retrieval_runnable = RunnableLambda(hybrid_retrieval)

# query = "How much funding did VJTI receive under the TEQIP III project"

# # Perform fusion retrieval
# top_docs = fusion_retrieval(vectorstore, bm25, query, k=5, alpha=0.5)
# docs_content = [doc.page_content for doc in top_docs]
# print(f"{query}: {docs_content}")

```

WARNING:sentence_transformers.SentenceTransformer:No sentence-transformers model found with name FacebookAI/xlm-roberta-base. (

```

from langchain.prompts import ChatPromptTemplate
from langchain_core.output_parsers import StrOutputParser
from langchain_ollama import OllamaLLM
from langchain.load import dumps, loads

llm = OllamaLLM(model="deepseek-r1:1.5b", temperature=0)

template_1 = """You are a helpful assistant that generates multiple search queries based on a single input query. \n
Generate multiple search queries related to: {input} \n
Output (4 queries):"""
prompt_generate_queries= ChatPromptTemplate.from_template(template_1)

#Generate Queries based on the user input
generate_queries = (
    prompt_generate_queries
    | llm
    | StrOutputParser()
    | (lambda x: x.split("\n"))
)

#Rank the document chunk fetched based on thier frequency
def reciprocal_rank_fusion(results: list[list], k=50):
    fused_scores = {}

    for docs in results:
        for rank, doc in enumerate(docs):
            doc_str = dumps(doc)
            if doc_str not in fused_scores:
                fused_scores[doc_str] = 0

            previous_score = fused_scores[doc_str]
            fused_scores[doc_str] += 1 / (rank + k)

    reranked_results = [
        loads(doc)
        for doc, score in sorted(fused_scores.items(), key=lambda x: x[1], reverse=True)]
    return reranked_results

```

```

#Retrieve content for each generated query
retrieval_chain_rag_fusion = (
    generate_queries
    | (lambda queries: [{"query": q, "source": "ALL"} for q in queries])
    | hybrid_retrieval_runnable.map()
    | reciprocal_rank_fusion
)

```

```

from langchain.chains import create_history_aware_retriever
from operator import itemgetter
from langchain.schema.runnable import RunnableBranch
from langchain.prompts import ChatPromptTemplate, HumanMessagePromptTemplate, MessagesPlaceholder, SystemMessagePromptTemplate
from langchain_core.runnables import RunnableLambda

retriever_prompt = (
    """Consider the conversation so far and the latest user query. Rewrite the question so that it

```



```
        makes complete sense on its own, without relying on earlier messages. Do not attempt to answer it;
        just return the reformulated version."""
    )

    contextualize_q_prompt = ChatPromptTemplate.from_messages(
        [
            ("system", retriever_prompt),
            ("human", "{input}"),
        ]
    )

    #Combine the retriever with chat history
    history_retriever = create_history_aware_retriever(llm,retrieval_chain_rag_fusion, contextualize_q_prompt)
```

```
from langchain.chains import create_retrieval_chain
from langchain.chains.combine_documents import create_stuff_documents_chain

system_prompt = (
    """Answer the question based on the below context. If the answer is not present
    in the context simply return that you don't know.
    context: {context}"""
)

final_prompt = ChatPromptTemplate.from_messages(
    [
        ("system", system_prompt),
        MessagesPlaceholder("chat_history"),
    ]
)
```