CS-GY 6613 Final Project

- **Project Overview:**
  - Briefly introduce the concept of Retrieval Augmented Generation (RAG) systems.
  - Explain the core idea: combining retrieval-based and generation-based models to create a system that answers domain-specific questions using both large-scale information retrieval and language generation.
  - Outline the domain of your project: ROS2 robotics, navigation stack, and the various subdomains like ROS2 middleware, Nav2 navigation, motion planning, and simulation.
- **Objective:**
  - The goal of this project is to build a proof-of-concept (PoC) RAG system that can answer detailed questions related to ROS2 robotics subdomains using a mix of document retrieval and model-based text generation.
  - Mention that the report will focus on the milestones, challenges, architecture, and implementation of the system.

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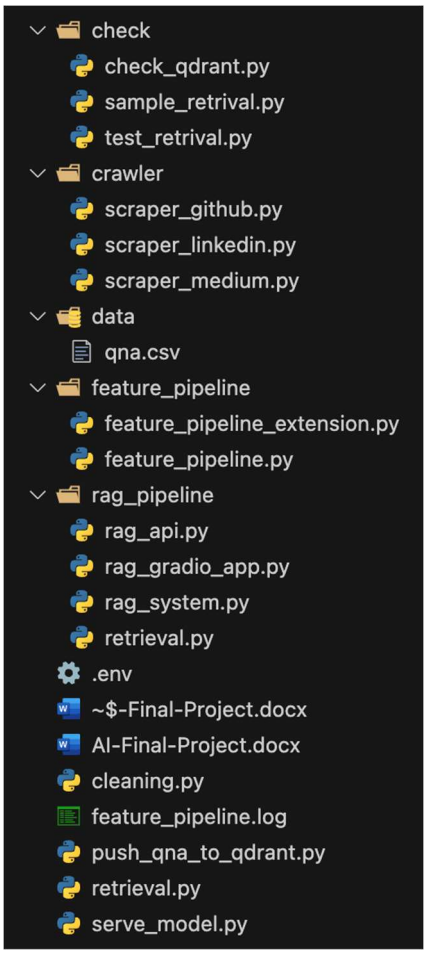
2. System Architecture

- **Structure:**



- **System Overview:**
  - Provide an overview of the architecture, explaining how different components interact to form the RAG system. Mention each major module:
    - **Crawler/Scraper**: Gathers raw data from GitHub repositories, Medium articles, and LinkedIn profiles related to ROS2 robotics.
    - **Cleaning**: Raw data is cleaned and stored in MongoDB.
    - **Featurization**: Converts the cleaned data into question-answer pairs stored in both MongoDB and Qdrant vector database.
    - **Check**: Checks Qdrant retrieval and connection.
    - **Serving Model**: The fine-tuned Hugging Face model is used to generate responses.
    - **Gradio App**: Allows users to interact with the system by selecting questions from a dropdown menu.
    - **ClearML**: Orchestrates and tracks experiments related to data ingestion and model training.
- **Flow of Data:**
  - Describe the data flow in the system starting from data scraping, cleaning, storing in MongoDB, converting to question-answer pairs, storing in Qdrant, model fine-tuning, and final serving via the Gradio app.
- **Components Diagram:**
  - Include a diagram of your system architecture (you can use the screenshot you attached earlier).

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3. Milestones & Deliverables

1. Environment and Tooling Milestone

- **Objective**: Set up a Docker Compose environment for the development of the RAG system.
- **Deliverables**:
  - Docker Compose file with containers for MongoDB, Qdrant, ClearML, and the app (PyTorch/TF models).
  - Screenshot showing all services running.
- **Setup Details**:
  - Explain how you configured the Docker setup for the necessary components and dependencies.

2. ETL Milestone

- **Objective**: Implement an ETL pipeline to ingest multiple media sources like GitHub repositories, YouTube videos, and Medium articles.
- **Details**:
  - Discuss the structure of your scrapers (e.g., `scraper_github`, `scraper_medium`, `scraper_linkedin`) and how they fetch data.
  - Describe the cleaning pipeline and how the raw data is stored in MongoDB.
  - Provide examples of scraped data and their storage format.

3. Featurization Pipeline Milestone

- **Objective**: Process raw data into question-answer pairs and store them in MongoDB and Qdrant.
- **Details**:
  - Describe how `feature_pipeline.py` and related scripts convert raw data into question-answer pairs.
  - Explain the usage of OpenAI API (if available) or fallback to manually created question-answer pairs stored in a `qna.csv` file.
  - Discuss how the featurized data is stored in MongoDB and pushed into the Qdrant vector database.

4. Fine-tuning Milestone

- **Objective**: Fine-tune a model for domain-specific question answering.
- **Details**:
  - Explain your approach to fine-tuning the Hugging Face model (based on GPT-2 or other base models).
  - If you didn't have access to OpenAI API, explain how you generated data for fine-tuning and used a self-made dataset.

5. Deploying the App Milestone

- **Objective**: Develop and deploy a Gradio app to allow users to interact with the RAG system.
- **Details**:
  - Describe the Gradio app's functionality, including the dropdown interface for users to select questions.
  - Explain how the app connects to the Qdrant vector database to retrieve the top 5 most similar question-answer pairs.
  - Describe how the fine-tuned model is used to generate a coherent and accurate answer.
- **Screenshots**: Provide screenshots of the Gradio app in action, showing the user interface and example interactions.

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4. Detailed Component Explanation

1. Crawler/Scraper Modules

- **Purpose**: Collect domain-specific data from external sources.
- **Components**: `scraper_github`, `scraper_medium`, `scraper_linkedin`.
- **Explanation**: Describe the functionality of each scraper module, the types of data collected, and how it's stored in MongoDB for further processing.

2. Data Cleaning Module (`cleaning.py`)

- **Purpose**: Clean and preprocess raw data before further usage.
- **Process**: Describe the data cleaning steps (e.g., removing irrelevant content, normalizing formats, handling missing data) and the final output that is stored in MongoDB.

3. Featurization Pipeline

- **Purpose**: Convert cleaned data into question-answer pairs suitable for the RAG model.
- **Process**: Describe how the featurization is done using OpenAI (if available) or manual data (from `qna.csv`), and how the question-answer pairs are stored in MongoDB and Qdrant.

4. Model Serving (`serve_model.py`)

- **Purpose**: Load and serve the fine-tuned model to answer user queries.
- **Details**: Explain how `serve_model.py` loads the fine-tuned Hugging Face model and uses it to generate answers based on the question retrieved from the Qdrant vector database.

5. Gradio App (`rag_pipeline/_gradio_app.py`)

- **Purpose**: Allow users to interact with the RAG system through a web interface.
- **Details**: Describe how the Gradio app works, including how it takes input from users, queries the Qdrant vector database, and uses the fine-tuned model to generate answers.

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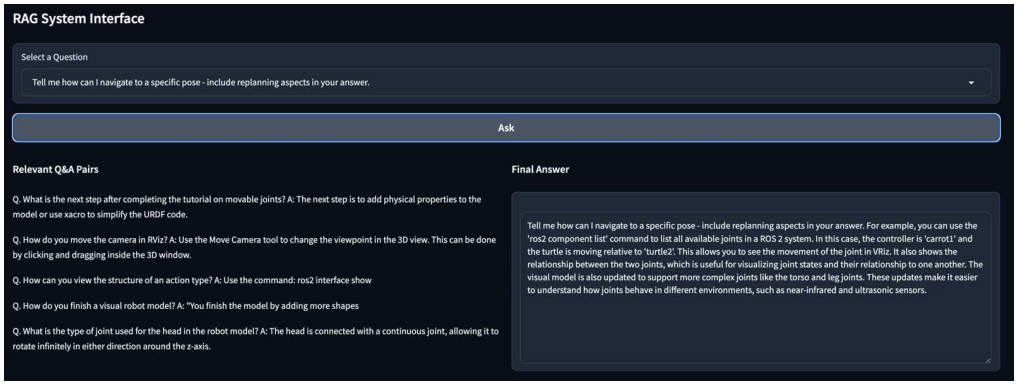
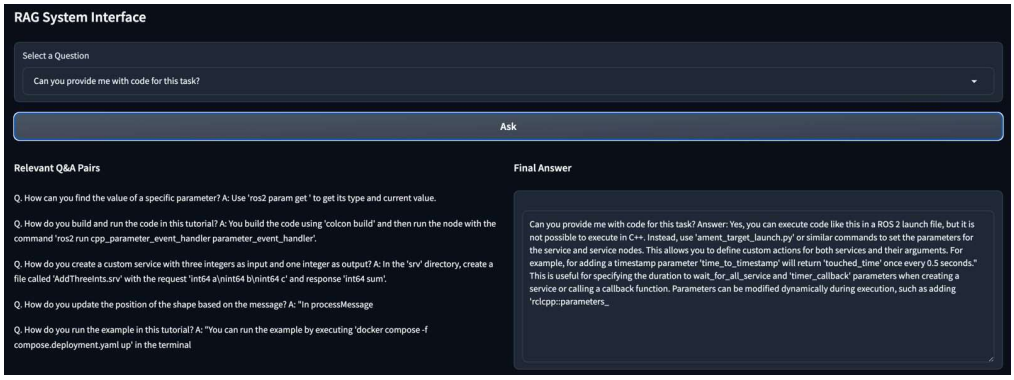
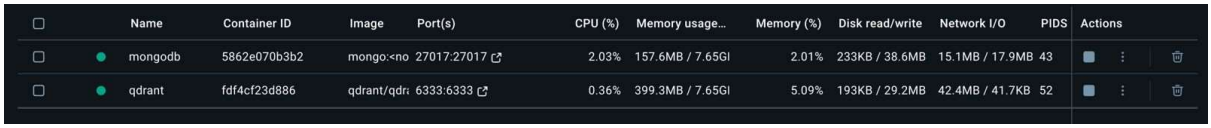
5. Results and Evaluation

Firstly, the output for the requested questions





Secondly, the docker containers for the Qdrant and MongoDB



	Name	Container ID	Image	Port(s)	CPU (%)	Memory usage...	Memory (%)	Disk read/write	Network I/O	PIDS	Actions
☐	mongodb	5862e070b3b2	mongo:<no	27017:27017	2.03%	157.6MB / 7.65GI	2.01%	233KB / 38.6MB	15.1MB / 17.9MB	43	
☐	qdrant	fdf4cf23d886	qdrant/qdr:	6333:6333	0.36%	399.3MB / 7.65GI	5.09%	193KB / 29.2MB	42.4MB / 41.7KB	52	

Thirdly, the python files hosting the model - serve_model.py

```
(Desktop/AI-FINAL) $ python3 serve_model.py
/Library/Frameworks/Python.framework/Versions/3.11/lib/python3.11/site-packages/bitsandbytes/cextension.py:34: UserWarning: The installed version of bitsandbytes was compiled without GPU support. 8-bit optimizers, 8-bit multiplication, and GPU quantization are unavailable.
  warn("The installed version of bitsandbytes was compiled without GPU support. "
'NoneType' object has no attribute 'cadam32bit_grad_fp32'
/Library/Frameworks/Python.framework/Versions/3.11/lib/python3.11/site-packages/peft/tuners/lora/layer.py:1264: UserWarning: fan_in_fan_out is set to False but the target module is `Conv1D`. Setting fan_in_fan_out to True.
  warnings.warn(
 * Serving Flask app 'serve_model'
 * Debug mode: off
INFO:werkzeug:WARNING: This is a development server. Do not use it in a production deployment. Use a production WSGI server instead.
 * Running on all addresses (0.0.0.0)
 * Running on http://127.0.0.1:5001
 * Running on http://192.168.1.234:5001
INFO:werkzeug:Press CTRL+C to quit
The attention mask and the pad token id were not set. As a consequence, you may observe unexpected behavior. Please pass your input's `attention_mask` to obtain reliable results.
Setting `pad_token_id` to `eos_token_id`:50256 for open-end generation.
The attention mask is not set and cannot be inferred from input because pad token is same as eos token. As a consequence, you may observe unexpected behavior. Please pass your input's `attention_mask` to obtain reliable results.
INFO:werkzeug:127.0.0.1 - - [08/Dec/2024 23:39:49] "POST /generate HTTP/1.1" 200 -
The attention mask and the pad token id were not set. As a consequence, you may observe unexpected behavior. Please pass your input's `attention_mask` to obtain reliable results.
Setting `pad_token_id` to `eos_token_id`:50256 for open-end generation.
INFO:werkzeug:127.0.0.1 - - [08/Dec/2024 23:40:22] "POST /generate HTTP/1.1" 200 -
The attention mask and the pad token id were not set. As a consequence, you may observe unexpected behavior. Please pass your input's `attention_mask` to obtain reliable results.
Setting `pad_token_id` to `eos_token_id`:50256 for open-end generation.
INFO:werkzeug:127.0.0.1 - - [08/Dec/2024 23:41:01] "POST /generate HTTP/1.1" 200 -
```

rag_api.py

```
(Desktop/AI-FINAL) $ python3 rag_pipeline/rag_api.py
INFO:sentence_transformers.SentenceTransformer:Use pytorch device_name: mps
INFO:sentence_transformers.SentenceTransformer:Load pretrained SentenceTransformer: sentence-transformers/all-MiniLM-L6-v2
DEBUG:urllib3.connectionpool:Starting new HTTPS connection (1): huggingface.co:443
DEBUG:urllib3.connectionpool:https://huggingface.co:443 "HEAD /sentence-transformers/all-MiniLM-L6-v2/resolve/main/modules.json HTTP/11" 200
 0
DEBUG:urllib3.connectionpool:https://huggingface.co:443 "HEAD /sentence-transformers/all-MiniLM-L6-v2/resolve/main/config_sentence_transform
ers.json HTTP/11" 200 0
DEBUG:urllib3.connectionpool:https://huggingface.co:443 "HEAD /sentence-transformers/all-MiniLM-L6-v2/resolve/main/README.md HTTP/11" 200 0
DEBUG:urllib3.connectionpool:https://huggingface.co:443 "HEAD /sentence-transformers/all-MiniLM-L6-v2/resolve/main/modules.json HTTP/11" 200
 0
DEBUG:urllib3.connectionpool:https://huggingface.co:443 "HEAD /sentence-transformers/all-MiniLM-L6-v2/resolve/main/sentence_bert_config.json
 HTTP/11" 200 0
DEBUG:urllib3.connectionpool:https://huggingface.co:443 "HEAD /sentence-transformers/all-MiniLM-L6-v2/resolve/main/adapter_config.json HTTP/
11" 404 0
DEBUG:urllib3.connectionpool:https://huggingface.co:443 "HEAD /sentence-transformers/all-MiniLM-L6-v2/resolve/main/config.json HTTP/11" 200
0
DEBUG:urllib3.connectionpool:https://huggingface.co:443 "HEAD /sentence-transformers/all-MiniLM-L6-v2/resolve/main/tokenizer_config.json HTT
P/11" 200 0
DEBUG:urllib3.connectionpool:https://huggingface.co:443 "GET /api/models/sentence-transformers/all-MiniLM-L6-v2/revision/main HTTP/11" 200 6
694
DEBUG:urllib3.connectionpool:https://huggingface.co:443 "GET /api/models/sentence-transformers/all-MiniLM-L6-v2 HTTP/11" 200 6694
DEBUG:httpx:load_ssl_context verify=True cert=None trust_env=True http2=False
DEBUG:httpx:load_verify_locations cafile='/Library/Frameworks/Python.framework/Versions/3.11/lib/python3.11/site-packages/certifi/cacert.pem
'
DEBUG:asyncio:Using selector: KqueueSelector
INFO:     Started server process [25224]
INFO:     Waiting for application startup.
INFO:     Application startup complete.
INFO:     Uvicorn running on http://0.0.0.0:8000 (Press CTRL+C to quit)
INFO:rag_system:Processing RAG for query: What is ROS2?
INFO:retrieval:Received query: What is ROS2?
Batches: 100%|                                                                                | 1/1 [00:00<00:00,  4.87it/s]
```

rag_gradio_app.py

```
(Desktop/AI-FINAL) $ python3 rag_pipeline/rag_gradio_app.py
ClearML Task: overwriting (reusing) task id=17b4b13b1f284a119fc7f7b91f4a554d
2024-12-08 23:37:54,407 - clearml.Task - INFO - No repository found, storing script code instead
ClearML results page: https://app.clear.ml/projects/1f34e7ce98b8473bad3ae2da928d667d/experiments/17b4b13b1f284a119fc7f7b91f4a554d/output/log
ClearML only supports '0.0.0.0:7860' as the Gradio server. Ignoring name and port '0.0.0.0:7860' in remote execution
Running on local URL:  http://0.0.0.0:7860

To create a public link, set `share=True` in `launch()`.
IMPORTANT: You are using gradio version 4.7.1, however version 4.44.1 is available, please upgrade.
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ClearML Monitor: GPU monitoring failed getting GPU reading, switching off GPU monitoring
Question asked: What is ROS2?
Q&A Pairs:

Final Answer:
I'm sorry, I couldn't generate an answer at this time.
Question asked: What is ROS2?
Q&A Pairs:
Q. What is ros2doctor?
A:  "ros2doctor is a diagnostic tool for ROS 2 that checks the system configuration and identifies issues with the ROS 2 installation or run
time environment."

Q. What is ros2_control?
A: ros2_control is a flexible framework for real-time control of robots implemented using ROS 2, enabling smooth integration and control of
hardware.

Q. What is a ROS 2 package?
A: A ROS 2 package is an organizational unit for your ROS 2 code that allows you to install, share, and easily build your code.

Q. What is a ROS 2 package?
A: An organizational unit for ROS 2 code, allowing it to be shared, installed, and easily used by others.

Q. What is the ros2 tool?
```

- **Evaluation of RAG System**:
    - Discuss how well the system performs in terms of answering domain-specific questions.
    - Include any evaluation metrics (e.g., accuracy, precision, recall, or qualitative evaluation).
    - Explain how you measure the utility and specificity of the answers provided by the system to ROS2 developers.
- **Challenges Faced**:
    - Discuss any technical challenges faced during the project (e.g., setting up Docker containers, fine-tuning the model, integration issues).
    - Mention the absence of OpenAI API key and how you worked around this limitation.

6. Conclusion and Future Work

- **Summary**: Summarize the work done and the overall success of building a RAG-based question-answering system for ROS2 robotics.
- **Future Enhancements**:
    - Suggest areas for future improvement, such as better fine-tuning of the model, additional data sources, or more refined question-answer pair generation.

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7. References

- Include any references to academic papers, documentation, or resources you used throughout the project (e.g., Hugging Face documentation, ROS2 tutorials, ClearML, etc.).

Appendices

- Include any relevant code snippets, configuration files, or additional screenshots that may help to clarify the report.

Member Details

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