CS791- Comprehensive viva

Multi-Agent System for Intelligent Query Processing

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Introduction

- **Overview**: A Python-based multi-agent system integrating weather, GitHub, Q&A, PDF querying, image analysis, and agentic RAG for intelligent, multi-domain query processing.

- **Key Features**:
  - Typo correction (e.g., "Ahmmedabad" → "Ahmedabad") using NVIDIA LLaMA-3
  - Asynchronous processing with asyncio for speed
  - Modular agents: WeatherAgent, GitHubAgent, QAAgent
  - Extensions: PDF Chatboard, Multi-Modal Image Analysis, Agentic RAG with evaluation.

- **Objective**: Deliver scalable, accurate, user-friendly query resolution.

- **Scope**: Leverages NVIDIA, Gemini, WeatherAPI, and GitHub API in Google Colab

Problem Definition

- **Given**: Diverse user queries across domains (weather, repositories, general knowledge, documents, images)
- **Objective**: Provide structured, efficient responses with minimal user effort
- **Challenges**:
  - **Varied Query Styles**: Inconsistent inputs (e.g., "Patan temp" vs. "weather in Patan")
  - **API Restrictions**: Rate limits and potential failures
  - **Scalability**: Handle multiple simultaneous queries quickly
  - **Accuracy**: Correct typos and resolve ambiguous inputs
- **Goal**: Build an AI-driven, typo-correcting, scalable query processing system

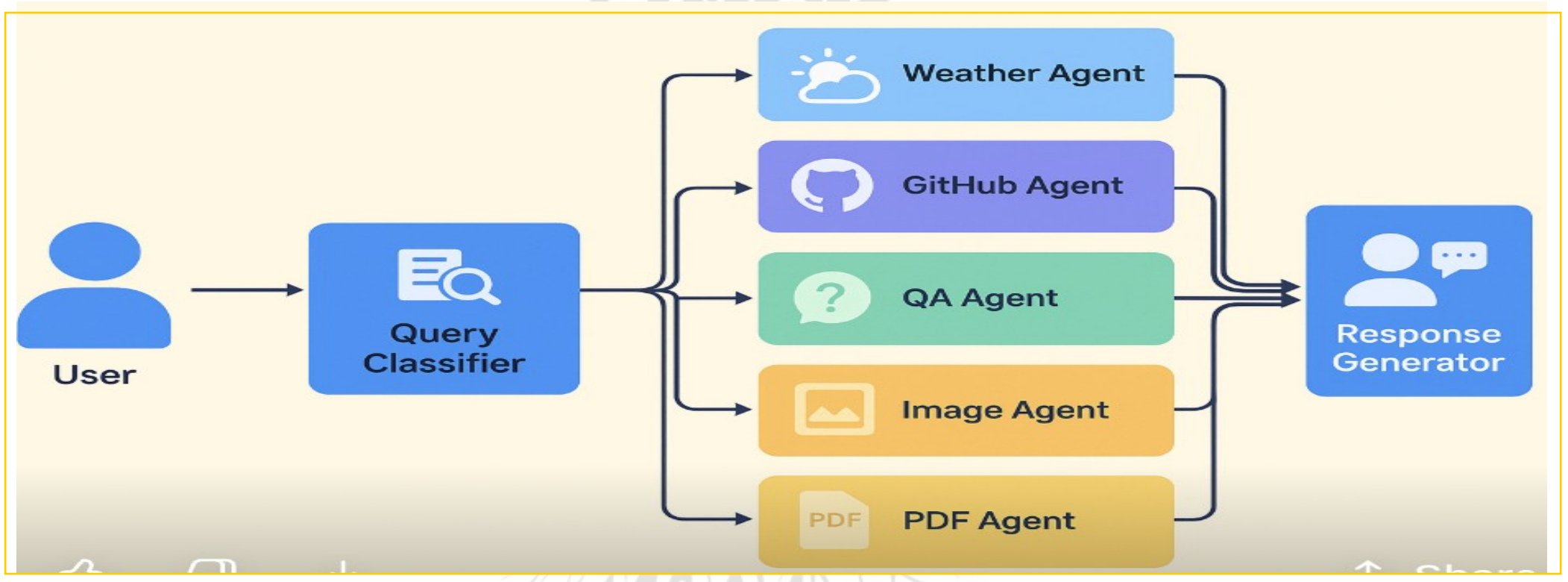
Motivation

- **Why It Matters**: Fast, accurate information access is critical for decision-making in education, software development, and daily planning

- **Real-World Impact**:
  - **Software Development**: Quick GitHub repo insights for collaboration
  - **Education**: Reliable answers for students and researchers
  - **Daily Use**: Real-time weather for planning (e.g., city storm response)

- **Benefits**:
  - Modularity: Easy to add new agents
  - Efficiency: Async processing and caching
  - User-Friendly: Typo correction and suggestions
  - Extensibility: Supports new APIs and tasks

WorkFlow Diagram



Implementation Details

- **Environment**: Google Colab, Python 3.10+, asyncio for asynchronous processing.

- **Key Libraries**:
  Core: langchain, langgraph, faiss-cpu, ragas, PyPDF2, google-generativeai.
  Support: requests, beautifulsoup4, pillow, pydantic, nest_asyncio, backoff.

- **Techniques**:
  Async I/O for parallel query handling.
  FAISS vector store for efficient retrieval.
  Pickle-based caching for API call reduction.
  Backoff retries for robust API interactions.

- **Key Functions**:
  correct_spelling(): Typo correction via NVIDIA LLaMA-3.
  process_query(): Agent-specific logic.
  main(): Async console interface.

PDF Chatboard Extension

- **What**: Console-based tool for uploading and querying PDFs.
- **Why**: Enables document-specific Q&A for research and education
- **How**:
  - Uploads PDFs via google.colab.files
  - Extracts text with PyPDF2 and cleans using regex
  - Answers queries with NVIDIA LLaMA-3.1-8B-Instruct via OpenAI SDK.
- **Key Functions**:
  - save_pdf_to_local(): Saves uploaded PDFs
  - extract_text_from_pdf(): Processes text
  - generate_answer(): Delivers concise responses (1-2 sentences)
- **Example**: Query “What is NLP?” on a PDF yields concise answer

PDF Chatboard Output

```
Your query: what is svm , give me ans from svm.pdf
I believe you meant: 'What is SVM? Give me an answer from SVM.pdf'

================================================================================
📋 Answer (Source: PDF Chatboard (RAG on SVM.pdf)):
================================================================================
Here is a concise answer:

SVM stands for Support Vector Machines, which is a binary classification technique that aims to maximize the margin between two classes by finding the optimal hyper
================================================================================

Your query: temp of patan, gujarat
```

Your query: what is svm , give me ans from svm.pdf I believe you meant: 'What is SVM? Give me an answer from SVM.pdf'

==========

📋

Answer (Source: PDF Chatboard (RAG on SVM.pdf)):

==========

Here **is a concise answer:** SVM stands for Support Vector Machines, which is a binary classification technique that aims to maximize the margin between two classes by finding the optimal hyperplane that separates them. The SVM decision function can also be represented as a linear programming problem, allowing for the generalization of the optimization problem to multi-class classification.

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Multi-Modal

- **What**: Analyzes .jpg/.png images using Gemini 2.5 Flash or local fallback
- **Why**: Provides structured visual analysis for diverse applications
- **How**:
  - Uploads images via google.colab.files
  - Gemini API for detailed analysis (scene, objects, colors, environment)
  - Local PIL-based fallback for API failures (metadata analysis)
- **Key Functions**:
  - VisionAnalyzer.setup_gemini(): Initializes Gemini model
  - gemini_vision_analysis(): Structured image analysis
  - advanced_local_vision(): Fallback for offline processing

Multi-Modal Output

Your query: how may boats in image_trial.png?

🔍 Analyzing image_trial.png...

==========

📋 Answer (Source: GEMINI 2.5 VISION ANALYSIS):

==========

There are **2** boats visible in the image.

IIITV & IIITV-ICD

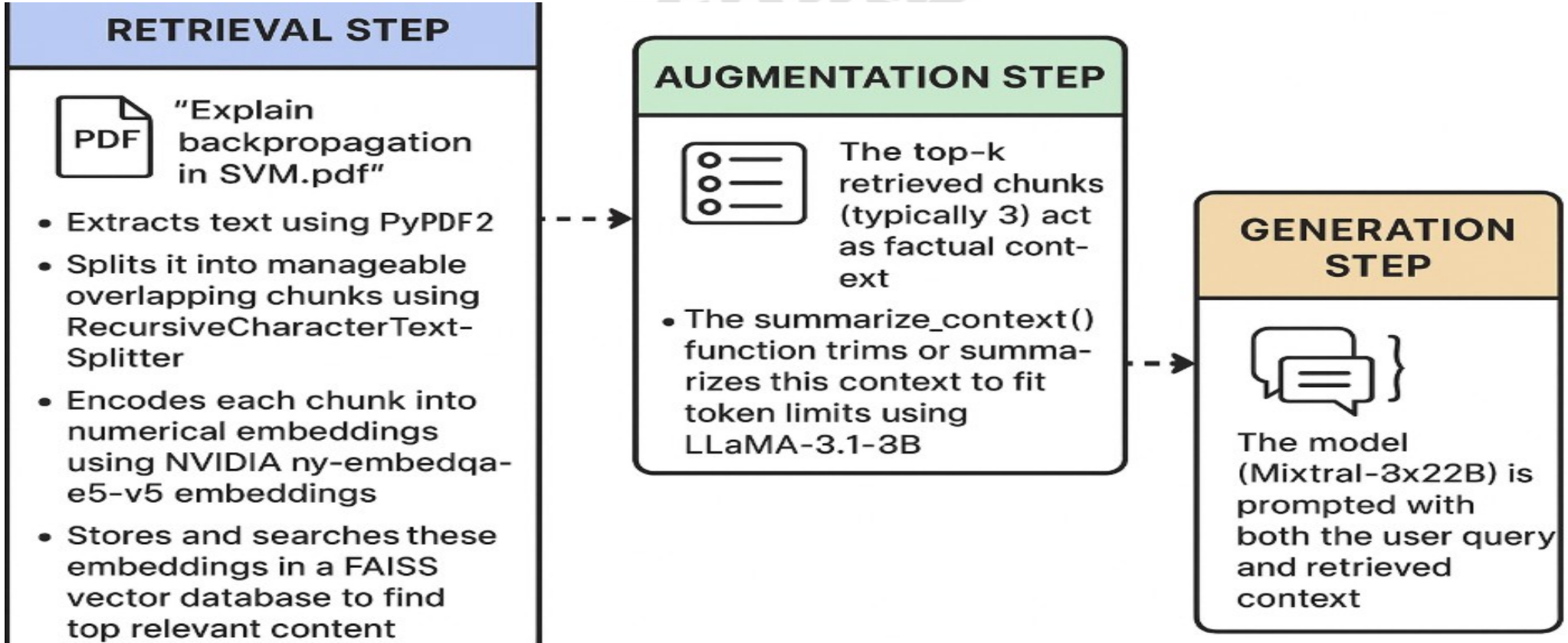
Agentic RAG

- **What**: Retrieval-Augmented Generation with evaluation
- **Why**: Enhances Q&A with context-aware, evaluated responses

How RAG Works

- **Retrieval Step**:
  When a user queries a PDF (e.g., *"Explain backpropagation in SVM.pdf"*), the system:
  - Extracts text using PyPDF2.
  - Splits it into manageable overlapping chunks using RecursiveCharacterTextSplitter.
  - Encodes each chunk into numerical embeddings using NVIDIA nv-embedqa-e5-v5 embeddings.
  - Stores and searches these embeddings in a FAISS vector database to find top relevant content.
- **Augmentation Step**:
  - The top-k retrieved chunks (typically 3) act as factual context.
  - The summarize_context() function trims or summarizes this context to fit token limits using LLaMA-3.1-8B.
- **Generation Step**:
  - The model (Mixtral-8x22B) is prompted with both the *user query* and *retrieved context*.
  - It produces an informed, concise answer consistent with the underlying document

Agentic RAG Wrok_flow



APIs

API	Source	Data Provided
WeatherAPI	weatherapi.com	Temperature, humidity, wind (JSON)
GitHub API	github.com	Repository metadata (stars, language)
NVIDIA API	integrate.api.nvidia.com	Query processing and response generation
Google Gemini API	genai.googleapis.com	Multi-modal image Analysis

Challenges and Solutions

- **Challenges**:
  - **API Rate Limits**: Frequent API calls lead to throttling
  - **Typo Handling**: Misspelled queries (e.g., "Mehasana" vs. "Mehsana")
  - **Async Complexity**: Managing concurrent tasks in Colab
  - **Data Scalability**: Processing large PDFs or image datasets

- **Solutions**:
  - **Caching**: Pickle-based response caching to reduce API calls
  - **Typo Correction**: NVIDIA LLaMA-3 for spelling fixes
  - **Asyncio**: Parallel query processing with nest_asyncio
  - **Modular Design**: FAISS and LangGraph for scalable retrieval

Results

- **Efficiency**: Python's asyncio saving time and resources for all queries.
- **Speed**: Delivers fast responses using asynchronous processing, ensuring quick results for any task.
- **Accuracy**: Achieves high reliability, with the Weather Agent being more accurate for cities worldwide.
- **Smart Correction**: Using Pre_train(LLaMA-3) model's API calls to fixes typos (e.g., "temp" to "temperature") to improve results for any query.
- Evaluation Results: {'faithfulness': 0.8333, 'answer_relevancy': 0.4270, 'context_precision': 0.6667, 'context_recall': 0.4444, 'answer_correctness': 0.7224}

```
Multi-Agent System Ready (Efficient Edition). Enter your query (e.g., 'weather in London', 'temp of Ahmedabad', GitHub URL, or any question):
Your query: weather in patan
I believe you meant: 'weather in Patan'
Multiple matches; using Patan, Gujarat, India. Alternatives: Patan, Gujarat, Patancan, Veracruz-Llave
The weather in Patan, Gujarat, India is Light rain shower with a temperature of 25.3°C (feels like 28.0°C). Humidity: 87%, Wind: 22.0 kph. (Updated: 2025-10-01 08:30)
Your query: temp of gandhinagar
I believe you meant: 'temperature of Gandhinagar'
The weather in Gandhinagar, Gujarat, India is Mist with a temperature of 24.4°C (feels like 26.8°C). Humidity: 83%, Wind: 20.9 kph. (Updated: 2025-10-01 08:30)
Your query: quit
Exiting. Goodbye!
```

Conclusion

- **Key Achievements**:
  - Integrated WeatherAPI, GitHub API, NVIDIA API, and Gemini API
  - Scalable multi-agent system with typo correction and async processing
  - Extended with PDF querying, image analysis, and evaluated RAG
- **Impact**:
  - Enhances real-time access for education, development, and planning
  - Demonstrates robust, modular AI system design
- **Takeaway**: Unified platform for intelligent, multi-domain query processing

Future Work

- **Additional Agents**:
  - Stock market data retrieval (real-time stock prices)
  - News summary agent for current events
- **Actionable Agents**:
  - Tasks like sending emails or updating databases
  - Example: Weather-based appointment booking.

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Thank You!