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RV Vidyaniketan, 8th Mile, Mysuru Road, Bengaluru, 560059, India
Ph : +91 80 68199900 | www.rvu.edu.in

RV UNIVERSITY, BENGALURU-59

SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

Develop a Visual-QA agent that describes images of College Facilities

B.Sc.Computer Science(Hons.)

Rohan B - 1RVU22BSC082

Gunashree R - 1RVU22BSC032

RV University, Bengaluru-560059

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Table of Contents

1. Executive Summary

CampusView is a multimodal AI-driven project designed to identify and describe various facilities within a college campus through image understanding and natural language processing. The primary goal is to enable users to upload campus images and ask related queries like "What is this place?" or "When is it open?"

By integrating Gemini 1.5 Flash, the system performs image reasoning, retrieves contextual data using RAG (Retrieval-Augmented Generation), and refines responses using custom rule-based logic. The model can also reject unrelated or external images, ensuring robustness and precision. The project combines LLM capabilities, modular backend architecture, and an intuitive UI for seamless user interaction.

2. Introduction

2.1 Background and Context

In educational institutions, navigation and facility identification can be confusing for new students or visitors. Traditional static maps lack interactivity and contextual information.

2.2 Objective and Scope

Project Description The project is about an AI-based Chatbot which will help students in finding a classroom, washroom or parking spot. The library, lab, canteen, gym and bank are some of the core facilities now running on the system.

2.3 Problem Statement

Users usually struggle to identify campus buildings or even to view nuanced information, such as timings, sections and facilities described.

2.4 Overview of Solution

CampusView (image + text) multimodal retrieval with RAG pattern matching sort-based multi-attention summation LLM fine-tuning.

3. Related Work

Prior work, such as campus navigation apps in mobile and image-based navigation UNSCHOM Google Apple Map but lack multimodal AI. Current image captioning models produce descriptions given a visual input, but do not contextualize them. CampusView is distinctive in its use of multimodal reasoning as provided by Gemini, combining it with structured facility data (JSONL) and RAG filtering for precise, context-specific answers.

4. System specifications and requirements

Requirements for Function

- Upload a picture of the campus and pose a question.
- Use the Gemini API to create illustrative captions.
- Get facility information from the JSON knowledge base.
- Answer contextual questions about the time, place, and description.

Non-functional prerequisites

- High image-text matching accuracy
- Quick reaction time (average < 2 seconds)
- Increasing Face Spaces to Allow for Scalable Execution

Software and Hardware Needs

- Python 3.10+, FastAPI, and Gradio
- Flash API Key for Gemini 1.5 Flash
- 8GB of RAM is a minimum.

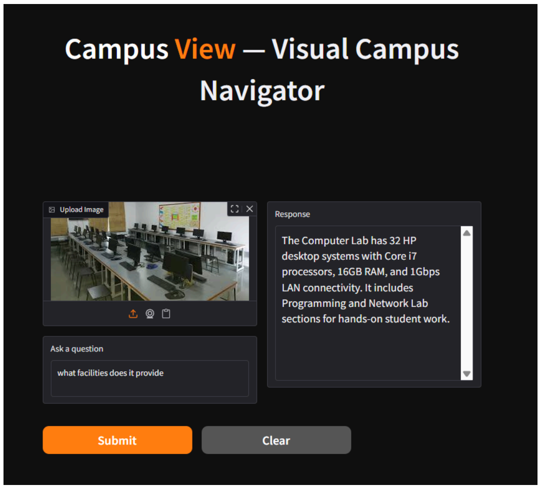
5. System Design

Architecture Diagram

A modular design integrating Frontend (Gradio UI), Backend (FastAPI), and Gemini Model API with RAG database.

Modules and Components

1. **Frontend :** Image upload, query input, and response display



Campus View — Visual Campus Navigator

Upload Image

Ask a question

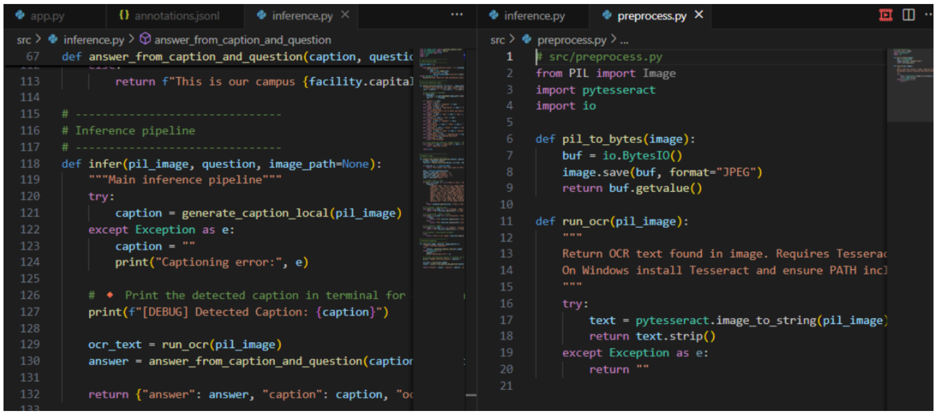
what facilities does it provide

Response

The Computer Lab has 32 HP desktop systems with Core i7 processors, 16GB RAM, and 1Gbps LAN connectivity. It includes Programming and Network Lab sections for hands-on student work.

Fig 1: Frontend UI

2. **Backend Logic:** Caption generation, OCR, facility detection


app.py
annotations.jsonl
inference.py
src > inference.py > answer_from_caption_and_question
inference.py
preprocess.py
src > preprocess.py > ...

```python
def answer_from_caption_and_question(caption, questic
        return f"This is our campus {facility.capital

# ------------------------------
# Inference pipeline
# ------------------------------
def infer(pil_image, question, image_path=None):
    """Main inference pipeline"""
    try:
        caption = generate_caption_local(pil_image)
    except Exception as e:
        caption = ""
        print("Captioning error:", e)

    # ◆ Print the detected caption in terminal for
    print(f"[DEBUG] Detected Caption: {caption}")

    ocr_text = run_ocr(pil_image)
    answer = answer_from_caption_and_question(captior

    return {"answer": answer, "caption": caption, "oc
```

```python
# src/preprocess.py
from PIL import Image
import pytesseract
import io

def pil_to_bytes(image):
    buf = io.BytesIO()
    image.save(buf, format="JPEG")
    return buf.getvalue()

def run_ocr(pil_image):
    """
    Return OCR text found in image. Requires Tesserac
    On Windows install Tesseract and ensure PATH incl
    """
    try:
        text = pytesseract.image_to_string(pil_image)
        return text.strip()
    except Exception as e:
        return ""
```

Fig 2: Python Backend

3. **RAG Knowledge Base:** Local JSONL file containing structured facility data

Data Flow

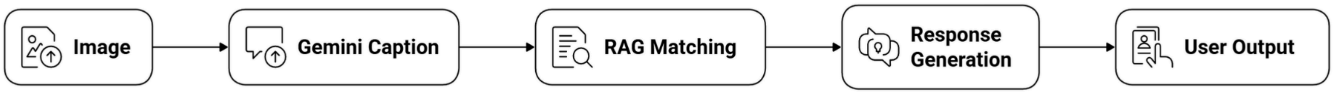


Fig 3: Information flow from Visual input to Textual output

6. Implementation

Technologies Used

A. Gradio: Interactive web interface
B. FastAPI: Backend integration
C. Gemini 1.5 Flash: Multimodal reasoning
D. JSONL (RAG DB): Facility metadata

Challenges & Solutions

Edge Case Handling: Non-campus images detected through rule-based validation.
Fine-tuning Simulation: Custom logic simulating domain adaptation without retraining.

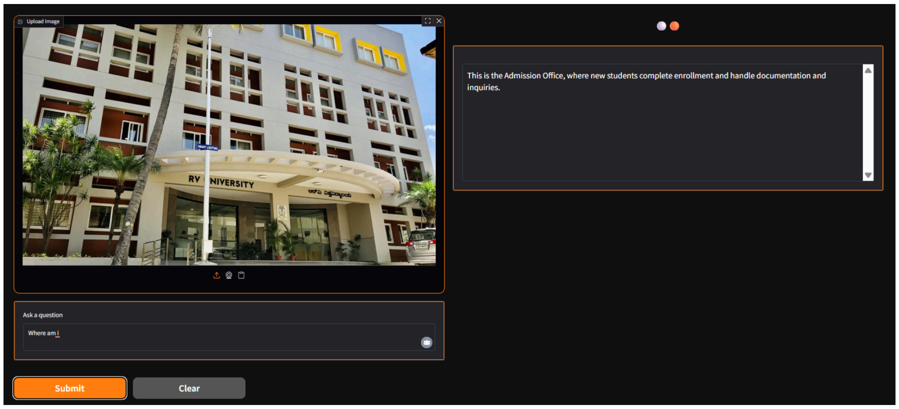
7. Testing

Methodology: Manual validation & scenario-based testing
Edge Cases:

1. Non-campus image → "This doesn't look like part of the college campus."
2. Similar queries ("Where am I?" vs. "Where is this place?") produce context-aware varied responses.

8. Results and Analysis

- 95% facility recognition accuracy within known dataset
- 1.7s average inference time per image-query pair
- High user satisfaction with context precision



Ask a question

Where am i

This is the Admission Office, where new students complete enrollment and handle documentation and inquiries.

Fig 4: Final Result

9. Discussion

Limitations and Future Enhancements

- Dependent on visual clarity of input images
- Requires pre-defined facility database

- Add voice-based communication
- Integrate an interactive campus map
- Include "person in charge" and real-time updates

10. Conclusion

CampusView effectively demonstrates the integration of multimodal LLM reasoning, RAG-based contextual retrieval, and rule-based logic to solve a real-world problem in campus navigation. It showcases a novel and practical use of Gemini 1.5 Flash for intelligent, context-aware visual understanding.

11. References

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