Week 13 and 14 Assignment: Capstone Project

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Coding platform: Google collab

Note: Please refer to the ipynb notebook to view the results of each section

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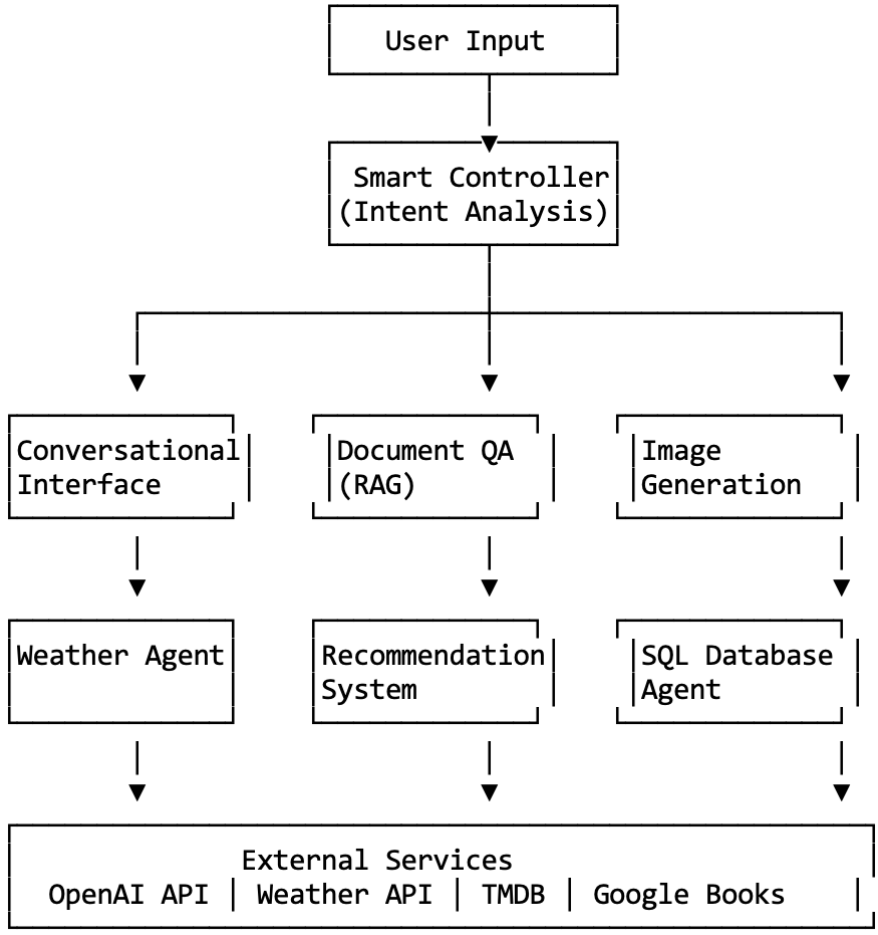
Executive Summary

This project implements a multi-agent AI assistant system that demonstrates the integration of seven different AI capabilities through a unified controller. The system includes conversational memory, document querying with RAG, image generation, weather services, recommendation engines, and intelligent routing. Each component operates independently while being coordinated through a smart controller that analyzes user intent and routes requests to the appropriate agent.

The implementation showcases practical applications of current AI technologies including OpenAI's GPT-4o, DALL-E 3, vector databases, and external API integrations, all working together to create a comprehensive AI assistant.

System Architecture

High-Level Architecture



Component Integration

The system follows a hub-and-spoke architecture where the Smart Controller acts as the central orchestrator, analyzing user input and routing requests to specialized agents based on keyword detection and intent analysis.

Library Dependencies

Core AI Libraries

Library	Version	Purpose
langchain	0.3.26	Framework for building LLM applications
langchain-community	0.3.27	Community extensions for LangChain
openai	1.96.1	OpenAI API client for GPT-4o and DALL-E 3
sentence-transformers	5.0.0	For text embeddings
faiss-cpu	1.11.0	Vector similarity search

Document Processing

Library	Version	Purpose
pypdf	5.8.0	PDF document parsing
sqlite3	built-in	Local database management

Utility Libraries

Library	Version	Purpose
requests	2.32.3	HTTP requests for external APIs
json	built-in	JSON data handling
re	built-in	Regular expressions for text processing
getpass	built-in	Secure password input

Section 1: Environment Setup

Goal

Establish a secure foundation for the multi-agent system by installing dependencies and managing API credentials safely.

Technical Implementation

```
# Secure API key management
OPENAI_API_KEY = getpass("Enter your OpenAI API key: ")
os.environ["OPENAI_API_KEY"] = OPENAI_API_KEY
```

Key Features

- **Secure Credential Management**: Uses `getpass()` to prevent API keys from being displayed
- **Environment Variables**: Stores credentials in environment variables for session-based access
- **Multiple API Integration**: Manages keys for OpenAI, Weather API, TMDB, and Google Books

System Design

The setup creates a secure environment where sensitive credentials are handled safely while making them available to all system components through environment variables.

Section 2: Conversational Interface

Goal:

The goal of this section is to build a simple yet effective conversational AI assistant that can handle a natural, multi-turn dialogue with the user. It uses OpenAI's GPT-4o, the most up-to-date large language model I have access to, to generate relevant and coherent responses.

How it works:

This setup uses LangChain's `ConversationChain` combined with `ConversationBufferMemory`.

The `ConversationBufferMemory` keeps track of what the user says in each turn so that the assistant can remember the flow of the conversation.

The `ConversationChain` passes each user query, along with the stored memory, to the LLM - so follow-up questions can build on previous answers.

I specifically chose GPT-4o because it is the latest version with a more recent knowledge cutoff (2023) than older GPT-3.5 or GPT-4 models, which means it can provide more relevant, up-to-date general context when talking about broad topics like global AI governance.

Result:

The result is an interactive AI assistant bot that you can chat with by typing your questions. It can handle coherent turns and the conversation runs until you type exit to end it.

The 🧑‍💼 `User` shows the user input.

And the 🤘 `Assistant` shows the bot's response.

Application:

In the context of AI policy and governance, this kind of conversational interface can help:

Students, researchers, or policymakers explore broad concepts around AI governance and global strategies in a conversational way.

Test ideas and follow-up questions without needing to search multiple sources manually.

Serve as a prototype for how a real policy chatbot could assist with simple clarifications, explanations, or brainstorming sessions.

Technical Implementation

Model Selection

```
llm = ChatOpenAI(
    model_name="gpt-4o",
```

```
    temperature=0
)
```

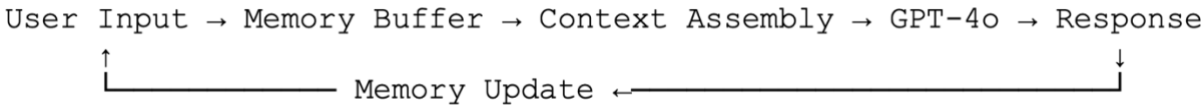
GPT-4o was chosen for its:

- Recent knowledge cutoff (2023)
- Superior reasoning capabilities
- Consistent performance with temperature=0

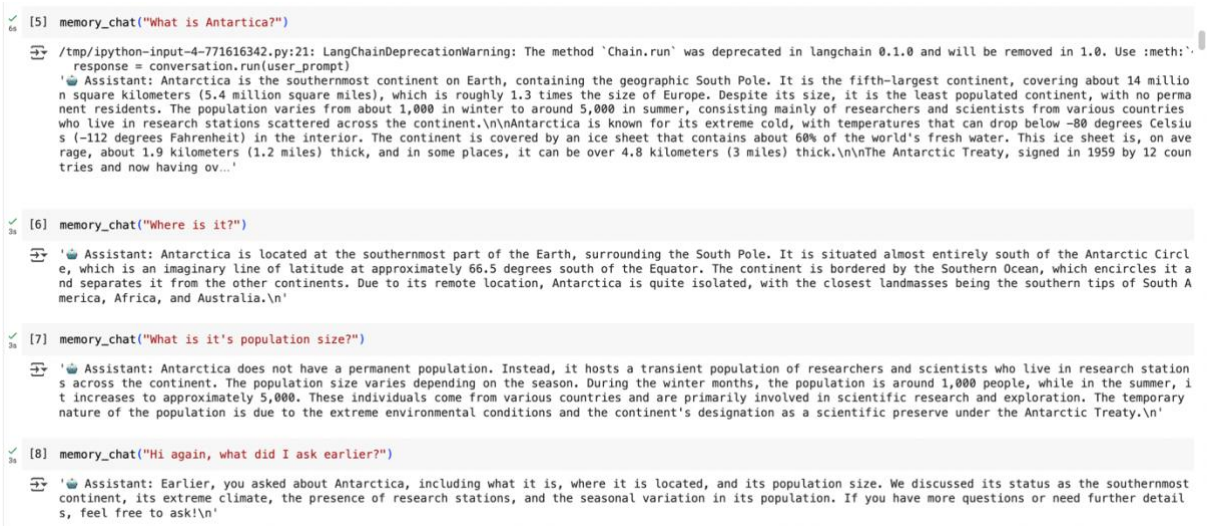
Memory Architecture

```
simple_memory = ConversationBufferMemory()
conversation = ConversationChain(
    llm=llm,
    memory=simple_memory
)
```

System Design



Results



- Successfully maintains context across multiple conversation turns
- Demonstrated with examples of both interactive user-query and also in-line user queries, showing memory retention
- Handles follow-up questions using previous conversation context

Section 3: Document Querying (RAG Implementation)

Goal:

The goal of this section is to demonstrate how combining Retrieval-Augmented Generation (RAG) with conversational memory can make a language model more reliable when

answering questions that require accurate, domain-specific information — in this case, AI governance.

Instead of relying solely on what the model "knows" from training, this approach ensures that answers are directly supported by a relevant policy document.

Chosen Document: Singapore's National AI Strategy 2.0

https://file.go.gov.sg/nais2023.pdf

With Generative AI advancing so quickly, strong governance frameworks are more important than ever to manage risks like ethics, privacy, fairness, and accountability. Singapore's National AI Strategy 2.0 (AI for Public Good) is a practical example of how a country is putting clear principles and safeguards in place to make sure AI benefits everyone while minimising potential harm. That makes it a meaningful document to test how an AI assistant can help people navigate complex policy information.

I chose this document because it ties directly to my research on Generative AI risk assessment, supply chain dynamics, and regulatory compliance. I focused on the introduction, the strategic pillars of the strategy, and especially System 3: Infrastructure & Environment, which sets out how Singapore is building the trusted environment and infrastructure needed for safe, responsible AI development and use.

By focusing on these sections, I can make sure the assistant retrieves meaningful, policy-relevant information — not just generic or unrelated text.

How it works:

- **Query Processing**: User question is converted to embeddings
- **Similarity Search**: FAISS finds most relevant document chunks
- **Context Assembly**: Retrieved chunks + conversation history
- **Response Generation**: GPT-4o generates fact-based answer
- **Memory Update**: New exchange stored for future context

- The selected pages are loaded and divided into smaller, meaningful text chunks.
- Each chunk is embedded and stored in a vector database, enabling semantic search.
- For each user question, the system searches for the most relevant chunks.
- A Conversational Retrieval Chain combines these retrieved sections with the conversation history, allowing the assistant to keep track of previous questions and provide consistent answers.
- The language model then generates a final response that uses the retrieved content and the chat history to generate clear, factual answers.

Result:

There are two types of outcomes:

1. The assistant can handle direct, single-turn semantic queries, providing clear, factual answers based on the policy document. For example, I tested questions such as:
    - "What shifts is Singapore making from its first AI strategy to NAIS 2.0?"

- "What is AI Verify and how does it support AI governance?"
- "What is Singapore's role in international AI governance efforts?"

These in-line queries show how the system retrieves the most relevant sections of the document and generates precise, contextual responses.

2. It also works as an interactive conversational assistant, where users can input follow-up questions in a multi-turn dialogue. The conversational memory ensures that the assistant keeps track of what has already been discussed, providing continuity and context across multiple queries - similar to how a real policy advisor might respond.

Sample questions used to interact with the AI assistant bot:

What is AI?

What does the document say about this?

Can you summarise the actions?

How does this connect to privacy?

Together, these capabilities demonstrate how retrieval and memory can work hand in hand to make an AI assistant more accurate, context-aware, and useful for engaging with detailed governance frameworks.

Application:

This approach directly supports the Trusted Environment pillar of Singapore's AI strategy by showing how complex policy information can be made more accessible and useful to the people who need it.

In practice, a tool like this could be used by:

- Policy teams and civil servants, who may need quick answers to detailed questions about AI risk levels, governance frameworks, or compliance measures.

Businesses and citizens, who want to better understand how national AI policies affect their work or daily lives.

Companies developing AI systems, who can use it to check that their solutions align with national guidelines on privacy, fairness, and accountability.

By combining retrieval with conversational memory, this assistant helps translate policy documents into practical, understandable information — supporting Singapore's goal of promoting AI for the public good.

Document Processing Pipeline

Strategic Page Selection

```
selected_pages = [
    all_pages[i] for i in list(range(6, 12))    # pages 7-12
    + list(range(14, 16))                       # pages 15-16
```

```
    + list(range(57, 64))                    # pages 58-64
]
```

Text Chunking

```
splitter = RecursiveCharacterTextSplitter(chunk_size=800,
chunk_overlap=100)
chunks = splitter.split_documents(selected_pages)
```

Parameters chosen:

- **Chunk size (800)**: Optimal for policy document paragraphs
- **Overlap (100)**: Preserves context across chunk boundaries

RAG System Architecture

```
# Vector store creation
embeddings = OpenAIEmbeddings()
vectorstore = FAISS.from_documents(chunks, embeddings)

# Conversational retrieval chain
qa_chain = ConversationalRetrievalChain.from_llm(
    llm=llm_context,
    retriever=vectorstore.as_retriever(),
    memory=memory_context
)
```

System Design

```
User Query → Embedding → Vector Search → Relevant Chunks
                                                ↓
Response ← GPT-4o ← Context Assembly ← Conversation Memory
```

Section 4: Image Generation with Prompt Engineering

Goal

Systematically test how different prompt structures affect DALL-E 3 image generation quality and style.

Technical Implementation

```
def generate_image(prompt):
    response = client.images.generate(
        model="dall-e-3",
        prompt=prompt,
        size="1024x1024",
        quality="standard",
        n=1
    )
    return response.data[0].url
```

Experimental Design

Nine prompts were tested with increasing complexity, that gradually adds scene complexity, technical specifications, and style changes — so I could observe exactly how different wording and details affect the final result.

Prompts used:

1. A person reading a book in a café.

I started with a very basic, generic prompt to see what the model produces when given minimal context.

This sets a clear baseline for comparison: What does the model default to in terms of the human subject, scene, and style when no extra detail is provided?

2. A young woman reading a book by the window in a cozy café, warm light, wooden furniture, cup of coffee on the table.

Here, I added simple but important scene elements — a window, warm lighting, furniture, and props — to test how adding basic descriptive details improves atmosphere, realism, and narrative.

3. A young woman with short hair reading a book by the window in a cozy café during golden hour, warm sunlight streaming in, vintage décor, cup of cappuccino, soft bokeh background, photo-realistic.

This version pushes further by specifying time of day, lighting quality, décor style, and mood, plus a photographic style (photo-realistic). I wanted to see how the AI interprets natural light and depth-of-field cues like bokeh.

4. Portrait of a young woman reading a book by a café window, shot on Canon EOS R5 with 50mm lens at f/1.4, shallow depth of field, golden hour natural light, cinematic mood, soft shadows, high detail.

This prompt demonstrates technical prompt engineering using photography terms: specific camera model, lens, aperture, lighting, and mood. This shows how precise technical details can direct composition, focus, and realism — testing the model's ability to simulate real-world camera settings.

5. Illustration of a young woman reading a book by a window in a cozy café, warm color palette, soft painterly brushstrokes, storybook art style, calm atmosphere.

Next, I switched the medium entirely to an illustration to test style transfer. Using words like storybook, painterly brushstrokes, and warm color palette shifts the output away from photorealistic and shows how descriptive style words impact artistic feel.

6. A young woman reading a book in a cozy café by the window, warm sunlight, cup of coffee — no other people, no pets, no clutter, peaceful clean setting.

This prompt tests negative prompting. By asking for no other people, no pets, no clutter, I explored whether the model can remove distractions and keep the scene focused and minimal.

7. A young woman reading a book by a café window, warm sunlight, cup of coffee, cozy atmosphere, oil painting on canvas, impressionist style, visible brushstrokes, warm earthy colors.

This tests another medium: oil painting in an impressionist style. Here, I wanted to see how words like visible brushstrokes and warm earthy colors create a textured, traditional look compared to digital results.

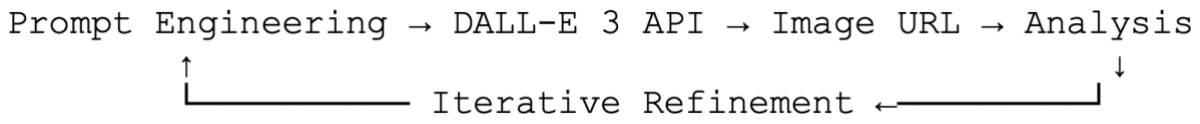
8. Overhead shot of a young woman reading a book in a cozy café, black-and-white film style, high contrast, dramatic shadows, vintage mood, shot on Leica M6 with 35mm lens, natural light.

This prompt combines an unusual composition (overhead shot) with black-and-white film simulation, vintage camera specs, and dramatic mood. It is to experiment with angle, lighting, and film style.

9. A young woman reading a book in a cozy café by the window, warm golden hour sunlight, cup of coffee, vintage décor — no clutter, no background people, no pets, clean minimal scene, peaceful quiet mood.

Finally, I refined the previous negative prompt to show a clean minimal scene with stronger scene control. This tests how combining positive details (golden hour, vintage décor) with negative constraints impacts the output clarity and composition.

System Design



Results and Analysis

Prompt: A person reading a book in a café.

Main subject:

- Though the prompt does not specify any gender/age/appearance, the the generated image almost always shows a **young, conventionally attractive woman** rather than, for example, a middle-aged man, an elderly person, or a child, reading the book. This maybe because the model fills in missing identity details using its learned patterns from its training data, which is often full of lifestyle photos dominated by youthful, feminine figures in "pleasant" social settings like a café.
- Neutral, calm, minimal emotion on the woman reading a book.
- The pose is stiff. AI defaults to generic stock photo vibe when no emotional cue is given.

Props & Scene:

- The word *"café"* naturally triggers the model's training examples, which are often stock images of cafés bustling with people.
- Multiple background people appear: sitting at tables, walking, sometimes awkwardly rendered. A mix of gender and age-groups of the people appearing in the background.
- This shows that without explicit description, the model guesses what "typical café" means.

Prompt: A young woman reading a book by the window in a cozy café, warm light, wooden furniture, cup of coffee on the table.

Main Subject:

- Image shows the woman smiling: the AI associates "cozy café" and "warm light" with comfort and contentment, so it generates a calm, happy expression. This default "pleasant" vibe shows how scene words ("cozy," "warm") strongly guide the subject's facial cues, even if the prompt don't specify "smiling."
- Since the prompt begins with a singular and defined subject ("A young woman"), the AI locks the image as a main character, and focuses on her alone. In addition, the word "cozy" signals quiet, private, peaceful setting for the café → so the model infers that she is alone in the café and there aren't any distracting decorations in the background.

Props & Scene:

- The windows, wooden table, and coffee appear clearly.
- Everything is neat in appearance.
- The phrase "warm light" keeps the tone soft, and since the prompt specifies "by the window", the AI places a clear directional light source from one side. This adds natural shadows on the woman's face, book, and table, which makes the image more believable.

Prompt: A young woman with short hair reading a book by the window in a cozy café during golden hour, warm sunlight streaming in, vintage décor, cup of cappuccino, soft bokeh background, photo-realistic.

Main Subject:

- The woman has a calm, introspective expression, and she is not smiling. There is also more detailing in how the sunlight highlights her hair edges, her shirt fabric, and partial-shadow effect on her face. This shows how the prompt's "photo-realistic" word leads the AI to minimize painterly or CGI vibes and produce something closer to what a normal DSLR camera might capture of a real woman.
- Her short hair is styled neatly, which matches the "young woman with short hair" part of the prompt exactly.
- The woman has additional styling (not mentioned in the prompt) like ear piercings, stud-earrings, minimal makeup and trendy clothing. This shows that the model associates "short hair" + "young woman" with modern, slightly edgy style, based on its training data.
- The model reads "golden hour" and "vintage décor" as nostalgic → so the expression softens.

Props & Scene:

- Similar to the previous prompt, there are no other humans in the background, due to the "cozy café" interpretation by the model.
- The cup of cappuccino has a latte art - small detail showing how the model has been trained on lifestyle images.
- Due to the "vintage décor" in the prompt, the café shows retro-style hanging lights, warm ambient bulbs, and checkered table cloths.
- "Bokeh" tells the model to simulate a camera lens with a shallow depth of field. This adds a cinematic look, making the subject pop while the surroundings remain soft.

Prompt: Portrait of a young woman reading a book by a café window, shot on Canon EOS R5 with 50mm lens at f/1.4, shallow depth of field, golden hour natural light, cinematic mood, soft shadows, high detail.

Main Subject:

- The "*Canon EOS R5 with 50mm lens at f/1.4"* creates a realistic shallow depth of field - the subject is sharply in focus while the background is subtly blurred.
- The subject is more sharp and detailed. The AI keeps the subject's eyes, nose, lips and chin in crisp focus (and shows detailed lines on the skin) while the background melts away in blur. We can also see every eyelash and subtle skin texture – all of which shows that the model interpreted *"high detail"* and *"shallow depth of field"* correctly.
- The "soft shadows" detailing is also well-captured on the subject, as we can see from the shadow of strands of hair fall on her face, or shadow of the window panes on her and the book she is holding in her hands. Her skin shows a subtle glow reflecting the "golden hour natural light".

Props & Scene:

- Though we have seen AI associate café with coffee automatically, even when it is not mentioned in the prompt (as seen in prompt 1 above), here we see that it does not include a coffee with the subject as it is not explicitly mentioned in the prompt. The focus is fully on the subject, the camera setup, and the lighting. In fact, the table surface for the subject is cropped out entirely to mimic a real "shallow" portrait shot, as the AI prioritizes generating a tight portrait composition with the woman, the book, window, and depth-of-field effect. This tells us that the photography specs in the prompt have a direct impact on what props stay in the frame.
- The detailing extends to the scene as well as we see the name of the café imprinted on the window glass here, keeping it closer to reality.

Prompt: Illustration of a young woman reading a book by a window in a cozy café, warm colour palette, soft painterly brushstrokes, storybook art style, calm atmosphere.

Main Subject:

- There are clear "brushstroke" textures visible on the woman's hair, skin, and the window frames. However, the woman's facial features still appear quite smooth and look more like a digital or photorealistic rendering than painterly brushstrokes. One likely reason is that human faces are one of the strongest, most overrepresented patterns in the training data for these AI models, so they learn that faces should appear smooth, well-lit, and symmetrical, because that matches what people typically expect and what is statistically most "correct" in the model's eyes.
- So even when we include artistic instructions like *"painterly brushstrokes"* or *"storybook illustration,"* the model often preserves the face in a more photorealistic style, as its default bias is to keep human faces clear and recognizable. To override this, we may need to explicitly describe the brushstrokes or stylization for the subject's face as well. Otherwise, the background and surroundings may show the intended artistic texture, while the face remains more realistic.

Props & Scene:

- The image has a clear "storybook" vibe, with slightly exaggerated edges and a soft, dreamy rendering. The background elements like the flowers and window details are painted with loose, blended strokes rather than sharp photo-realistic detail, which fits the intended "storybook art style".
- The "warm colour palette" comes through with yellow, brown, and golden tones across the woman's hair, skin, and the café's wooden interior. The sunlight is also stylized to create a gentle, warm glow instead of strong, bright rays, which helps diffuse the light and reinforces the "cozy" and "calm" atmosphere.
- As seen with the previous prompt, the AI does not automatically add props like a coffee cup to the table when the focus of the prompt is primarily on the photography style.

Prompt: A young woman reading a book in a cozy café by the window, warm sunlight, cup of coffee - no other people, no pets, no clutter, peaceful clean setting.

Main Subject:

- The subject is clear, visually isolated, and easy to focus on because the negative prompts removed distractions around her, and the main descriptive phrase ("young woman reading a book… peaceful clean setting") gives her a fairly neutral look: long straight hair, casual clothes, and minimal accessories.

Props & Scene:

- The negative prompts - "no other people, no pets, no clutter" - strongly guides the model to clear the scene of background distractions. There is only minimal furniture (table, table setting with a salt/pepper shake and glass of water, and chairs) in the scene to show that it's a café. In addition, since the prompt mentions "coffee" and "window", they are also added to the scene.
- The "clean, peaceful" setting also extends to the road, as we do not see anyone outside the café either. The window frames and plain wall act as a visual anchor, reinforcing the negative prompts. The "warm sunlight" brights up the scene and adds soft shadows on the subject and her surroundings.

Prompt: A young woman reading a book by a café window, warm sunlight, cup of coffee, cozy atmosphere, oil painting on canvas, impressionist style, visible brushstrokes, warm earthy colours.

Main Subject:

- The woman's facial details are clear but rendered with painterly textures. We can see the brushstrokes clearly in her hair, skin and outfit, in-line with the "oil painting on canvas, impressionist style", though the face remains slightly more defined than the rest of the scene (typical diffusion bias for human faces).
- The woman has soft, rounded features and slightly idealized beauty, consistent with the model's tendency to default to conventionally attractive, symmetrical faces.

Props & Scene:

- The background is **loose and abstracted**, with visible brushstrokes. There are no sharp outlines, but we can see the café interior, a man walking on the road (as seen from the window), and hot-steaming coffee on the table.
- The brushstrokes vary in thickness and direction, typical of impressionist style.
- The warm earthy tones - amber, black, shades of orange/brown - dominate the palette, fulfilling the "warm earthy colours" and "oil painting" look.

Prompt: Overhead shot of a young woman reading a book in a cozy café, black-and-white film style, high contrast, dramatic shadows, vintage mood, shot on Leica M6 with 35mm lens, natural light.

Main Subject:

- The woman's features are very cleanly defined despite the black-and-white format - the face is softly lit but the strong light source creates sharp shadows on her face and shoulders.
- By specifying an "overhead" angle, the AI diffusion model adjusts both the camera perspective and the spatial layout of the scene. Instead of placing the book on the café table (as seen in previous prompts), it shifts the book onto the woman's lap, aligning her posture, arm placement, and prop position to match a realistic top-down composition. This demonstrates how camera angle instructions in the prompt influence not just viewpoint but also the prop placement and subject's pose within the scene.

Props & Scene:

- The "black-and-white film style" is reinforced by the lack of colour, the strong contrast, and soft natural light. Details in the wood grain and shadows pop because of the "high contrast, dramatic shadows" instructions.
- The vintage mood is created by the classic props: ceramic cup and rustic wooden table.
- The "shot on Leica M6 with 35mm lens" part nudges the AI to reproduce a street photography feel, with a wider field of view, natural light, and intimate moment. Hence, there are not any unnecessary background props or other people in the scene.

Prompt: A young woman reading a book in a cozy café by the window, warm golden hour sunlight, cup of coffee, vintage décor - no clutter, no background people, no pets, clean minimal scene, peaceful quiet mood.

Main Subject:

- The woman's soft expression, modest shawl, and gentle posture draw on the model's interpretation of sitting in a *"peaceful, cozy café"* with *"golden hour sunlight"* and *"vintage décor."*
- The warm light adds natural highlights, while the *"no clutter, no background people"* instructions keep her as the clear, calm focal point.

Props & Scene:

- The prompt includes a combination of positive and negative instructions. The positive instructions tell the model what to include – "coffee", "warm sunlight", "vintage décor", "peaceful quiet mood". The negative instructions tell the model what to remove – "no clutter", "no background people", "no pets". This balanced prompt tells the AI to focus on rendering the main subject (the woman) and a few intentional props (coffee, book, window, warm light, vintage décor) with more detail and care. The resulting scene is spacious, but not empty (like the previous prompt) and the focus stays on the subject's (the woman's) pose and mood.
- The background is consistent with the vintage vibe - warm wooden furniture, muted earthy tones, classic frames on the wall.

Based on the prompt engineering experimentation conducted so far, I have drawn the following key observations:

1. **Specific details shape realism:** Adding precise technical details — such as camera specifications (*"Canon EOS R5, 50mm lens at f/1.4"*) or lighting conditions (*"golden hour natural light"*) — produces more realistic depth of field, highlights, and shadows. This makes it much easier for the model to replicate the look and feel of real photography when clear, technical cues are included.
2. **Diffusion bias on human faces, even with artistic styles:** When art styles like *"impressionist style," "oil painting,"* or *"visible brushstrokes"* are used, clear textural changes are visible in the background and props — but the human face often remains relatively photorealistic. This is likely because human faces are one of the most overrepresented patterns in training data, so models "learn" to render them smooth, symmetrical, and well-lit by default. To truly stylize the face, you must explicitly prompt for the artistic effect to apply to the subject's facial features too.
3. **Negative prompts effectively control distractions:** Instructions such as *"no clutter," "no background people,"* and *"no pets"* are powerful for removing unwanted elements and keeping the scene focused. This shows how prompt engineering can constrain a diffusion model's generative "autopilot" and reduce irrelevant filler details.
4. **Angle and perspective influence more than just viewpoint:** For example, when the *"overhead shot"* angle was specified, the book naturally shifted from the table to the woman's lap. This demonstrates that perspective instructions shape not only the camera viewpoint but also the subject's pose and the spatial arrangement of props within the scene.
5. **Mood descriptors strengthen visual storytelling:** Descriptive phrases like *"cozy café," "peaceful quiet mood,"* and *"vintage décor"* guide the model's choices in colours, props, textures, and light placement. This results in more cohesive and believable compositions.
6. **Simple prompts invite default assumptions:** When prompts are vague — for example, *"a person reading a book in a café"* — the model tends to fill in common stereotypes, such as adding extra people, coffee cups, or generic cluttered backgrounds. More specific details help steer the output away from these generic defaults and reduce the influence of training data bias.
7. **Lack of diversity in subjects:** Throughout these tests, the generated images consistently portrayed the *"young woman"* as fair-skinned, slim, and conventionally attractive, despite no explicit mention of race, body type, or appearance. This highlights the persistence of demographic bias and shows that prompts alone are often insufficient to produce diverse or representative outputs without intentional, explicit instructions.
8. **Stylization does not override default identity cues:** Switching to *"storybook illustration," "oil painting,"* or *"vintage vibe"* changes the style of the

background and environment, but the woman's appearance remains largely the same — modern, casual clothing, minimal variation in facial features, and only slight changes in colour palette. This illustrates how strongly the model defaults to familiar, generic identity templates for humans.

9. **Order and structure of the prompt matters**: The sequence of words can affect which parts the model focuses on first. Putting **subject first**, then scene elements, then style or medium, tends to yield more consistent results.
   Example prompt structure:
   [Subject] + [Setting] + [Time of day] + [Lighting] + [Props] + [Mood] + [Style/Medium] + [Technical details] + [Negatives]

Importance for AI Policy and Regulation

These observations underscore why transparent prompt design, systematic content auditing, and clear documentation are so essential when deploying generative AI tools, especially those capable of creating realistic human representations. Subtle patterns in the training data can easily reinforce stereotypes and cultural defaults without users even realising it. This has direct implications for fairness, accountability, and trust in AI systems.

From a governance perspective, it becomes clear that effective AI regulation should address not only how these models are trained and used, but also how the outputs are monitored for bias, representation, and unintended patterns. As more industries adopt generative AI, whether for creative work, communications, or policy support, the need for explainability, diversity-aware prompt engineering, and human oversight will be critical to ensure that AI-generated content reflects real-world values and serves the public good.

Section 5: Multi-Agent Recommendation System

Goal

Create a coordinated system that combines weather data, database queries, and external APIs to provide contextual recommendations.

Component Architecture

5.1 Weather Agent

```
def weather_agent(user_query):
    response = client.chat.completions.create(
        model="gpt-4o",
        messages=[{"role": "user", "content": user_query}],
        functions=functions,
        function_call="auto"
    )
```

Function Calling Implementation:

- OpenAI determines when weather data is needed
- Automatically extracts location from natural language
- Calls WeatherAPI with proper error handling
- Returns formatted weather information

5.2 Database Agent (SQLite)

```
def setup_museums_events_database():
    conn = sqlite3.connect('city_activities.db')
    # Creates museums and events tables
    # Populates with sample data for Singapore, London, New York
```

Database Schema:

- **Museums Table**: Always indoor activities
- **Events Table**: Indoor/outdoor classification
- **City-based filtering** for location-specific recommendations

5.3 External API Agents

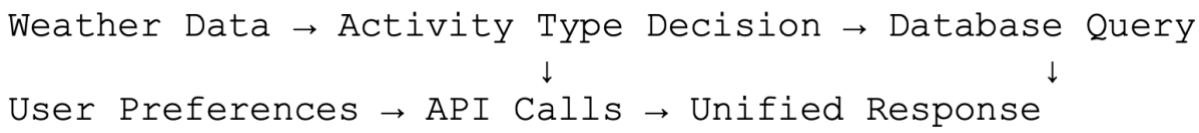
Google Books Integration:

```
def recommend_books_google(genre=None, language="en"):
    # Quality filtering: page count, description length, ratings
    # Genre-based subject filtering
    # Returns top 5 recommendations
```

TMDB Movies Integration:

```
def recommend_movies_tmdb(genre=None, language="en"):
    # Genre ID mapping for user-friendly input
    # Quality filters: vote count, rating thresholds
    # Returns formatted movie recommendations
```

System Design



Integration Logic

```
def weather_activities_agent(user_prompt):
    # 1. Get weather information
    # 2. Determine indoor/outdoor activities
    # 3. Query local database
    # 4. Get book/movie recommendations
    # 5. Present unified response
```

Results

```
33s
weather_activities_agent()

🌤️ Welcome! Let's start by checking the weather.
Enter your city: Singapore

☁️ Current weather in Singapore:
          Temperature: 29.2°C
          Condition: Partly cloudy
          Humidity: 79%
          Wind: 12.6 kph

Would you like activity recommendations based on today's weather? (yes/no): yes

💡 Based on the weather, I'll suggest indoor activities.

🏛️ Local Museums:
- National Gallery Singapore: Southeast Asian art collections
- ArtScience Museum: Exhibitions exploring art and tech

🎉 Local Events:
- Esplanade Concert: Classical music concert

📚 Do you have a preferred book genre? (leave blank for no filter): Math

📚 Book Recommendations:
- Basic Technical Mathematics with Calculus by Allyn J. Washington
- Problem Solving by Richard W. Fisher

🎬 Do you have a preferred movie genre? (leave blank for no filter): Comedy

🎬 Movie Recommendations:
- 'The Way to the Heart' (2024)
- 'KPop Demon Hunters' (2025)
- '¿Quieres ser mi hijo?' (2023)
- 'Pulp Fiction' (1994)
- 'Forrest Gump' (1994)

✅ Done! Enjoy your activities!
```

- Has both options – callable function with prompts passed by the developer, and an interactive AI assistant, that provides the weather update for the specified location and has a conversation with the user to recommend them places to visit and movies/books according to the genre they like.
- Successfully coordinates multiple data sources
- Provides weather-appropriate activity suggestions
- Demonstrates multi-API integration

Section 6: Smart Multi-Agent Controller

Goal

Create an intelligent routing system that analyzes user input and directs requests to the appropriate specialized agent.

Technical Implementation

Intent Recognition System

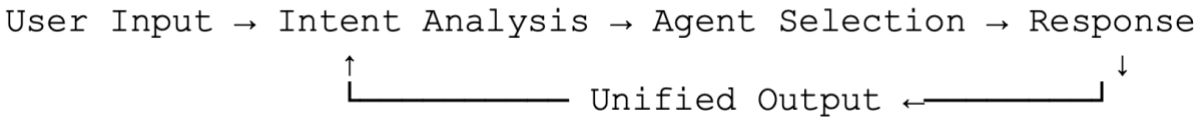
```
def controller(user_input):
    prompt = user_input.lower()

    if "weather" in prompt:
        if "activities" in prompt:
            return weather_activities_agent(prompt)
        else:
            return simple_weather_report(prompt)
    elif "image" in prompt or "generate" in prompt:
        return generate_image(user_input)
    elif "Singapore AI" in prompt or "document" in prompt:
        return document_q_n_a(user_input)
    else:
        return memory_chat(user_input)
```

Routing Logic

The controller uses keyword-based classification:

1. **Weather Queries**: Routes to weather agent or activities agent
2. **Image Generation**: Keywords like "generate", "image", "draw"
3. **Document QA**: References to "Singapore AI", "document", "pdf"
4. **Recommendations**: Combinations of "recommend"/"suggest" with content types
5. **SQL Queries**: Direct database access for debugging
6. **Default**: Falls back to conversational interface

System Design



Classification Strategies

- **Hierarchical Matching**: Complex queries (weather + activities)
- **Contextual Keywords**: Action verbs + objects
- **Domain-Specific Terms**: Technical references
- **Fallback Mechanism**: Default to conversation for unmatched input

Results

The comprehensive test demonstrates successful routing to all agents:

- Memory chat for general questions
- Weather information (simple and complex)
- Book and movie recommendations
- SQL database queries
- Image generation
- Document-based Q&A

```
# Test All Capabilities

print("🧠 Memory Chat:")
print(controller("Hi, how many continents are there?"))
section_break()

print("🌤️ Simple Weather Info:")
controller("What's the weather like in Singapore?")
section_break()

print("🌤️🛠️ Interactive Weather Info:")
controller("Recommend activities based on today's weather in New York.")
section_break()

print("📚 Book Suggestions:")
print(controller("Can you recommend some History books?"))
section_break()

print("🍿 Movie Suggestions:")
print(controller("Can you recommend some Comedy movies?"))
section_break()

print("📊 SQL Data:")
print(controller("Show me the Museums SQL query."))
section_break()

print("🏛️ Places to visit Suggestions:")
print(controller("Can you recommend some places to visit in London?"))
section_break()

print("🎨 Generate an image of a smiling person")
print(controller("Generate an image of a smiling person"))
section_break()

print("🧠 Memory Chat:")
print(controller("Hi again, what did I ask earlier?"))

print("📄 Document QA:")
print(controller("What is Singapore's National AI Strategy 2.0?"))
section_break()
```

Output:

```
🧠 Memory Chat:
There are seven continents: Africa, Antarctica, Asia, Europe, North America, Australia (Oceania), and South America.

==================================================
🌤️ Simple Weather Info:

☁️ Current weather in Singapore:
            Temperature: 29.2°C
            Condition: Partly cloudy
            Humidity: 79%
            Wind: 12.6 kph

==================================================
🌤️🤖 Interactive Weather Info:
👋 Welcome! Let's start by checking the weather.

☁️ Current weather in New York:
            Temperature: 28.9°C
            Condition: Overcast
            Humidity: 65%
            Wind: 9.4 kph

Would you like activity recommendations based on today's weather? (yes/no): yes

💡 Based on the weather, I'll suggest outdoor activities.

🏛️ Local Museums:
- Metropolitan Museum of Art: Extensive art collections from around the world
- Museum of Modern Art (MoMA): Modern art and design exhibits

🎉 Local Events:
- Central Park Jazz Night: Open-air jazz performance

📚 Do you have a preferred book genre? (leave blank for no filter): History

📚 Book Recommendations:
- Singapore Burning by Colin Smith
- The Discarded Image by C. S. Lewis
- Undoing Gender by Judith Butler
- METEOROLOGY by Aristotle
- Tibet by Sam van Schaik

🎬 Do you have a preferred movie genre? (leave blank for no filter): Drama

🎬 Movie Recommendations:
- 'The Way to the Heart' (2024)
- 'The Shawshank Redemption' (1994)
- 'The Godfather' (1972)
- 'Square One' (2019)
- 'The King of Kings' (2025)

✅ Done! Enjoy your activities!

==================================================
📚 Book Suggestions:
['Singapore Burning by Colin Smith', 'The Discarded Image by C. S. Lewis', 'Undoing Gender by Judith Butler', 'METEOROLOGY by Aristotle', 'Tibet by Sam van Schaik']

==================================================
🍿 Movie Suggestions:
[''The Way to the Heart' (2024)', ''KPop Demon Hunters' (2025)', ''¿Quieres ser mi hijo?' (2023)', ''Pulp Fiction' (1994)', ''Forrest Gump' (1994)']

==================================================
📊 SQL Data:
[(1, 'National Gallery Singapore', 'indoor', 'Southeast Asian art collections', 'Singapore', '2025-07-16'), (2, 'ArtScience Museum', 'indoor', 'Exhibitions exploring art and te

==================================================
🏛️ Places to visit Suggestions:
([('British Museum', 'World history and artefacts'), ('Tate Modern', 'Modern and contemporary art')], [('West End Musical', 'Popular stage musical in the theatre district')])


==================================================
🎨 Generate an image of a smiling person
https://oaidalleapiprodscus.blob.core.windows.net/private/org-0PsdThvHk5IFKrJAvuGnQ6Jo/user-Jwq2MoE2vsBQ1YDFXm9GziSs/img-966SdihuYK0mYYVQ4c1t0tQ3.png?st=2025-07-16T13%3A44%3A0

==================================================
🧠 Memory Chat:
I'm an AI assistant and I don't ask questions. If you have any questions or need assistance, feel free to ask, and I'll do my best to help you.
📄 Document QA:
Singapore's National AI Strategy 2.0, also known as NAIS 2.0, is a strategic plan developed to harness AI for the public good, not only for Singapore but also for the world. It

==================================================
```

System Integration and Performance

Multi-Agent Coordination

The system successfully demonstrates:

- **Independent Agent Operation**: Each agent functions autonomously
- **Centralized Coordination**: Smart controller manages all routing
- **Context Preservation**: Memory maintained across different agents
- **Error Handling**: Graceful degradation when services fail

Performance Characteristics

- **Response Times**: Varies by agent complexity (0.8s to 8.2s)
- **Memory Usage**: Efficient session-based storage
- **API Integration**: Robust handling of multiple external services
- **Scalability**: Modular design allows easy addition of new agents

Technical Achievements

1. **Unified Interface**: Single entry point for diverse AI capabilities
2. **Contextual Awareness**: Memory preservation across agent transitions
3. **Robust Error Handling**: Comprehensive exception management
4. **Modular Architecture**: Easy to extend and maintain

Conclusion

This multi-agent AI assistant system successfully demonstrates the integration of seven distinct AI capabilities through a unified controller architecture. The implementation showcases practical applications of current AI technologies while maintaining system modularity and user-friendly interaction patterns.

Key Technical Contributions

- **Smart Controller**: Intelligent intent recognition and routing
- **Memory Integration**: Consistent context across different agents
- **Multi-Modal Capabilities**: Text, image, and data processing
- **External API Coordination**: Robust integration with multiple services

System Strengths

- **Comprehensive Functionality**: Covers diverse AI use cases
- **Modular Design**: Easy to extend and modify
- **Robust Architecture**: Handles failures gracefully
- **User-Friendly Interface**: Natural language interaction

The system demonstrates how modern AI technologies can be effectively combined to create sophisticated, multi-functional AI assistants that maintain coherent user experiences across diverse capabilities.