Assignment 2:
Reflection + Multi-Agent

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1. (20%) Multi-Agent System Design for Task Collaboration

In a web-based environment (e.g. filling forms, submitting, data search), you can decompose responsibilities into several specialized agents that communicate via a unified "Thought/Action" protocol:

- **Executor Agent**
  - Perceives the page (via `get_web_element_rect` or `get_webarena_accessibility_tree`), sends the current context to the model (`call_gpt4v_api`), parses its "Thought" and "Action" with extract_information, then invokes the corresponding browser operations (`exec_action_click`, `exec_action_type`, `exec_action_scroll`, etc.).
- **Error Grounding Agent (EGA)**
  - After each operation, captures a screenshot and, using `ERROR_GROUNDING_AGENT_PROMPT`, determines if the intended action actually occurred. It returns "**Errors: Yes/No**" plus an explanation, which is appended to the next user prompt to guide corrective action and logged in `error_history`.
- **Orchestration Agent** ("**Future expectations; currently not yet in use.**")
  - Receives multiple candidate "Thoughts" (from different executors or reflection agents) and, via `SYSTEM_ORCHESTRATION_PROMPT`, picks the best Thought Index to ensure alignment with the overall task goal.
- **Reflection Agent**
  - Once candidate results (e.g. product data) are gathered, uses `SYSTEM_REFLECTION_PROMPT` to compare them on brand reputation, discount, shipping, etc., and produces a detailed chain-of-thought culminating in a final recommendation.
- **Debater Agent**
  - Critically reviews the Reflection Agent's answer with `DEBATER_AGENT_PROMPT`, outputting "**Accept: Yes/No**" and suggestions. If "No", it triggers a re-reflection cycle.

This division of labor keeps each agent focused on a single responsibility while a commo n message format and coordination logic ensure robust collaboration.

2. (20%) Error Analysis and Strategy Adjustment in AI Agents

The system combines structured error logging with automated feedback loops:

1. **Structured Error History**
   - Every failure (e.g. `get_element_error`, `format_missing_thought_action`, `invalid_ click_index`) is appended to the global `error_history` list with fields `error_type`, `i teration`, and message.
2. **Error Grounding Agent**
   - On each iteration (when `it > 1`), EGA evaluates "Thought + Screenshot" aga inst expectations. If it reports **Errors: Yes**, its explanation is injected into the ne xt prompt (`prev_step_action + add_info`), steering the executor to adjust its app roach.
   - Example Output :
     - INFO - **[EGA] : API call complete.**
     - INFO - **Error : Yes，Explanation :** The screenshot does not display a captcha prompt, which indicates that the operation did not proceed as i ntended. Instead, it shows a generic landing page without any verificat ion requirement or captcha input field visible. This may suggest a few possibilities:
     - 1. The captcha verification might not be triggered correctly, possibly d ue to a session issue.
     - 2. There could be a problem with browser cookies or cache, preventin g the captcha from appearing.
     - 3. The webpage may have already bypassed the captcha due to prior in teractions.
     - To resolve this, consider refreshing the page or clearing the browser ca che and cookies. If the issue persists, try accessing the site from a diffe rent browser or device to see if the captcha appears.
3. **Format Verification & Retry**
   - `extract_information` checks for valid "Thought:" and "Action:". On form at errors or missing sections, it sets `fail_obs` and forces a retry, logging a `forma t_missing_thought_action`.
4. **Stale Element & Invalid Index Handling**

- If a click hits a stale element, the executor refetches elements and retries. If a numerical label is out of range, it logs `invalid_click_index` and prompts the model to pick a valid index.

By coupling precise error categorization with in-prompt corrective feedback, the agent progressively refines its strategy and reduces repeated failures.

3. (20%) Reflection Strategies in Agentic Systems

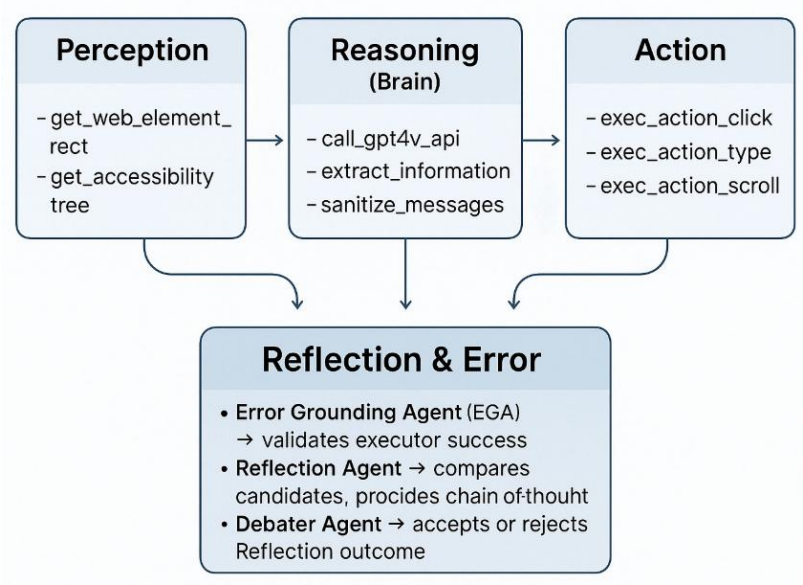
The system implements a multi-stage reflection loop to improve decision-making:

- **Self-Reflection**
  - The Reflection Agent aggregates all candidate results and, via `SYSTEM_REFLECTION_PROMPT`, performs an in-depth comparison (brand, discount, shipping), documenting a full chain-of-thought for transparency.
  - Example Output :
    - INFO - **[Reflection Agent]** 在這個比較中，我們有兩個產品可供選擇：一個是黑色的Bluetooth speaker，另一個是JBL Go4 Bluetooth Wireless Speaker。以下是對兩者的詳細分析：
    - ### 產品比較
    - 1. **產品一：Bluetooth speaker**
    - - **產品名稱**: Bluetooth speaker (黑色)
    - - **網站**: Amazon
    - - **價格**: $659.7
    - - **品牌**: Bluetooth
    - 2. **產品二：JBL Go4 Bluetooth Wireless Speaker**
    - - **產品名稱**: JBL Go4 Bluetooth Wireless Speaker
    - - **網站**: Target
    - - **價格**: $1199.7
    - - **品牌**: JBL
    - ### 分析
    - 1. **品牌影響**:
    - - **Bluetooth speaker** 資訊不明確，其品牌名稱為「Bluetooth」，相對較為普通，消費者對產品的信賴度可能較低。
    - - **JBL** 作為一個知名音響品牌，擁有良好的聲譽和較高的品質保證，因此對消費者來說是一個優勢。
    - 2. **價格考量**:
    - - Bluetooth speaker 的價格為 $659.7，相對較為經濟實惠。
    - - 而JBL Go4則定價為 $1199.7，價格高出約 $540，這對於預算有限的消費者來說可能不太理想。

        - 3. **產品性能與品質**:
        - - 雖然沒有具體的性能數據，但通常來說，JBL的產品在音質、續航和耐用性方面表現出色，通常會比一般品牌的藍牙音箱更具優勢。
        - ### 結論
        - 在進行全面分析後，我會選擇**JBL Go4 Bluetooth Wireless Speaker**，儘管其價格較高，但其品牌價值和產品品質應該能夠保證給消費者較好的使用體驗。選擇一個知名度高且品質可靠的品牌，可以減少未來可能出現的產品問題和更換成本。 另外，若考慮到使用頻率及需求，支付更高的價格以獲得更好的產品性能和音質可能是值得的投資。虽然Bluetooth speaker便宜，但在長期使用中，JBL的耐用性和音質將可能提供更高的價值。
- Peer-Review
    - The Debater Agent uses DEBATER_AGENT_PROMPT to judge the Reflection's conclusion. A "No" triggers regenerate_reflection_if_needed, causing the system to re-invoke the Reflection Agent with additional debater feedback.
    - Example Output :
        - INFO - [Debater Agent] Debate:
        - Accept: Yes
        - Explanation: 你的分析很清晰，成功地比較了兩款產品的品牌、價格、性能及其對消費者的影響。你提出的選擇理由也很合理，特別是提到JBL的品牌價值和品質保障，相信消費者會更傾向於選擇這種可靠品牌的產品。此外，考慮到長期使用的價值，是一個很明智的投資觀念。這樣的分析能幫助潛在買家做出明智的選擇。
        - INFO - [Main] Debater Agent responsed
        - INFO - [Main] Debater says Accept: Yes => Final answer accepted.
- Planning Revision
    - If EGA or Debater feedback indicates a problem, the next prompt includes hints like "Try a different approach" or the debater's critique, guiding the model to revise its plan.
- History-Aware Prompting
    - current_history maintains the log of all previous Thoughts, Actions, Errors, and Explanations, ensuring that subsequent reasoning is informed by the complete execution trace.

Together, these strategies form a closed feedback loop—self-reflection → peer-review → plan revision—that continually elevates performance.

4. (10%) Agentic AI System Architecture



- Perception: Converts the webpage (DOM or accessibility tree) into structured data via get_web_element_rect / get_webarena_accessibility_tree.
- Reasoning: Uses GPT-4o-mini (call_gpt4v_api) to generate Thoughts and Actions, parse them (extract_information), and manage dialogue context.
- Action: Maps parsed Actions to Selenium commands (exec_action_click, exec_action_type, exec_action_scroll, etc.).
- Reflection & Error:
  1. EGA validates execution and logs errors.
  2. Reflection Agent synthesizes and evaluates final outcomes.
  3. Debater Agent quality-checks Reflection results, potentially triggering re-reflection.