MC05 - Large Language Models and Agents

Short Course - JCD 2026

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From LLMs to LLM-based Agents

From Prompting Techniques to Interaction Patterns

Tool Calling

From LLMs to LLM-based Agents

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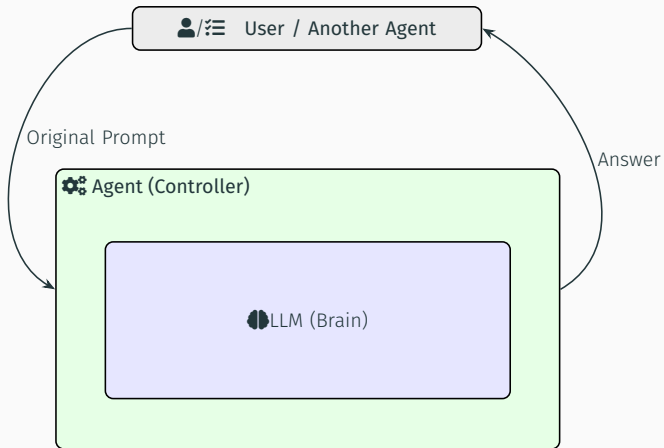Yet at scale, LLMs exhibit reasoning-like abilities (planning, inference, language understanding).

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An LLM-based agent combines:

- These **reasoning-like abilities** of the LLM,
- **Control logic** to orchestrate steps and manage context,
- Access to **external tools** (search, databases, APIs),
- Mechanisms for **perception and action**, so reasoning can affect the real world.

LLM-based Agent

Demo Time ▶

From Prompting Techniques to Interaction Patterns

Prompting Techniques: Examples

⚡ Zero-shot

Prompt:

```
What is 47 + 35?
```

Output:

```
82
```

💡 Few-shot

Prompt:

```
Examples:
12 + 7 = 19
5 + 9 = 14
23 + 18 = 41

Now, what
is 47 + 35?
```

Output:

```
82
```

🖇 Chain-of-Thought

Prompt:

```
What is 47 + 35?
Let's think
step by step.
```

Output:

```
First, add tens:
40 + 30 = 70
Then, ones:
7 + 5 = 12
Sum:
70 + 12 = 82
Answer: 82
```

- Prompting techniques (Zero-shot, Few-shot, Chain-of-Thought) steer a **single LLM call**:
- But complex tasks require multi-step reasoning and tool use.

Examples of complex tasks that require multi-step reasoning and tool use:

- **Q** Answering questions over a large knowledge base (search + reasoning)
- 🛢 Text-to-SQL (NL → SQL query → execution → formatted result)
- ✈ Planning a trip (dates, flights, hotels, budget)
- 🔢 Solving math word problems (step-by-step reasoning + calculation)
- 📊 Data analysis (retrieve data → transform → summarize)

Interaction Patterns

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> In the context of LLMs, an interaction pattern refers to the structured way a user or a system communicates with a model to achieve a specific outcome. Rather than just asking a single question, these patterns define the "flow" of reasoning, the role the AI plays, and how it processes information to reach a solution.

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    - ReAct (Reason + Act)
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    - Reflexion
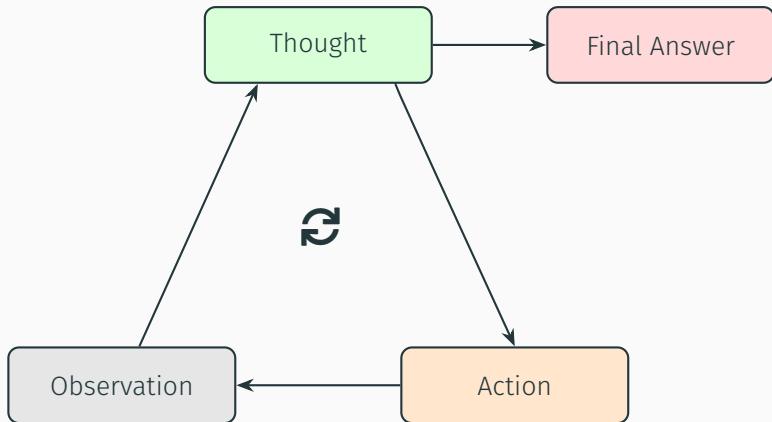
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- Examples:
    - ReAct (Reason + Act)
    - Plan-and-Act
    - Reflexion
- We focus on ReAct.

ReAct: Synergizing Reasoning and Acting in Language Models [?]

The agent **thinks**, **acts**, and **observes** in a loop,
until enough information is gathered to deliver the final answer.

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- Data requirement: We must query a payroll/financial database filtered by
  - month + year (resolved from "last month")
  - department = `Sales`
- Goal: Return a single, clear number (the total payroll expense) with the correct time reference.

The next slide shows a step-by-step trace (Thought $\rightarrow$ Action $\rightarrow$ Observation) ending in the final answer.

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- Thought: I have the information. I can now answer the user.
- Final Response: The total payroll expense for the Sales department in January 2026 was $142,500.00.

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To answer these questions, we need to talk about the mechanism of tool calling.
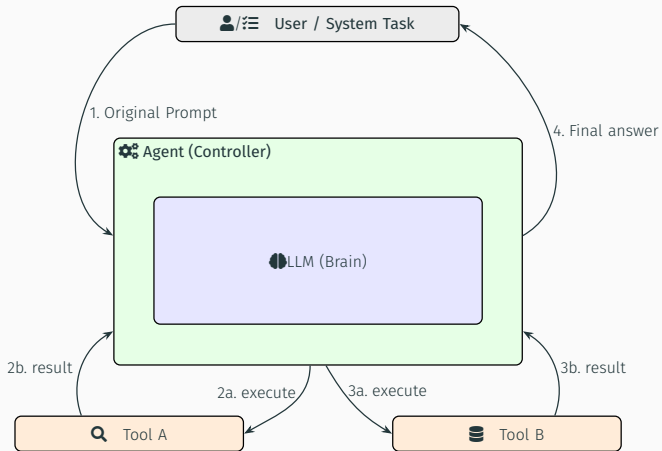
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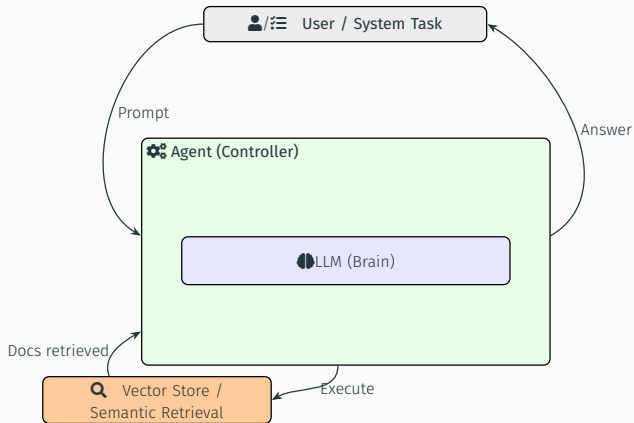Multi-step tasks often require **external actions**, not just text generation.

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> In the context of LLMs, tool calling refers to the capability of a model to invoke external functions (tools) — such as APIs, databases, calculators, or search engines — as part of its reasoning process. Instead of relying only on internal knowledge, the model can retrieve fresh data, perform computations, and interact with systems to produce grounded and verifiable answers.
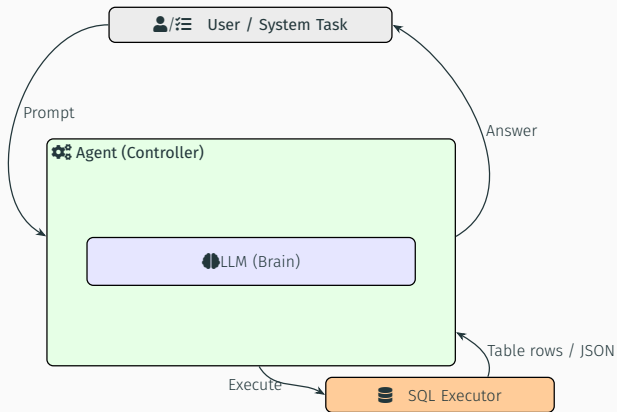
Tool Calling

Tool Registration?

- LLMs do not "magically" know what tools exist.
- Each tool must be **registered** via a structured description that includes:
    - **Name** and **purpose** of the tool,
    - **Input parameters** (types, constraints, defaults),
    - **Expected outputs**.
- This information is added to the LLM context, so the model can decide when and how to use the tool.
- Tool registration is the gateway for RAG, Text-to-SQL, and many other applications.

Tool Registration?

Tool Registry (JSON specs) → **Registration** → 🧠 LLM

↓ Tool call intent

⚙️ Orchestrator / Agent

↓ Execution

Tools (Search API, SQL Executor, ...)