



Tool Learning

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THUNLP



Background

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Tools and Intelligence

- Tools are extensions of human capabilities designed to enhance productivity, efficiency, and problem-solving
- Throughout history, humans have been the **primary agents** in the invention and manipulation of tools
- Question: can **artificial intelligence** be as capable as humans in tool use?





Tools and Intelligence

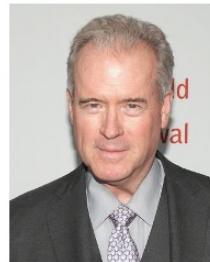
- The answer is **yes** with **foundation models**
 - Strong semantic understanding
 - Extensive world knowledge
 - Powerful reasoning and planning capabilities...



Noam
Chomsky



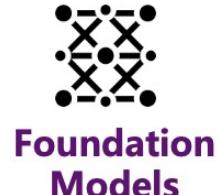
Edward
Feigenbaum



Robert
Mercer



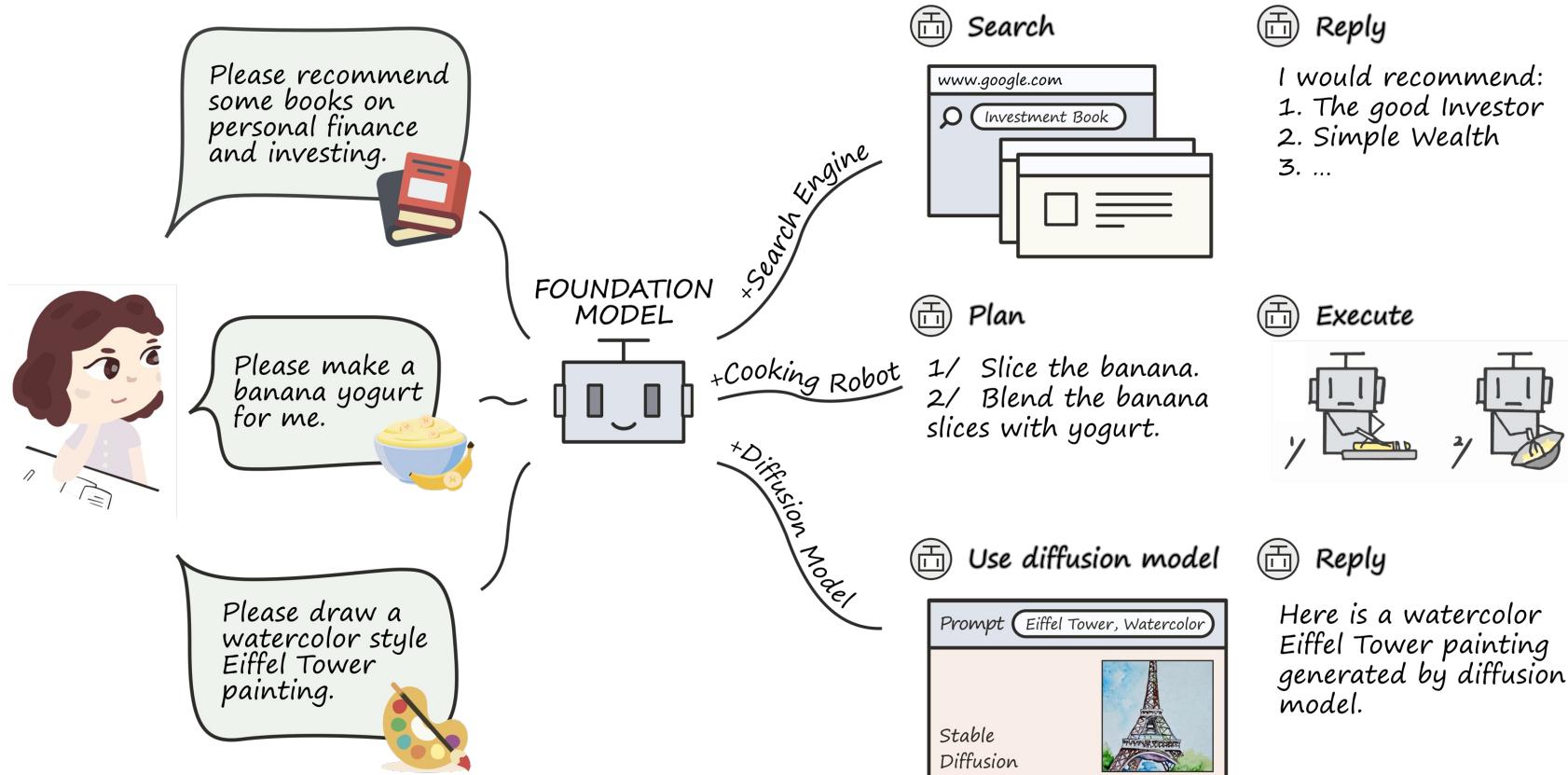
Yoshua
Bengio





Tools and Intelligence

- Tool Learning [1]: foundation models can follow human instructions and manipulate tools for task solving





Categorization of Tools

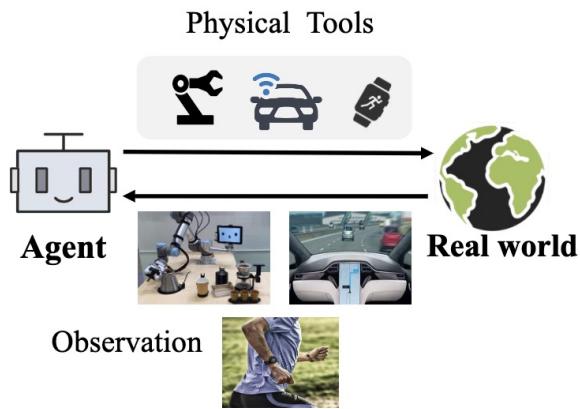
- Deterministic tools:
 - Tools with fixed functionalities and stable input-output mappings
 - e.g., calculator, clock...
- Black-box API:
 - Tools with their internal workings undisclosed
 - e.g., Bing search API, Google Translation API...
- Neural models:
 - Neural networks optimized for specific tasks
- Robots:
 - Tools that interact with the physical world through actuators, sensors, and control systems



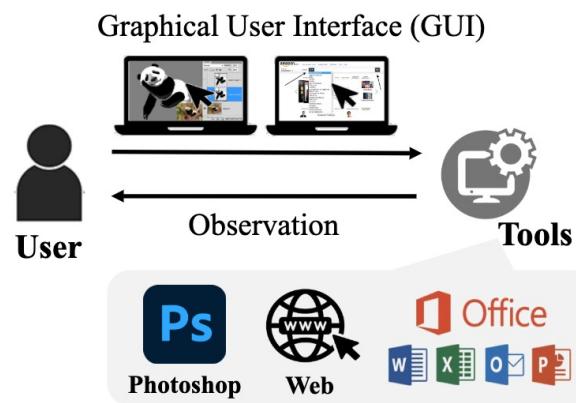
Categorization of Tools

- From the perspective of interface:
 - **Physical interaction-based tools**: directly interact with the physical world
 - **GUI-based tools**: interact with visual representations of tools
 - **Program-based tools**: interact with the source codes

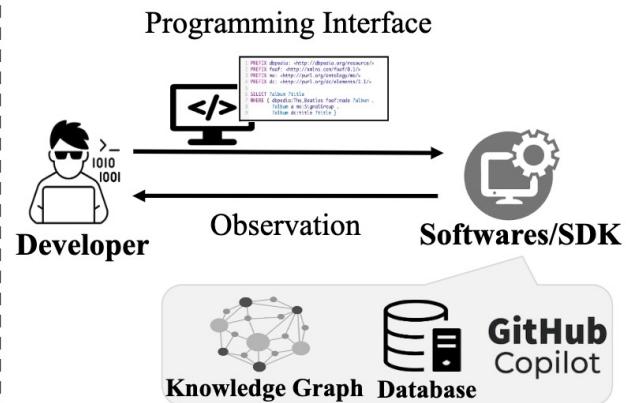
(a) Physical Interaction-based Tools



(b) GUI-based Tools



(c) Program-based Tools



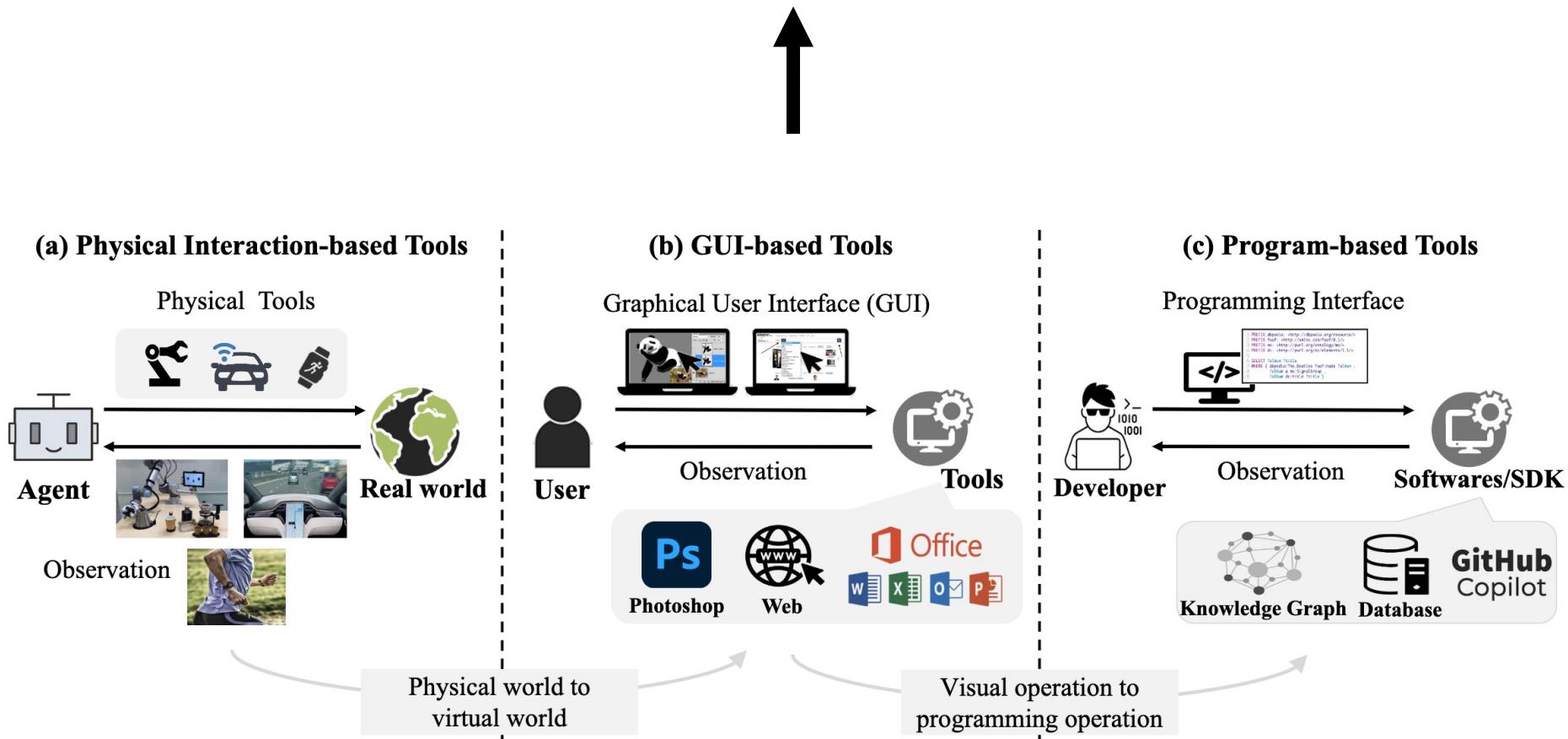
Physical world to
virtual world

Visual operation to
programming operation



Categorization of Tools

After processing, tools' input and output can be unified as **sequences of tokens** for foundation models

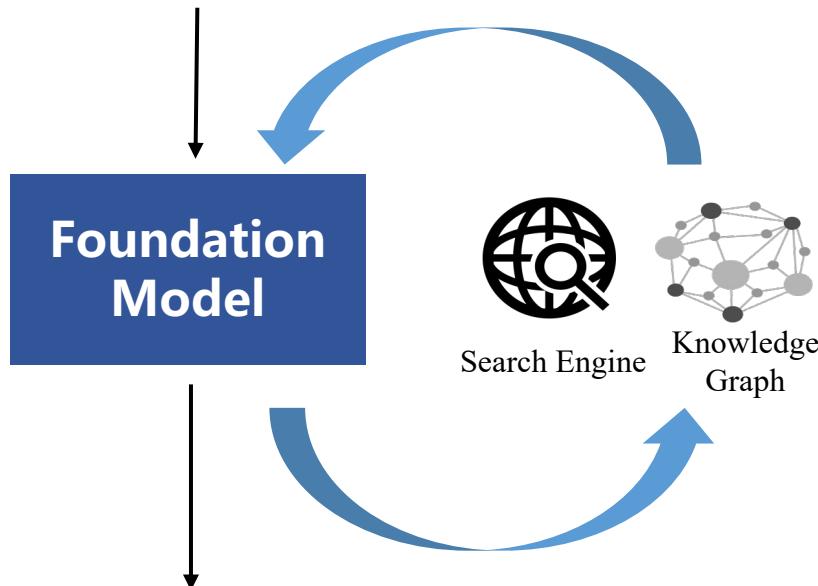




Inability of Foundation Models

- Models cannot provide **real-time information**

Input: What's the latest news of CoVID-19?

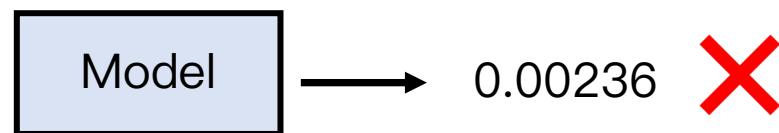


Output: There are currently 676 million infections, the mutant strain is...

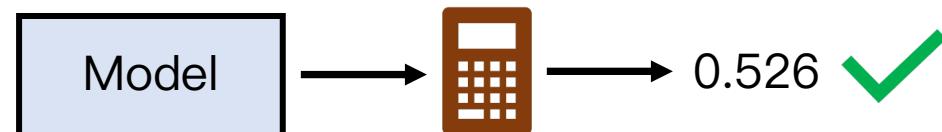
- Models cannot handle **specialized tasks**

Input: Please calculate $12321 / 23432$

without tools



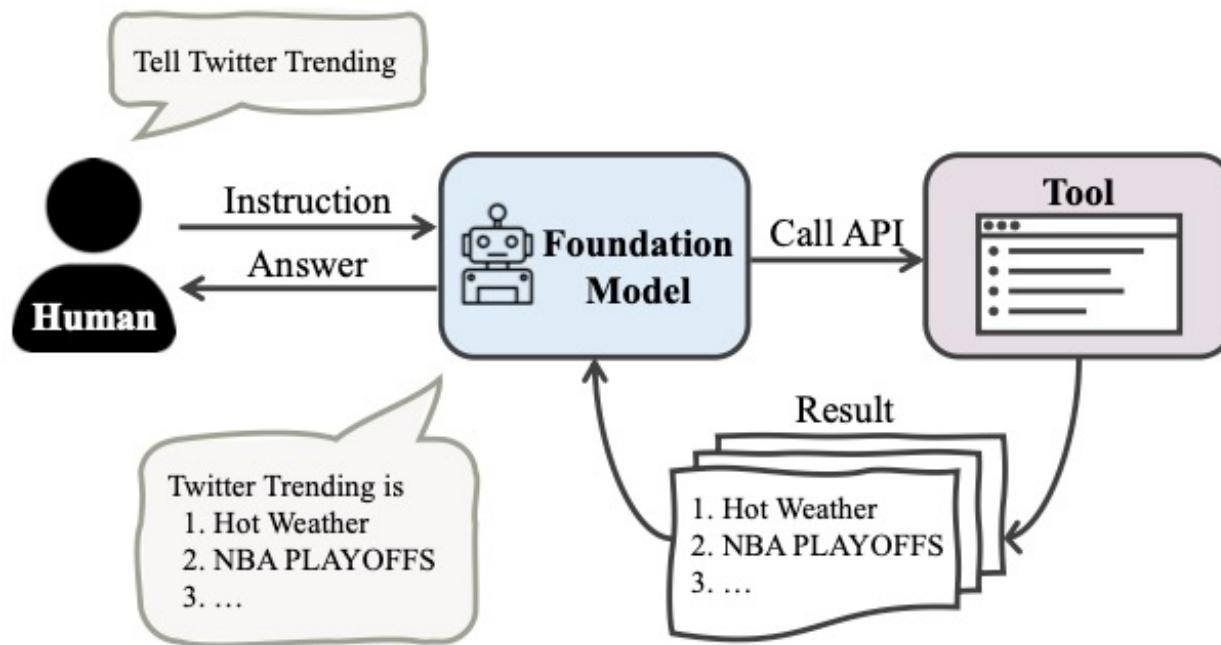
with tools





Categorization of Tool Learning

- Tool-augmented learning
 - Augment foundation models with the execution results from tools
 - Tools are viewed as complementary resources that aid in the generation of high-quality outputs

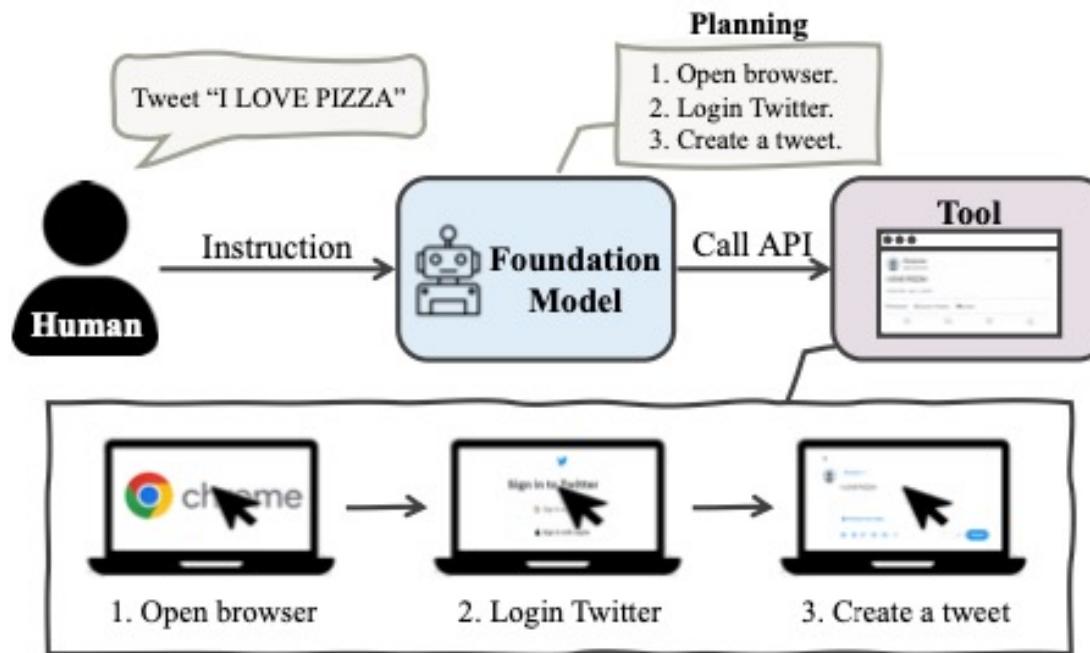




Categorization of Tool Learning

- Tool-oriented learning

- Utilize models to govern tools and make sequential decisions in place of humans
- Exploiting foundation models' vast world knowledge and reasoning ability for complex reasoning and planning





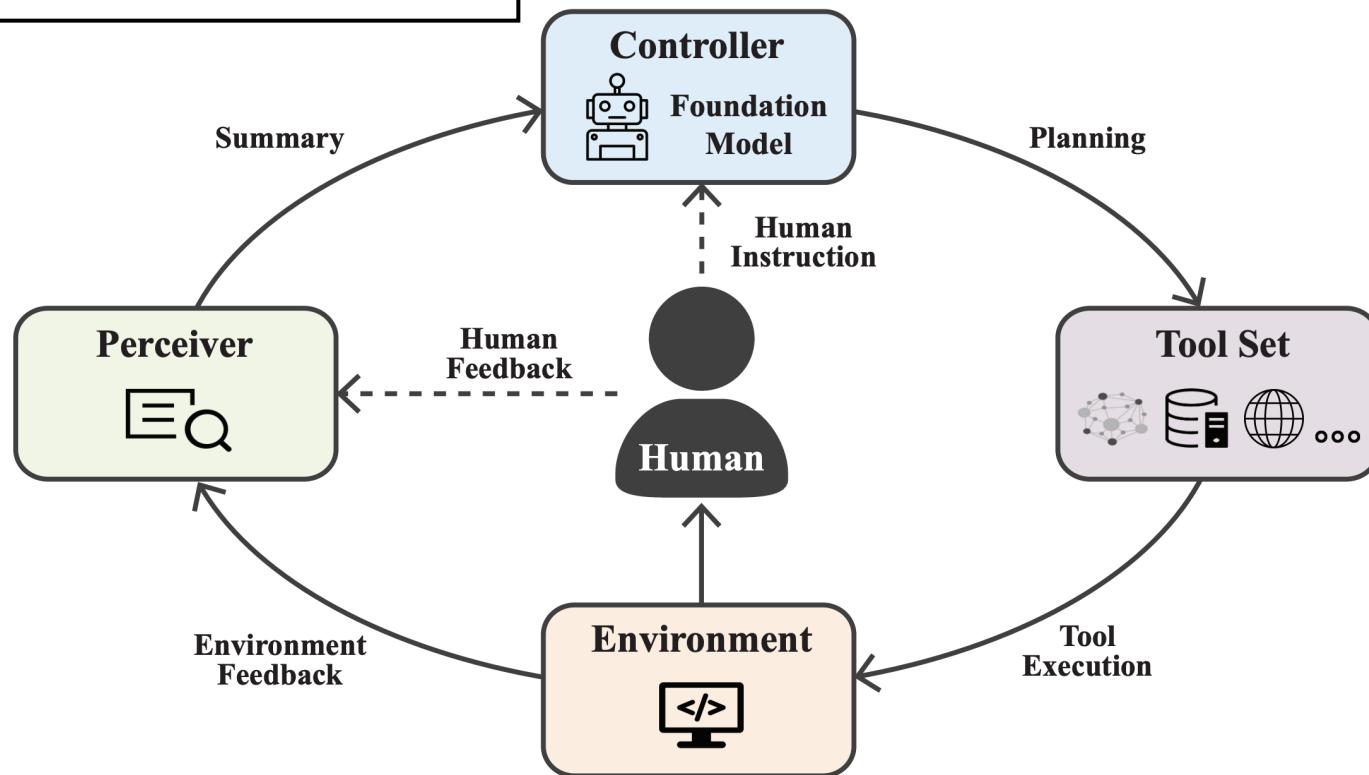
Framework

THUNLP



Framework

Controller provides feasible plans to fulfill user requests

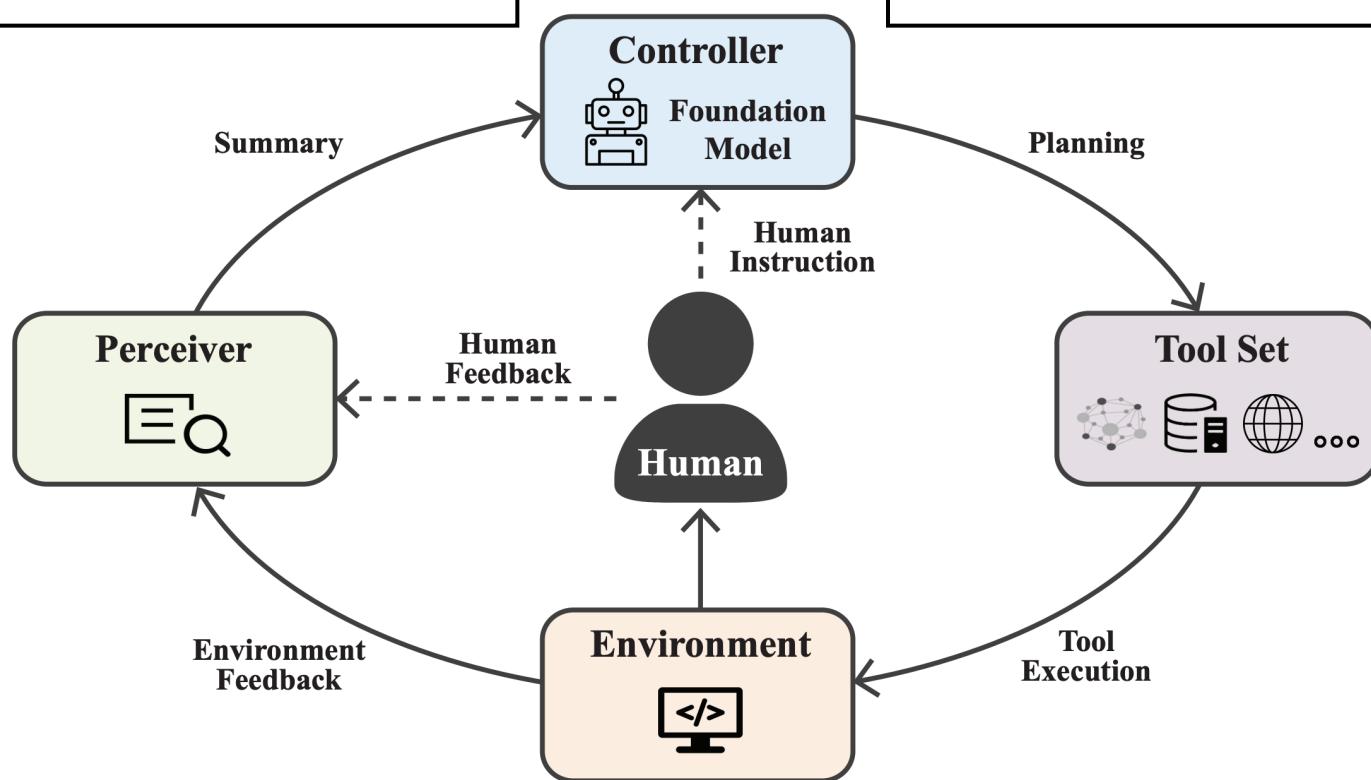




Framework

Controller provides feasible plans to fulfill user requests

Tool Set: a collection of tools with different functionalities

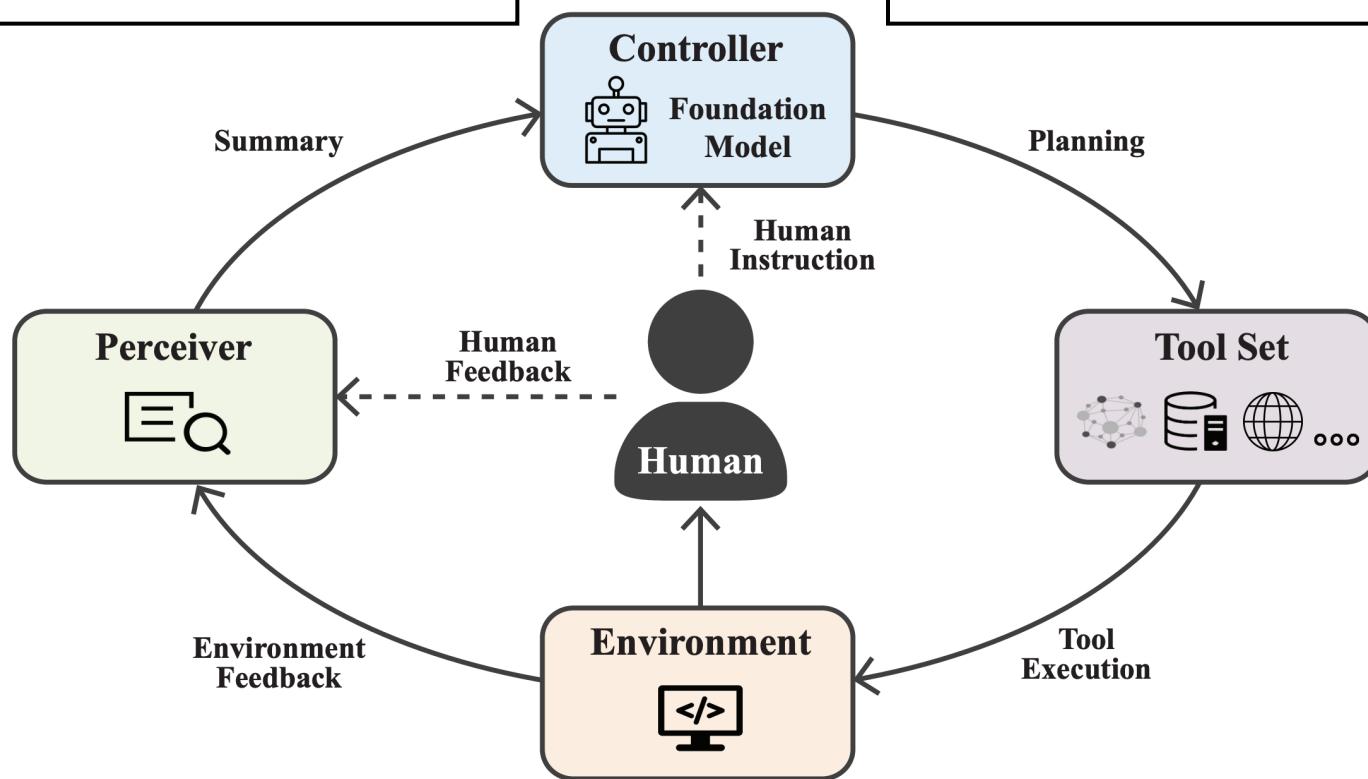




Framework

Controller provides feasible plans to fulfill user requests

Tool Set: a collection of tools with different functionalities



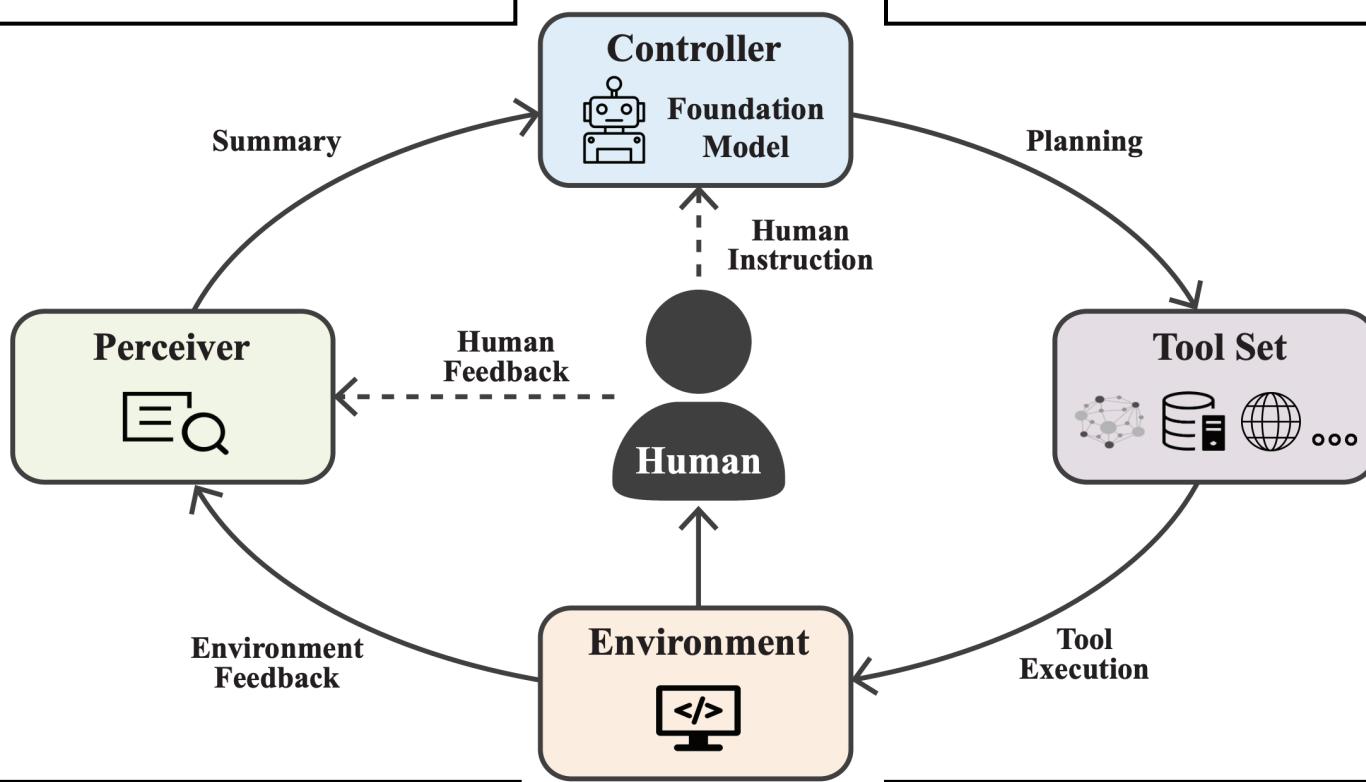
Environment provides the platform where tools operate



Framework

Controller provides feasible plans to fulfill user requests

Tool Set: a collection of tools with different functionalities



The **perceiver** summarizes feedback to the controller

Environment provides the platform where tools operate



Framework

- Controller \mathcal{C} generates a plan a_t

$$p_{\mathcal{C}}(a_t) = p_{\theta_{\mathcal{C}}}(a_t \mid x_t, \mathcal{H}_t, q)$$

Feedback History Instruction

The diagram illustrates the inputs to the controller. Three variables are shown in red boxes: x_t , \mathcal{H}_t , and q . Above the equation, three labels are positioned: "Feedback" with an arrow pointing to x_t , "History" with an arrow pointing to \mathcal{H}_t , and "Instruction" with an arrow pointing to q .

- Two sub-tasks
 - Selecting the appropriate tool based on the user intent
 - Deciding the actions to execute using the selected tool

$$p_{\theta_{\mathcal{C}}}(a_t \mid x_t, \mathcal{H}_t, q) = \sum_{\mathcal{T}_i \in \mathcal{T}} \frac{p_{\theta_{\mathcal{C}}}(a_t \mid \mathcal{T}_i, x_t, \mathcal{H}_t, q)}{p_{\theta_{\mathcal{C}}}(\mathcal{T}_i \mid x_t, \mathcal{H}_t, q)}$$

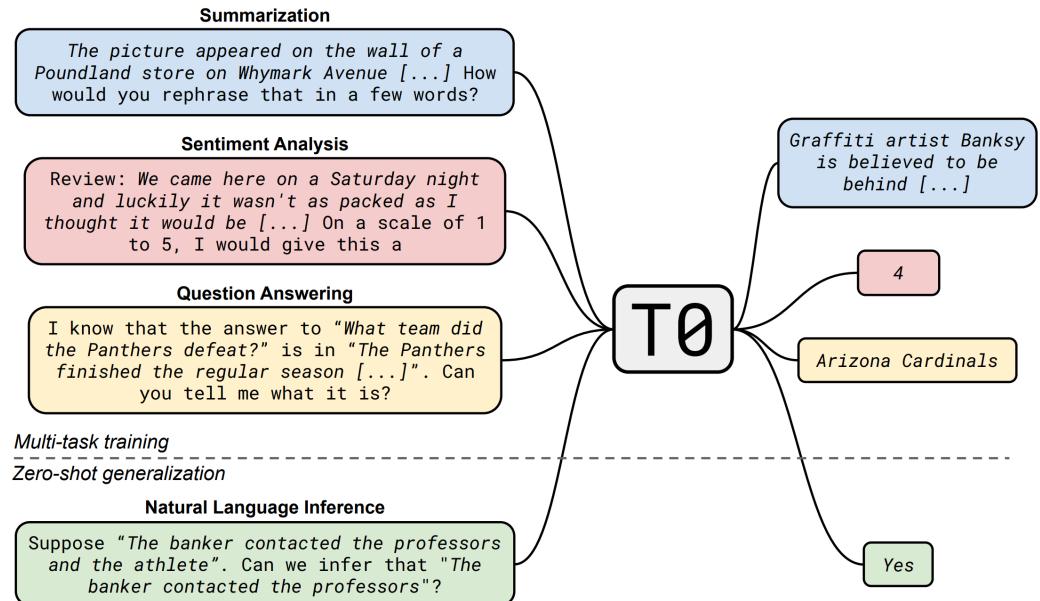


Intent Understanding

- Comprehending the underlying purpose of an instruction
- Learning a mapping from the instruction space to the model's cognition space

• Instruction Tuning

- Wrap tasks with diverse instructions
- Supervised fine-tuning
- Extraordinary generalization capability



[1] Finetuned Language Models Are Zero-Shot Learners

[2] Multitask Prompted Training Enables Zero-Shot Task Generalization

[3] OPT-IML : Scaling Language Model Instruction Meta Learning through the Lens of Generalization



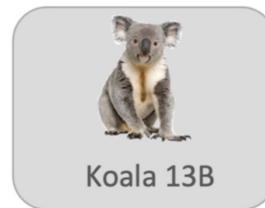
Intent Understanding

- Many amazing instruction fine-tuned foundation models

Stanford
Alpaca



Baize

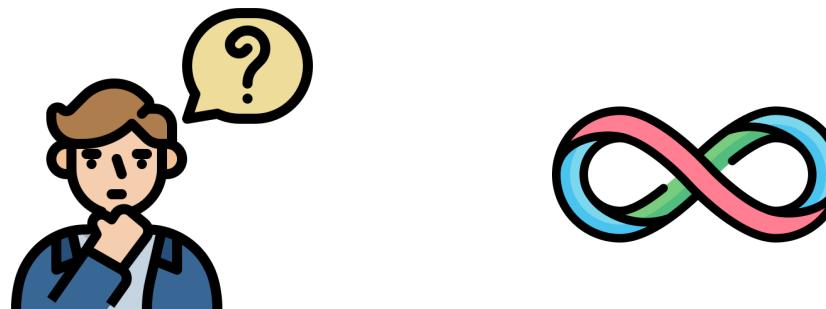


BELLE



Intent Understanding

- Scaling up the model size and the diversity of instruction-tuning datasets
 - Enhancement of generalization capability
- Challenges
 - Understanding Vague Instructions: vagueness and ambiguity in the user query
 - Theoretically Infinite Instruction Space: infinite expression and personalized instructions





Tool Understanding

- Eliciting tool understanding with prompting
- Zero-shot prompting:
 - Describe API functionalities, their input/output formats, possible parameters, etc.
 - Allow the model to understand the tasks that each API can tackle
- Few-shot prompting:
 - Provide concrete tool-use demonstrations to the model
 - By mimicking human behaviors from these demonstrations, the model can learn how to utilize these tools



Tool Understanding

- Eliciting tool understanding with prompting

Zero-shot Prompting: Here we provide a tool (API) "forecast_weather(city:str, N:int)", which could forecast the weather about a city on a specific date (after N days from today). The returned information covers "temperature", "wind", and "precipitation".

Please write codes using this tool to answer the following question: "What's the average temperature in Beijing next week?"

Few-shot Prompting: We provide some examples for using a tool. Here is a tool for you to answer question:

Question: "What's the temperature in Shanghai tomorrow?"

```
return forecast_weather("Shanghai", 1) ["temperature"]
```

Question: "Will it rain in London in next two days?"

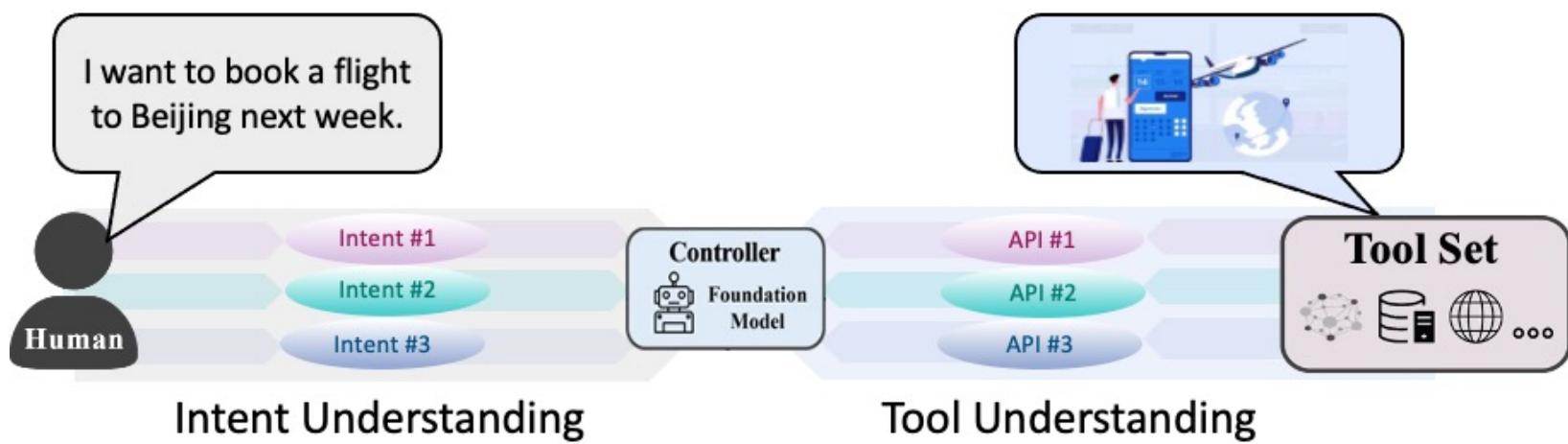
```
for i in range(2):
    if forecast_weather("London", i+1) ["precipitation"] > 0:
        return True
return False
```

Question: "What's the average temperature in San Francisco next week?"



Tool Understanding

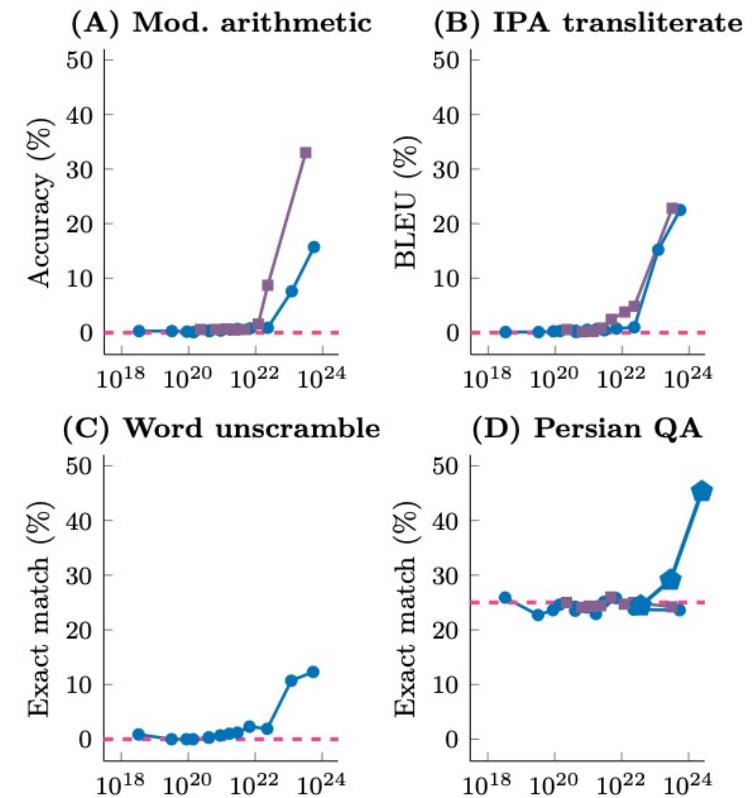
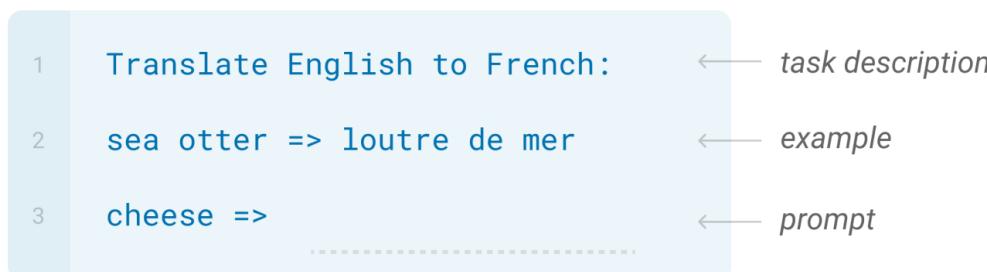
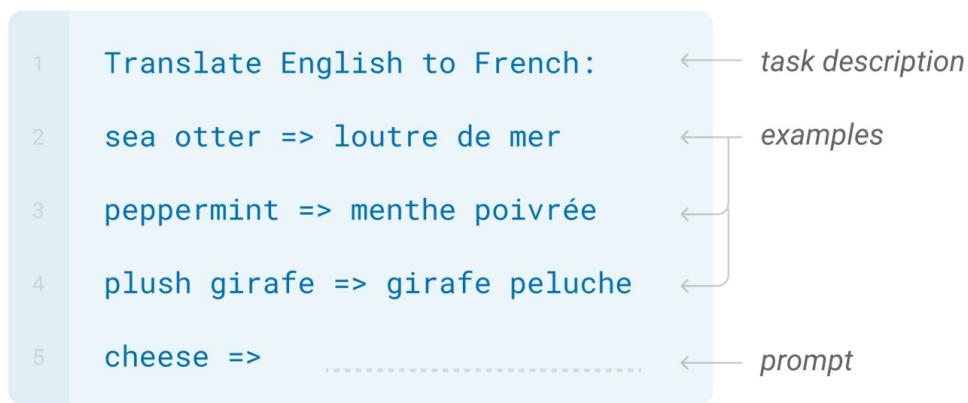
- Challenges: extremely complex tools and a large tool set
- Possible solutions:
 - **User Specification**: users point out which tools to utilize
 - **Tool Selection**: retrieve a small set of tools at first
 - **Supervised Fine-tuning**: optimize models to better understand the usage of tools





Planning and Reasoning

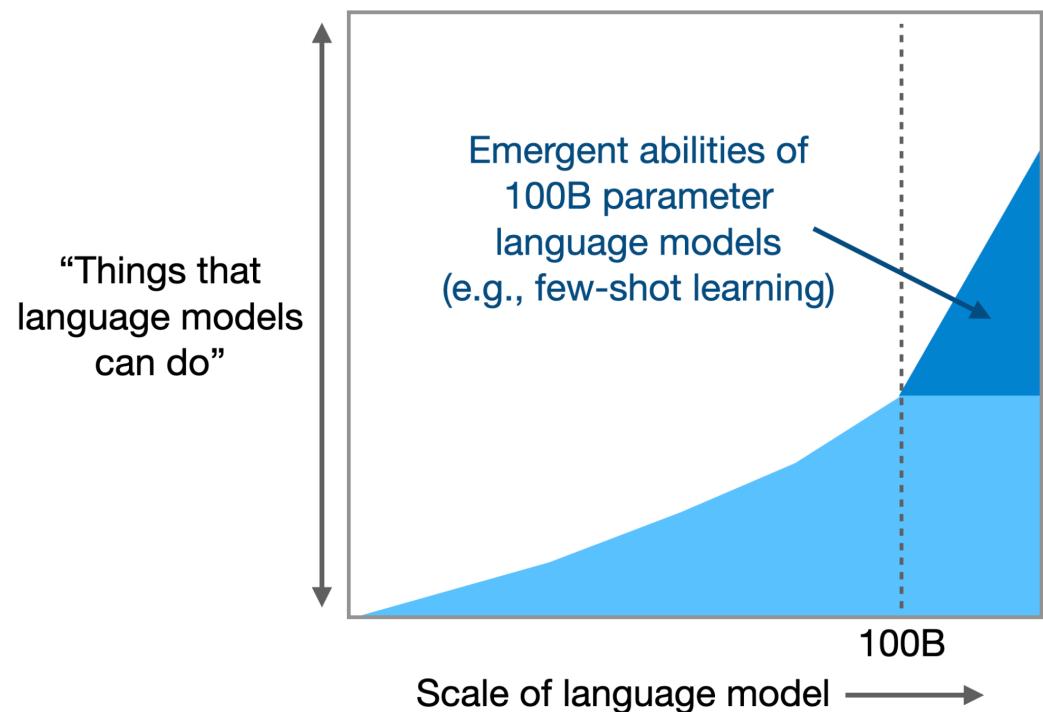
- Emergent Abilities of Foundation Models
 - Model Size \times Training Data = Training Compute
 - Example: In-context learning





Planning and Reasoning

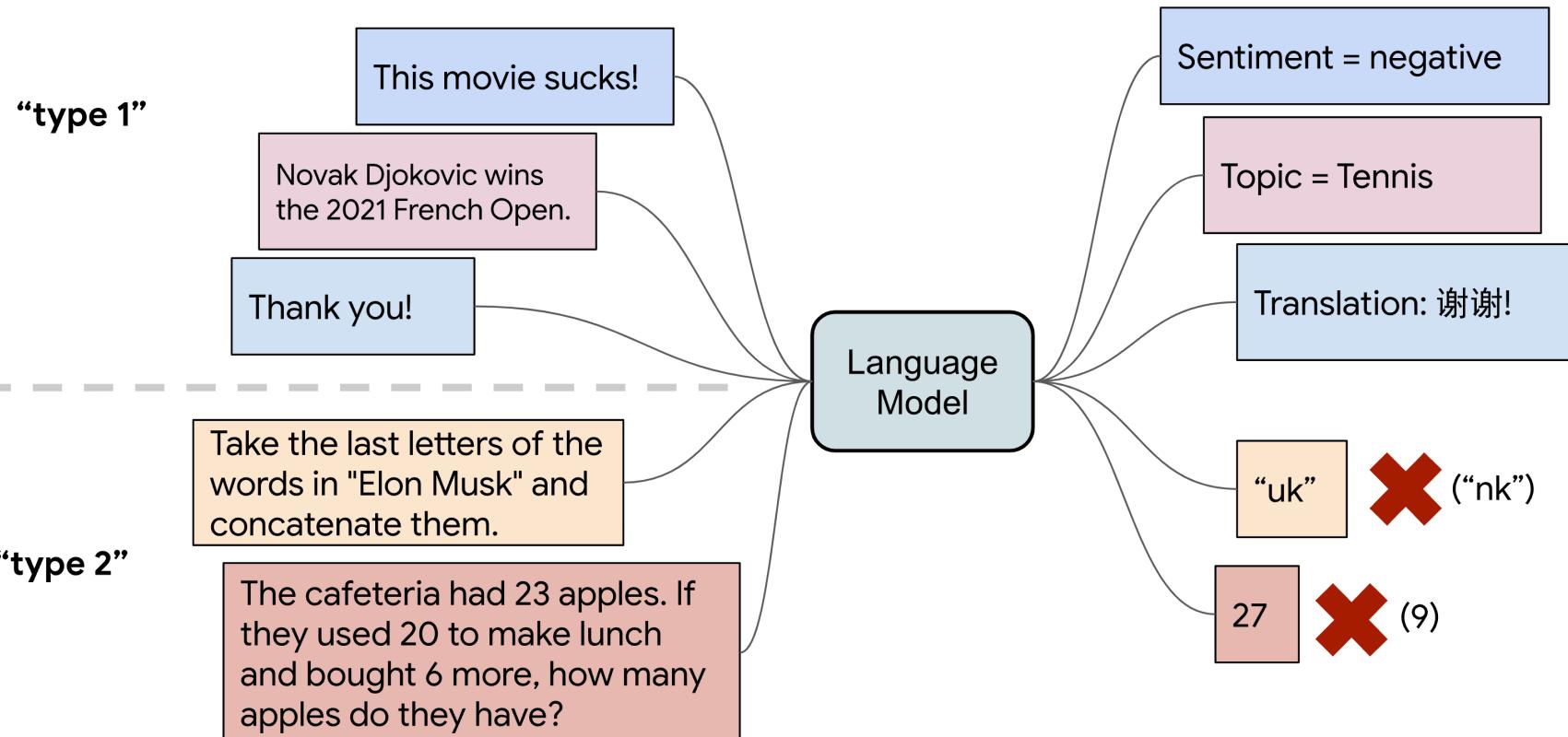
- Emergent Abilities of Foundation Models
- Four Features:
 - Unpredictable
 - Unintentional
 - Unknown unknowns
 - One model, many tasks





Planning and Reasoning

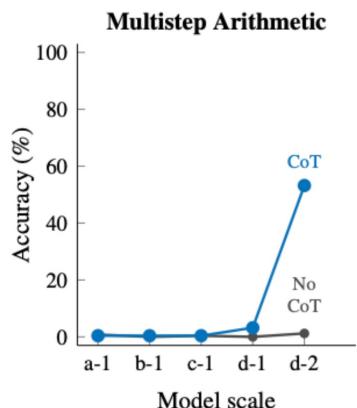
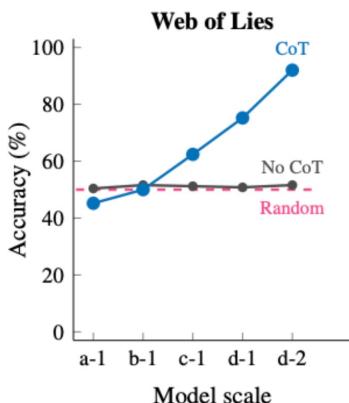
- Reasoning
 - Traditional prompting and reasoning





Planning and Reasoning

- Chain-of-thought
 - Teach models to reason
 - Think step by step



① 输入问题: Input Question

Angelo and Melanie want to plan how many hours ... how many days should they plan to study total over the next week if they take a 10-minute break every hour?

安吉洛和梅拉妮想要计划接下来一周的学习时间，如果他们每隔一个小时休息十分钟，他们应该计划多少天来学习？



思维链: Chain-of-Thought

1. Angelo and Melanie think they should dedicate 3 hours to each of the 2 chapters.
2. For the worksheets they plan to dedicate 1.5 hours for each worksheet.
3. Angelo and Melanie need to start with planning 12 hours to study, at 4 hours a day. $12/4=3$ days.

....

8. They want to study no more than 4 hours each day.
 $15 \text{ hours} / 4 \text{ hours each day} = 3.75$
9. They will need to plan to study 4 days to allow for all the time they need

1. 安吉洛和梅拉妮认为他们应该把每个章节的学习时间定为3个小时。
 2. 他们计划每个练习册花费1.5个小时的时间。
 3. 安吉洛和梅拉妮需要先规划12个小时的学习时间，每天4个小时。 $12/4=3$ 天。
-
8. 他们希望每天的学习时间不超过4个小时。 $15 \text{ 小时} / \text{每天} 4 \text{ 小时} = 3.75$ 。
 9. 他们需要计划学习4天来安排所有需要的时间。



输出答案: Output Answer

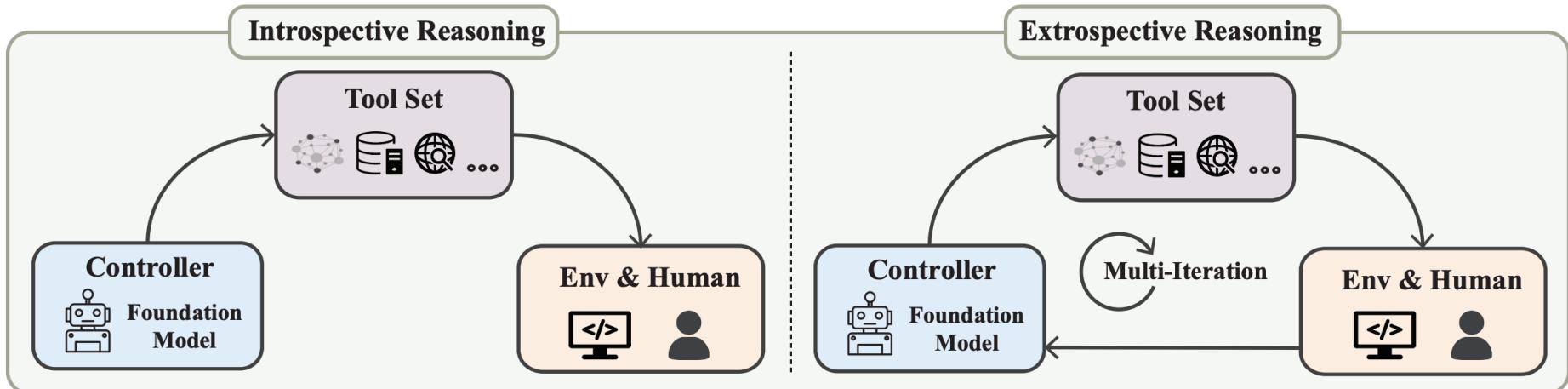
By summing up all the information, the final answer is 4 days.

总结了所有信息之后，最后的答案应该是4天



Planning and Reasoning

- Introspective Reasoning
 - Generate a static plan without interacting with the environment
- Extrospective Reasoning
 - Generate a dynamic plan considering the change of environment and feedbacks





Planning and Reasoning

- Introspective Reasoning
 - Use models to generate static plans
 - Decide the most appropriate actions and perform them

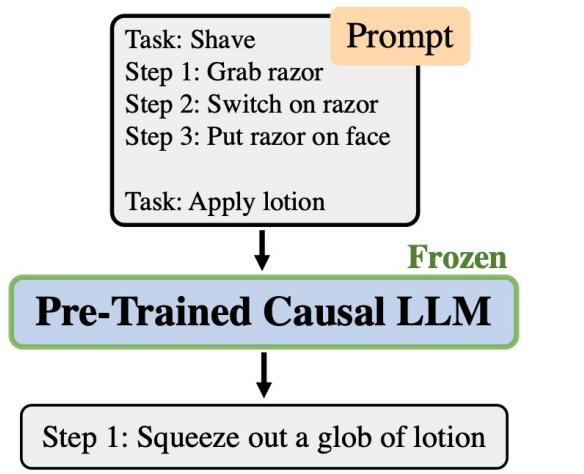




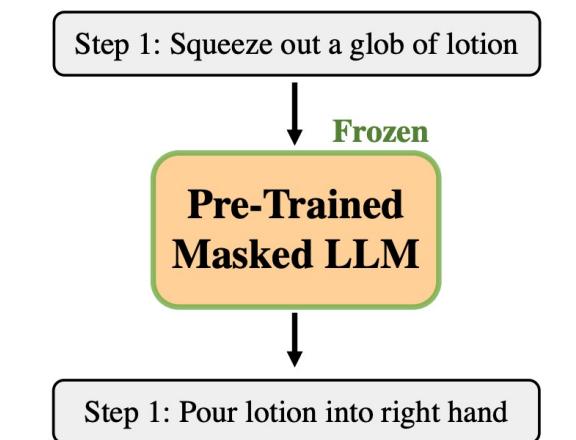
Planning and Reasoning

- Introspective Reasoning

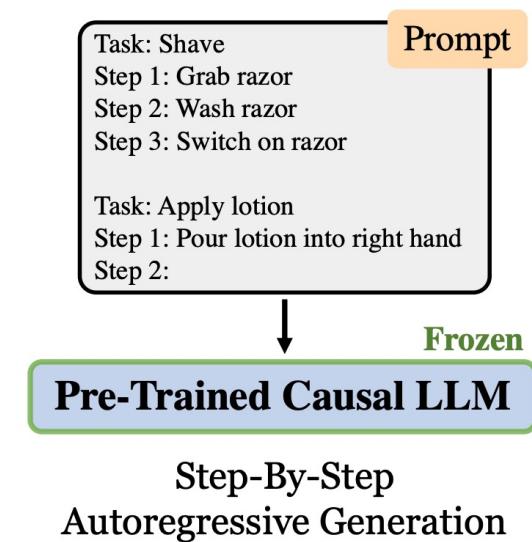
- If prompted appropriately, PLMs can effectively decompose high-level tasks into mid-level plans without any further training



Zero-Shot Planning via Causal LLM



Translation to Admissible Action





Planning and Reasoning

- Extrospective Reasoning

- Challenge: foundation models are not embodied or grounded to the physical world
- Solution: constrain the model to propose natural language actions that are both feasible and contextually appropriate

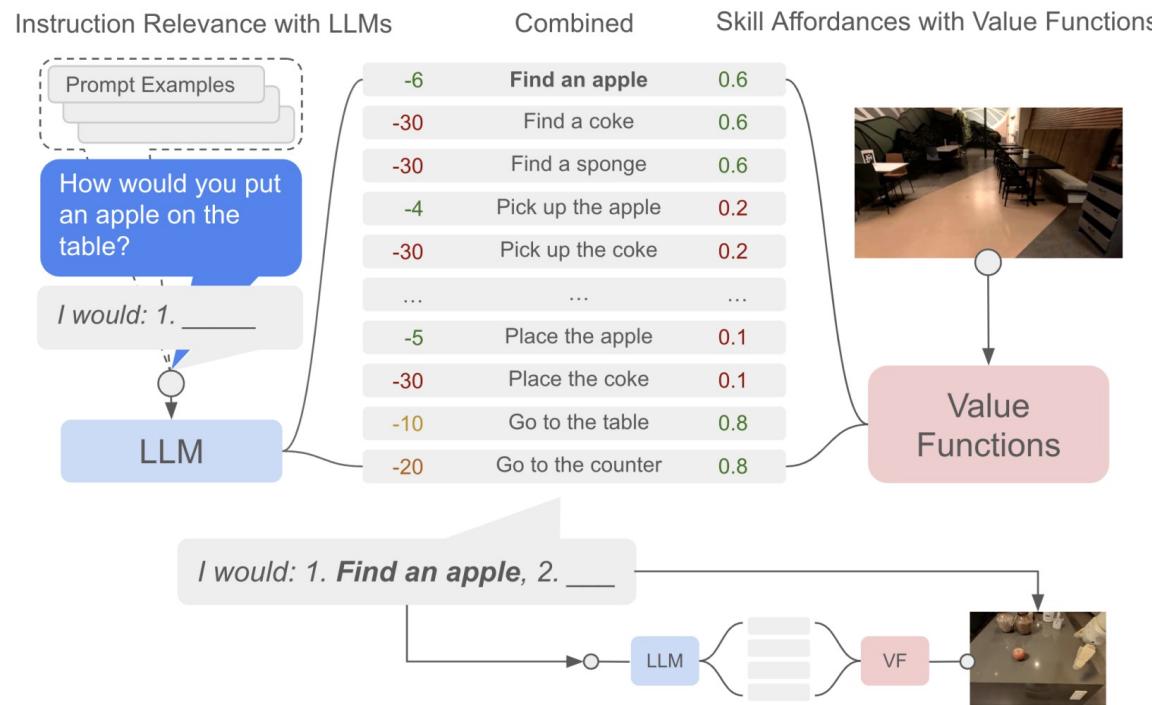


Do as I can, Not as I say!



Planning and Reasoning

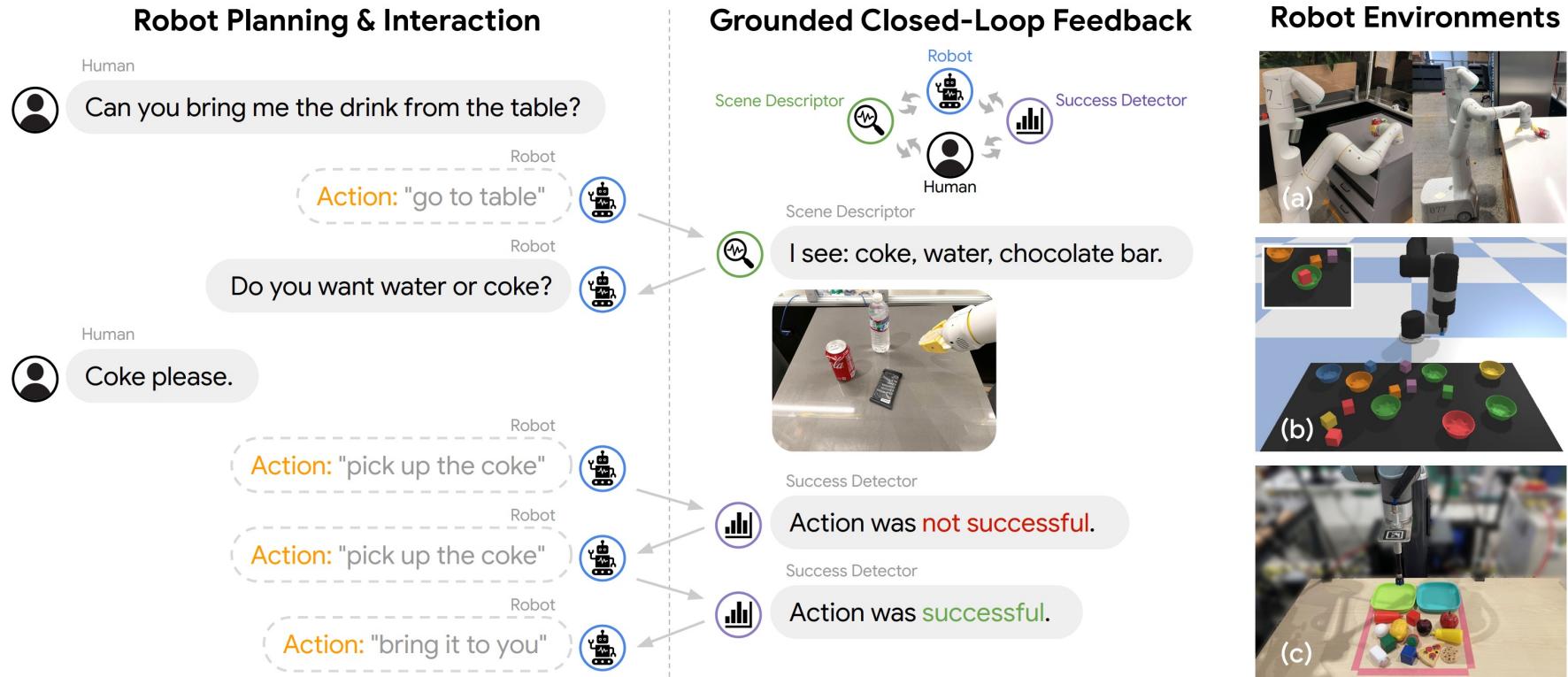
- Extrospective Reasoning
 - Combine **models** and **value functions**
 - Perform “permitted” actions
 - Value functions are based on current observations
 - The agent will be more physically grounded





Planning and Reasoning

- Extrospective Reasoning
 - Inner Monologue [1]: injecting information from various sources of feedback into model planning





Planning and Reasoning

- **ReAct:** Combining reasoning and acting
- Prompting large language models to “think” and “act” in an interleaved manner

(2) AlfWorld

You are in the middle of a room. Looking quickly around you, you see a cabinet 6, a cabinet 1, a coffee machine 1, a countertop 3, a stove burner 1, and a toaster 1.

Your task is to: Put some pepper shaker on a drawer.

(2a) Act-Only

Act 1: Go to drawer 1
Obs 1: The drawer 1 is closed.

Act 2: Open drawer 1
Obs 2: You open the drawer 1. The drawer 1 is open. In it, you see a dishponge 2, and a spoon 1.

Act 3: Go to sinkbasin 1
Obs 3: On the sinkbasin 1, you see a dishponge 3, a spatula 1, and a spoon 2.

Act 4: Take peppershaker 1 from sinkbasin 1
Obs 4: Nothing happens.

Act 5: Take peppershaker 1 from sinkbasin 1
Obs 5: Nothing happens.

X

(2b) ReAct (Reason + Act)

Act 1: Think[First I need to find a pepper shaker...more likely to appear in cabinets (1-6), countertops (1-3), ...]
Act 2: Go to cabinet 1
Obs 2: On the cabinet 1, you see a vase 2.
(Here the agent go to cabinet 1, then cabinet 2, 3, then countertop 1 and 2)
Act 6: Go to countertop 3
Obs 6: On the countertop 3, you see a apple 1, a bread 1, a pepper shaker 1, and a vase 3.
Act 7: Take pepper shaker 1 from countertop 3
Obs 7: You pick up the pepper shaker 1 from the countertop 3.
Act 8: Think[Now I find a pepper shaker 1. Next, I need to put it in/on drawer 1.]
Act 9: Go to drawer 1
Obs 9: Drawer 1 is closed.
Act 10: Open drawer 1
Obs 10: You open Drawer 1 ...
Act 11: Put pepper shaker 1 in/on drawer 1
Obs 11: You put pepper shaker 1 in/on the drawer 1.

✓



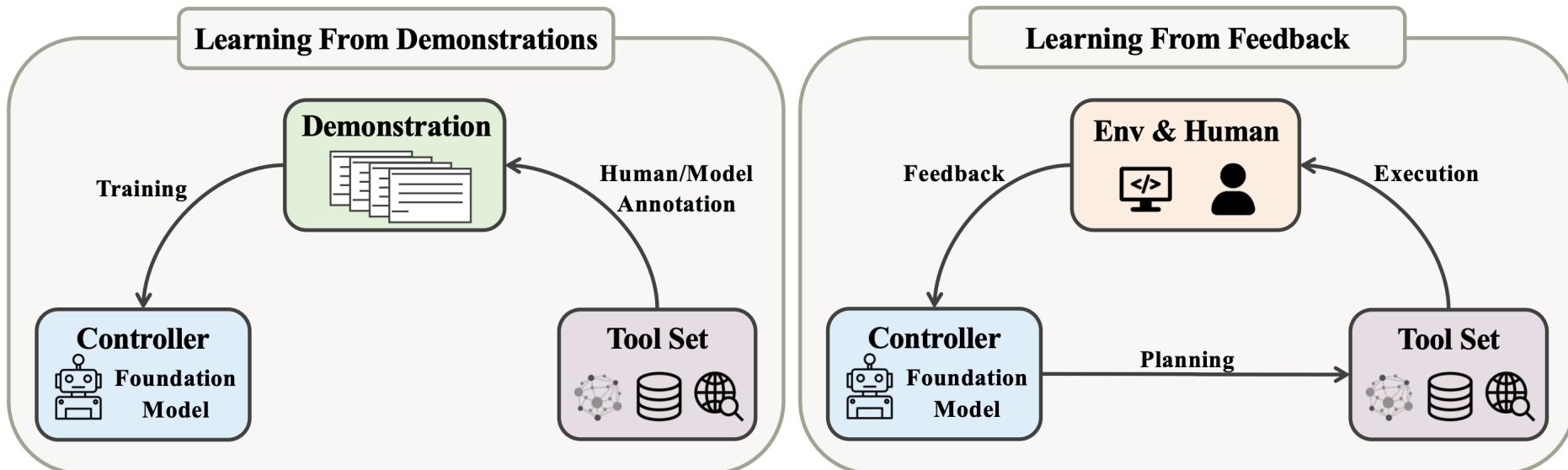
Planning and Reasoning

- Multi-step Multi-tool Scenarios
 - Humans won't stick to one scenario and one tool
- Understanding the Interplay among Different Tools
 - Models should not only understand individual tools, but learn their combination usage and order the tools logically
- From Sequential Execution to Parallel Execution
 - Tools do not have to be performed sequentially, parallel performing leads to superimposed effects
- From Single-agent Problem-Solving to Multi-agent Collaboration
 - Complex tasks often necessitate collaboration among multiple agents, each with their unique expertise



Training Strategies

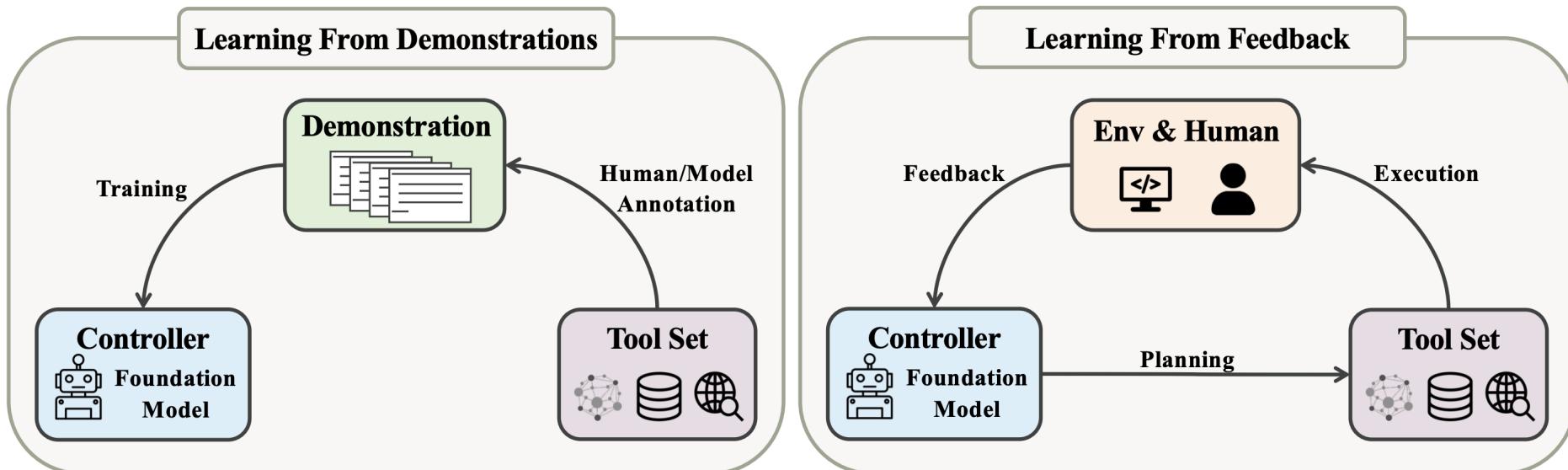
- Tool learning does not have to rely on frozen models
 - We can train models with supervision, either from demonstrations or feedback





Training Strategies

- **Learning from demonstrations:** often involves (human) annotations
- **Learning from feedback:** often involves reinforcement learning





Training Strategies

- **Learning from demonstrations:** often involves annotations

$$\theta_{\mathcal{C}}^* = \arg \max_{\theta_{\mathcal{C}}} \mathbb{E}_{(q_i, a_i^*) \in \mathcal{D}} \prod_{t=0}^{T_i} p_{\theta_{\mathcal{C}}}(a_{i,t}^* \mid x_{i,t}, \mathcal{H}_{i,t}, q_i),$$

- **Supervised Learning:**
 - Behavior cloning / imitation learning
- **Semi-supervised Learning:**
 - Construct weak, noisy supervision from large-scale unlabeled data
- **Self-supervised Learning:**
 - Leverage the in-context learning ability of foundation models to bootstrap tool-use examples



Training Strategies

- **Learning from feedback:** often involves reinforcement learning

$$\theta_C^* = \arg \max_{\theta_C} \mathbb{E}_{q_i \in Q} \mathbb{E}_{\{a_{i,t}\}_{t=0}^{T_i} \in p_{\theta_C}} \left[R(\{a_{i,t}\}_{t=0}^{T_i}) \right],$$

- Reinforcement Learning (RL) for Tool Learning
 - Action space is defined based on tools
 - Agent learns to select the appropriate tool
 - Perform the correct actions that maximize the reward signal



WebGPT

• Supervised Learning OpenAI

- Clone human behavior to use search engines
- Supervised fine-tuning + reinforcement learning
- Only need 6,000 annotated data

How can I train the crows in my neighborhood to bring me gifts?

This question does not make sense | This question should not be answered

Search results for: how to train crows to bring you gifts Quotes ↗

← how to train crows to bring Find in page ↑ + Add new quote

[How to Make Friends With Crows - PetHelpful](#)
If you did this a few times, your crows would learn your new place, but as I said, I'm not sure if they will follow or visit you there since it's probably not in their territory. The other option is simply to make new crow friends with the crows that live in your new neighborhood.

[Gifts From Crows | Outside My Window](#)
The partial piece of apple may have been left behind when the crow was startled rather than as a gift. If the crows bring bright objects you'll know for sure that it's a gift because it's not something they eat. Brandi Williams says: May 28, 2020 at 7:19 am.

↑ ↑ ↑ ↓

[1] Gifts From Crows | Outside My Window (www.birdsoutsidemywindow.org)
Many animals give gifts to members of their own species but crows and other corvids are the only ones known to give gifts to humans.

Number of quote tokens left: 463
Number of actions left: 96

Done quoting! Write an answer

♦Question
How can I train the crows in my neighborhood to bring me gifts?

♦Quotes
From Gifts From Crows | Outside My Window (www.birdsoutsidemywindow.org)
> Many animals give gifts to members of their own species but crows and other corvids are the only ones known to give gifts to humans.

♦Past actions
Search how to train crows to bring you gifts
Click Gifts From Crows | Outside My Window www.birdsoutsidemywindow.org
Quote Back

♦Title
Search results for: how to train crows to bring you gifts

♦Scrollbar: 0 - 11

♦Text
[0] How to Make Friends With Crows - PetHelpful [pethelpful.com]
If you did this a few times, your crows would learn your new place, but as I said, I'm not sure if they will follow or visit you there since it's probably not in their territory. The other option is simply to make new crow friends with the crows that live in your new neighborhood.

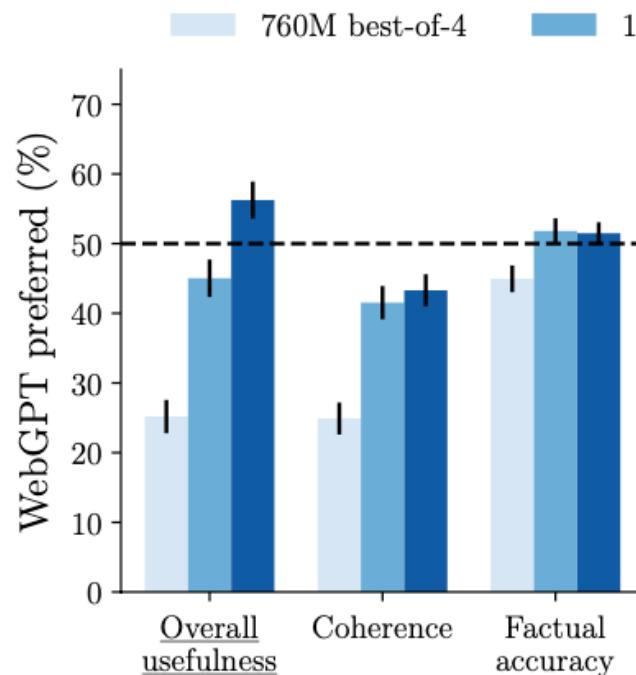
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♦Actions left: 96
♦Next action

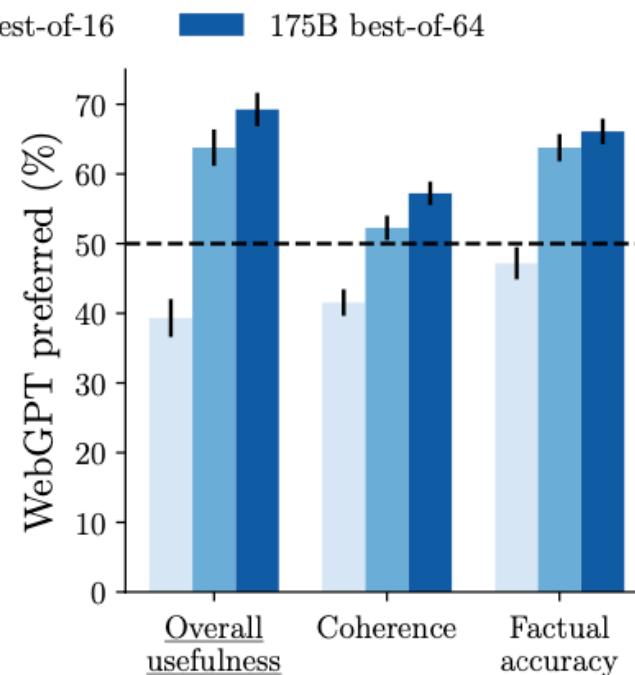


WebGPT

- Supervised Learning OpenAI
 - Excellent performance in long-form QA, even surpassing human experts



(a) WebGPT vs. human demonstrations.



(b) WebGPT vs. ELI5 reference answers.



WebCPM

- Motivation
 - WebGPT is **not public**, and its inner workings remain opaque
- Our Efforts (WebCPM)
 - Open-source interactive web search interface
 - The **first public** QA dataset that involves interactive web search, and also the first Chinese LFQA dataset
 - Framework and Model Implementation

WEBCPM: Interactive Web Search for Chinese Long-form Question Answering

**Yujia Qin¹, Zihan Cai¹, Dian Jin¹, Lan Yan¹, Shihao Liang³, Kunlun Zhu³,
Yankai Lin^{2*}, Xu Han¹, Ning Ding¹, Huadong Wang¹, Ruobing Xie⁴, Fanchao Qi¹,
Zhiyuan Liu^{1*}, Maosong Sun^{1*}, Jie Zhou⁴**

¹NLP Group, DCST, IAI, BNRIST, Tsinghua University, Beijing

²Gaoling School of Artificial Intelligence, Renmin University of China, Beijing

³ModelBest Inc. ⁴Pattern Recognition Center, WeChat AI, Tencent Inc.

qyj20@mails.tsinghua.edu.cn



• Interface (search mode) and pre-defined actions

Question | 麦田怪圈是什么？它们是如何形成的？ *What are crop circles? How are they made?*

Query | 麦田怪圈如何形成？ *How do crop circles form?*

Window (search mode)



2/9

Undo Reset

Quote

Merge

Fact #1 2023-01-21 19:59:00

麦田圈是指通过压扁农作物产生的几何图案...

Crop circle refers to a geometric pattern produced by flattening crops ...

Fact #2 2023-01-21 20:05:12

Content of Fact #2

...

难解谜团：麦田怪圈究竟是如何形成的？ Page <1>
Unsolved mysteries: How did crop circles form?

麦田怪圈出现最多的季节是在春天和夏天，有人认为，夏季天气变化无常，龙卷风是造成怪圈的主要原因...
The crop circles appear most often in spring and summer.
Some people think that the weather in summer is erratic, and tornadoes are the main cause of the strange circles...

Title of page <2> Page <2>
A snapshot of the page content

Title of page <3> Page <3>
A snapshot of the page content

← Go Back

Number of remaining actions (86/100)

Finish

Action Name	Functionality
Search <query>	Call Bing search with <query>
← Go Back	Return to the previous window
Load Page <1>	Load the details of page <1>
Load Page <2>	Load the details of page <2>
Load Page <3>	Load the details of page <3>
↑ Scroll Up	Scroll up for a pre-set stride
↓ Scroll Down	Scroll down for a pre-set stride
Quote <content>	Extract <content> from the current page as a supporting fact
↑ Merge	Merge two facts into a single fact
Finish	End the search process



- Interface (browsing mode)

Question | 麦田怪圈是什么？它们是如何形成的？*What are crop circles? How are they made?*

Query | 麦田怪圈如何形成？*How do crop circles form?*

Window (browsing mode)

麦田怪圈是指在麦田上，通过某种未知力量把农作物压平而产生出来的几何图案。相当一部分人认为，所谓麦田怪圈只是某些人的恶作剧。英国科学家安德鲁经过长达17年的调查研究认为，麦田怪圈有80%属于人为制造...
Crop circles refer to geometric patterns produced by flattening crops by some unknown force on wheat fields. A considerable number of people believe that the so-called crop circles are just some people's prank. After 17 years of investigation and research, British scientist Andrew believes that 80% of the crop circles are man-made...

1/3

Undo **Reset**

Quote **Merge**

Fact #1 2023-01-21 19:59:00
麦田圈是指通过压扁农作物产生的几何图案...
crop circle refers to a geometric pattern produced by flattening crops ...

Fact #2 2023-01-21 20:05:12
< content of Fact #2>
...

Go Back Number of remaining actions (85/100) **Finish**



WebCPM

记录工具 帮助记录操作行为 [更多] 98 / 100 记录中
剩余操作次数提示区域

记录工具 帮助记录操作行为 [更多] 98 / 100
剩余操作次数提示区域

记录工具 帮助记录操作行为 [更多] 91 / 100
摘要

关键词搜索框

搜索结果展示区

摘要展示区

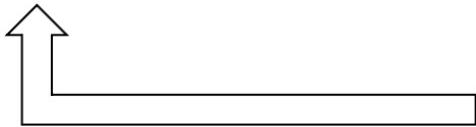
STEP 1
输入当前要搜索的子问题并点击搜索



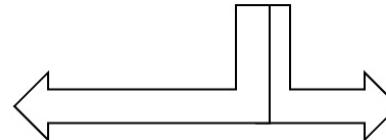
STEP 2
选择下一步操作是搜索/下翻/返回等



STEP 3
从当前界面里找出需要摘的部分



STEP 1-3
重复若干次



STEP 4
人工整理成最终答案



WebCPM

- 黑客是如何对计算机进行攻击的？

The screenshot shows the WebCPM search interface. At the top, there is a search bar with a magnifying glass icon, a "Clear" button, and a prominent blue "START" button with a green dot. Below the search bar, there are two input fields: one for entering a search query and another for "Search". To the right of these fields are buttons for "摘要" (Summary), "将选中的内容添加到摘要" (Add selected content to summary), and "合并摘要" (Merge summary). A "返回 (0)" (Return (0)) link is also present. The main content area displays a message "暂无内容" (No content) and a large empty box labeled "暂无内容" (No content). Navigation arrows (< >) are located above the main content area.



- Interface (browsing mode)

Question | 麦田怪圈是什么？它们是如何形成的？*What are crop circles? How are they made?*

Query | 麦田怪圈如何形成？*How do crop circles form?*

Window (browsing mode)

麦田怪圈是指在麦田上，通过某种未知力量把农作物压平而产生出来的几何图案。相当一部分人认为，所谓麦田怪圈只是某些人的恶作剧。英国科学家安德鲁经过长达17年的调查研究认为，麦田怪圈有80%属于人为制造...
Crop circles refer to geometric patterns produced by flattening crops by some unknown force on wheat fields. A considerable number of people believe that the so-called crop circles are just some people's prank. After 17 years of investigation and research, British scientist Andrew believes that 80% of the crop circles are man-made...

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crop circle refers to a geometric pattern produced by flattening crops ...

Fact #2 2023-01-21 20:05:12
< content of Fact #2>
...

Go Back Number of remaining actions (85/100) **Finish**



WebCPM

- WebCPM contains 5,500 high-quality question-answer pairs, together with 14,315 supporting facts and 121,330 web search actions
- Data format: <question, web search actions, supporting facts, answer>

Resource	IWSQA (this work)	DuReader (He et al., 2018)	CMRC (Cui et al., 2019)	C ³ (Sun et al., 2020)	WebGPT (Nakano et al., 2021)	GopherCite (Menick et al., 2022)
Language?	ZH	ZH	ZH	ZH	EN	EN
Is Public?	✓	✓	✓	✓	✗	✗
Targets long-form QA?	✓	✗	✗	✗	✓	✓
Has free-form answer?	✓	✓	✗	✗	✓	✓
Has web search behavior?	✓	✗	✗	✗	✓	✗
Avg. question length	29.0	9.6	16.3	12.2	—	—
Avg. supporting fact length	512.5	187.3	495.5	116.9	—	—
Avg. answer length	244.4	104.9	17.0	5.5	—	—



WebCPM

Question:

麦田怪圈是什么？它们是如何形成的？

Action Sequence:

Search → Load Page <1> → Scroll Down × 5 → Scroll Up → Scroll Down × 11 → Go Back → Search → Load Page <1> → Go Back → Load Page <3> → Scroll Down × 4 → Scroll Up × 3 → Quote → Scroll Down → Quote → Scroll Down → Quote → Scroll Down → Quote → Finish

Supporting Facts:

1. 麦田怪圈（Crop Circle），是指在麦田或其它田地上，通过某种未知力量（大多数怪圈是人类所为）把农作物压平而产生出来的几何图案。这个神秘现象有时被人们称之为“Crop Formation”。麦田怪圈的出现给了对支持外星人存在论的人们多种看法。
2. 人为说：人为说一般认为，麦田圈是用木板压成的。木板两头系上绳子形成圈套，在制作时，一脚踩在木板上拖动木板压倒麦子，并拉着细绳与圆心保持固定的距离，逐渐就可以形成一个圆圈。为了便于制造，主要形状所有圆圈的直径都可以被6除尽。以前曾经出现过制作麦田圈被当场抓获的事情，制作者使用的就是这种工具。
3. 自然形成说：也有人认为，麦田圈只是一种，成因还未被人类发现。就像雷电，古时候人类也是以为是雷神电母做的，对于麦田圈中经常出现人文信息的现象，他们认为这只是人们“先入为主”造成的错觉。
4. 磁场说：有专家认为，磁场中有一种神奇的移动力，可产生一股电流，使农作物“平躺”在地面上。美国专家杰弗里·威尔逊研究了130多个麦田怪圈，发现90%的怪圈附近都有连接高压电线的变压器，方圆270米内都有一个水池。由于接受灌溉，麦田底部的土壤释放出的离子会产生负电，与高压电线相连的变压器则产生正电，负电和正电碰撞后会产生电磁能，从而击倒小麦形成怪圈。

Answer:

麦田怪圈是指在麦田或其它田地上，通过某种未知力量（大多数怪圈是人类所为）把农作物压平而产生出来的几何图案。**【1】**而麦田怪圈的形成有三个说法，人为说、自然说与磁场说。人为说一般认为，麦田圈是用木板压成的。木板两头系上绳子形成圈套，在制作时，一脚踩在木板上拖动木板压倒麦子，并拉着细绳与圆心保持固定的距离，逐渐就可以形成一个圆圈。为了便于制造，主要形状所有圆圈的直径都可以被6除尽。**【2】**自然形成说认为麦田怪圈的成因还未被人类发现。就像雷电，古时候人类也是以为是雷神电母做的，对于麦田圈中经常出现人文信息的现象，他们认为这只是人们“先入为主”造成的错觉。**【3】**磁场说认为，磁场中有一种神奇的移动力，可产生一股电流，使农作物“平躺”在地面上。**【4】**



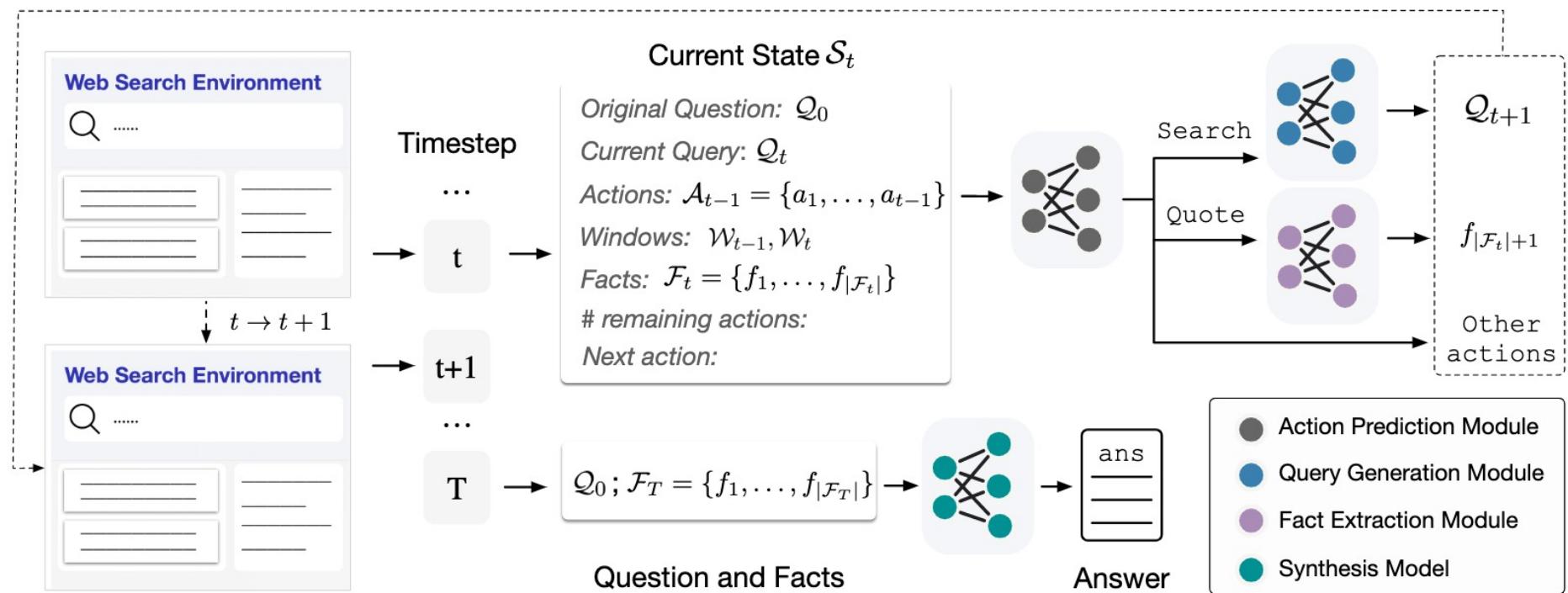
WebCPM

- Our framework consists of two models:
- 1. Search model, consisting of:
 - Action prediction module
 - Search query generation module
 - Supporting fact extraction module
- 2. Information synthesis model



WebCPM

For an action sequence of T steps, the **search model** executes actions to collect supporting facts, which are sent to the **synthesis model** for answer generation.





WebCPM



Textual Input for PLM

Interface

记录工具 辅助记录搜索行为 | 记录中

剩余操作步骤 85 / 100

< 返回(1) 黑客是如何对计算机进行攻击的 Q

撤消 重置

浏览内容 内容查找 Q 下一上一 1/8

大白话讲解，小白也能懂，黑客是如何攻击你的电脑的！ - 知乎
有位朋友留言想了解黑客是如何攻击电脑的。今天大白就用通俗的语言给大家讲解一下。我们使用电脑最终使用的软件，是操作系统，也就是你看到的windows界面，所以关键点就在于对这个操作系统windows的理解上。类...

黑客是怎么侵入别人电脑的？ - 腾讯云开发者社区-腾讯云
黑客入侵讲解分析-黑客是怎么入侵别人电脑的？.1、获取口令 这又有三种方法：一是通过网络监听非法得到用户口令，这类方法有一定的局限性，但危害性极大，监听者往往能够获得其所在网段的所有用户账号和口令，对局域网安全威胁巨大；二是在知道用户...

黑客是如何发起网络攻击的？ - 腾讯云开发者社区-腾讯云
电脑是如何变成“肉鸡”？.1、入侵主机漏洞.不法黑客的入侵个人PC电脑，先是针对网络用户的主机进行安全能力扫描，专找那些安全系数较低、有安全漏洞的主机进行入侵。.2、用户点击危险链接、下载未知文件.黑客除了主动去入侵外，还有一些黑客通过在...

问题：“黑客是如何对计算机进行攻击的？”，
摘要：“摘要0：不法黑客的入侵个人PC电脑，先是针对网络用户的主机进行安全能力扫描，专找那些安全系数较低、有安全漏洞的主机进行入侵。
摘要1：黑客除了主动去入侵外，还有一些黑客通过在一些网站、软件等下载包中设下陷阱——软件或文件时可能就会被植入病毒，进而被不法黑客控制，电脑最终沦为“肉鸡”。”，
当前搜索问题：“黑客是如何对计算机进行攻击的？”，
"last_view": "近日，某网络游戏遭到DDOS攻击导致服务器崩溃，大量玩家频繁掉线，游戏长时间无法登录，严重影响玩家体验和口碑，使得该网络游戏用户量大幅度下降。
什么是DDoS攻击？
DDoS攻击翻译中文为“分布式拒绝服务”，主要通过大量僵尸网络“肉鸡”模拟合法用户请求占用大量网络资源，以达到瘫痪服务器和网络的目的。而用来发起攻击的僵尸网络“肉鸡”主要是我们常用的电脑，随着物联网设备的不断发展，现在“肉鸡”的主要来源逐渐从传统PC转向物联网设备。
电脑是如何变成“肉鸡”？
不法黑客的入侵个人PC电脑，先是针对网络用户的主机进行安全能力扫描，专找那些安全系数较低、有安全漏洞的主机进行入侵。
2、用户点击危险链接、下载未知文件
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当你的电脑成为“肉鸡”后，黑客一般会进行“潜伏”，平常用户在使用过程中也感觉不到电脑有什”，
当前界面：“近日，某网络游戏遭到DDOS攻击导致服务器崩溃，大量玩家频繁掉线，游戏长时间无法登录，严重影响玩家体验和口碑，使得该网络游戏用户量大幅度下降。
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当你的电脑成为“肉鸡”后，黑客一般会进行“潜伏”，平常用户在使用过程中也感觉不到电脑有什”，
剩余操作步数：“95”，
历史操作：“开始；搜索黑客是如何对计算机进行攻击的？；一号页面黑客是如何发起网络攻击的？ - 云+社区 - 腾讯云 - Tencent；新增摘要；新增摘要；”，
下一步操作：“下翻”



WebCPM

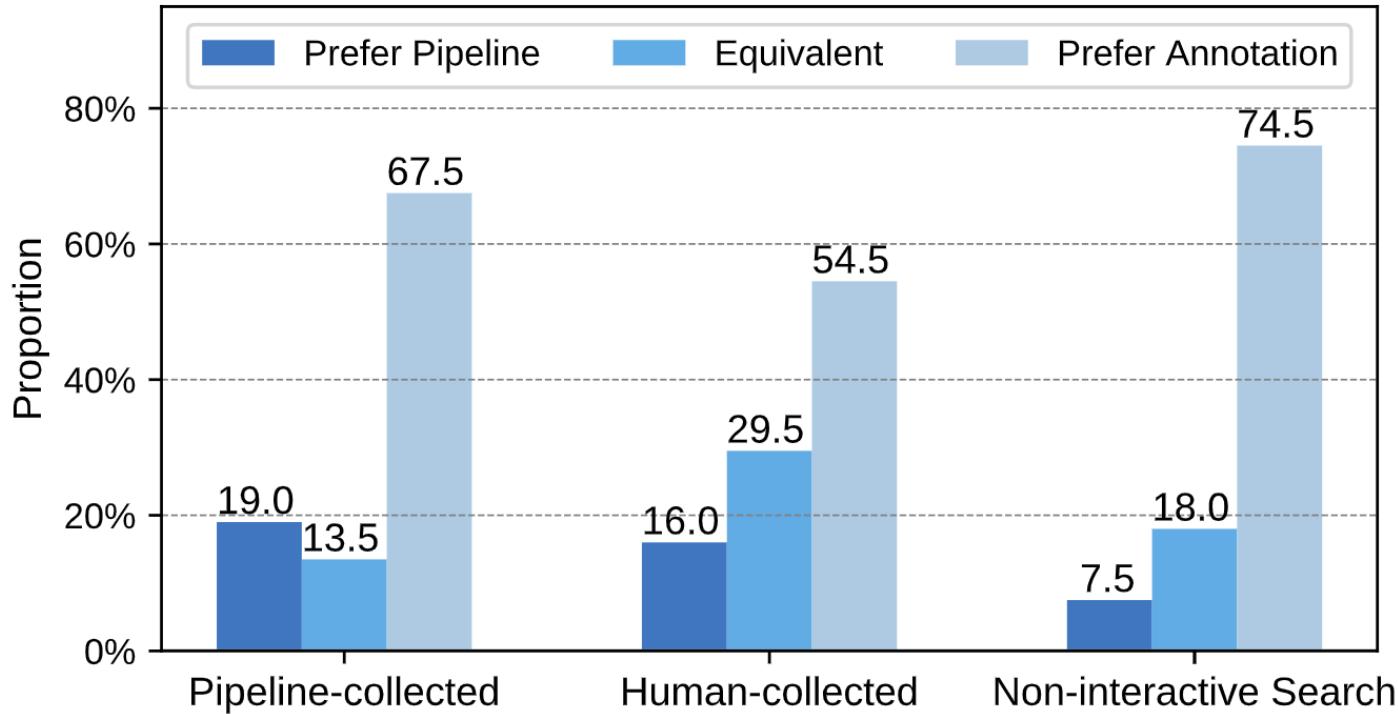
Holistic Pipeline Evaluation (based on human preference)

Model-generated Answer v.s. Human Annotation

Three sources of supporting facts are sent to the synthesis model

(1) pipeline-collected, (2) human-collected, (3) non-interactive search (TF-IDF)

(a) Pipeline Evaluation on Our Test Set





WebCPM

- Query Strategies:
- Copying the original question
- Decomposing the question into multiple sub-questions
- Rephrasing questions with related terms
- ...

Question and Generated Query

计算机科学与电气工程有什么区别？优缺点是什么？
What's the difference between computer science and electrical engineering? What are their advantages and disadvantages?

- [1] 计算机科学与工程 *Computer science and engineering*
- [2] 电气工程是什么 *What is electrical engineering*
- [3] 计算机科学的优缺点 *Advantages and disadvantages of computer science*

为什么在你累的时候揉眼睛感觉这么好？
Why does it feel good to rub your eyes when you're tired?

- [1] 为什么在你累的时候揉眼睛感觉这么好？ *Why does it feel good to rub your eyes when you're tired?*
- [2] 累的时候揉眼睛 *Rubbing your eyes when you're tired*
- [3] 眼睛酸了累了手揉一揉就缓解 *Rubbing your eyes relieves fatigue when your eyes are tired and sore*
- [4] 眼保健操缓解眼睛疲劳 *Eyecare exercise relieves eye fatigue*



WebShop

- Learning to perform online shopping

A
Instruction:
I'm looking for a small portable folding desk that is already fully assembled; it should have a khaki wood finish, and price lower than 140.00 dollars
Search
Results:
1. portable folding desk khaki wood
2. results
Description: Product laptop desk. Product weight: walnut. Product weight: 4.6 pounds. Material: high quality thick steel pipe, black brushed sheet. Special design: black brushed smooth table top, increase the length and width of the table, it is possible to place the computer and various items. Function: Can be used as computer desk, dining table, bedside table. Product size: 23.6x15.7x11 inches
item-detail
Large Size Styling with light weight
Holds laptops up to 17 inches. It also have spacious space (23.6x15.7x11 inches) for your laptop, notebook, mouse, pen and coffee. Its generous size gives this versatile desk even more flexibility.
Wide Application Our foldable lap desk can be used as a
item-detail
MENHG Folding Laptop Table Bed Desk PC Lap Desk with Drawer Book Stand Reading Holder Leg Space Laptop Bed Tray Foldable Lazy Table Breakfast Desk Sofa Small Desk for Small Space
Price: \$100.00 Rating: N/A
Description Overview Buy Now
Color: black, khaki, white
Reward: 1.0
4.1 4.2 3

B
Instruction:
I'm looking for a small portable folding desk that is already fully assembled [...]
[btn] Back to Search [/btn]
Results:
Page 1 (Total results: 50) [btn] Next [/btn]
[btn] MENHG Folding Breakfast Tray [...] [/btn]
\$109.0
[btn] KPSP Folding Study Desk Bed [...] [/btn]

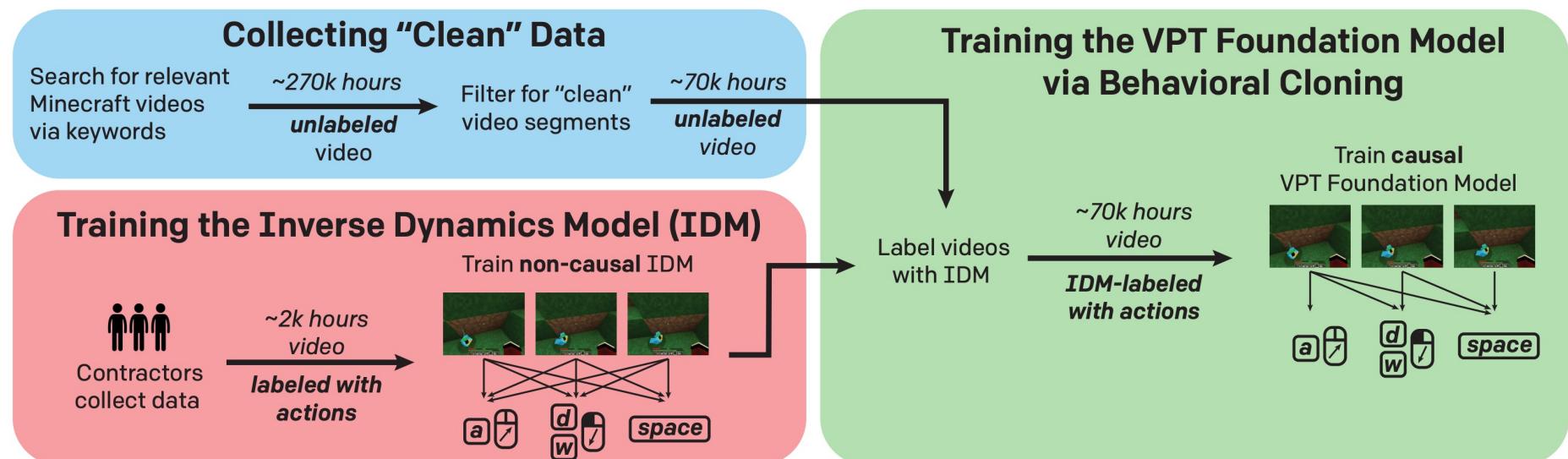
C \bar{U} (Instruction): I'm looking for a small portable...
 \bar{y} (Description): MENHG Folding Laptop Table Bed...
 y_{price} : \$109.0
 Y_{opt} (Options): { black, khaki, white }
 Y_{att} (Attributes): { steel pipe, no assembly, portable }



Video Pre-training

- Semi-supervised Learning

- Predict pseudo-labels of the action taken at each time-step in a Minecraft video game
- IDM: minimize $p_{\text{IDM}}(a_t | o_1 \dots T)$

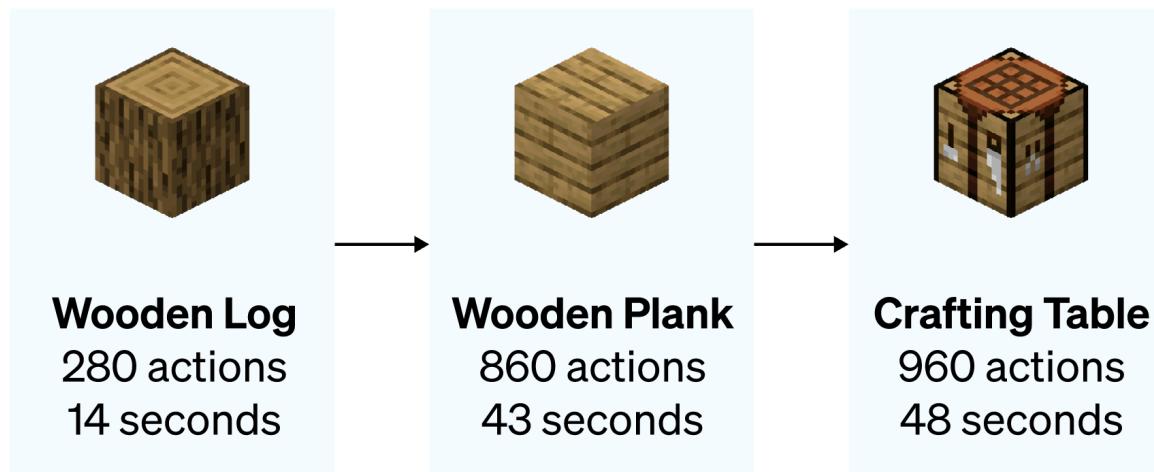




Video Pre-training

- After Training

- The model can do things that **pure RL cannot do**
- e.g., make a table, chop woods, collect logs, craft plank...
- Model performs professional actions like humans
- e.g., swimming, hunting animals for food

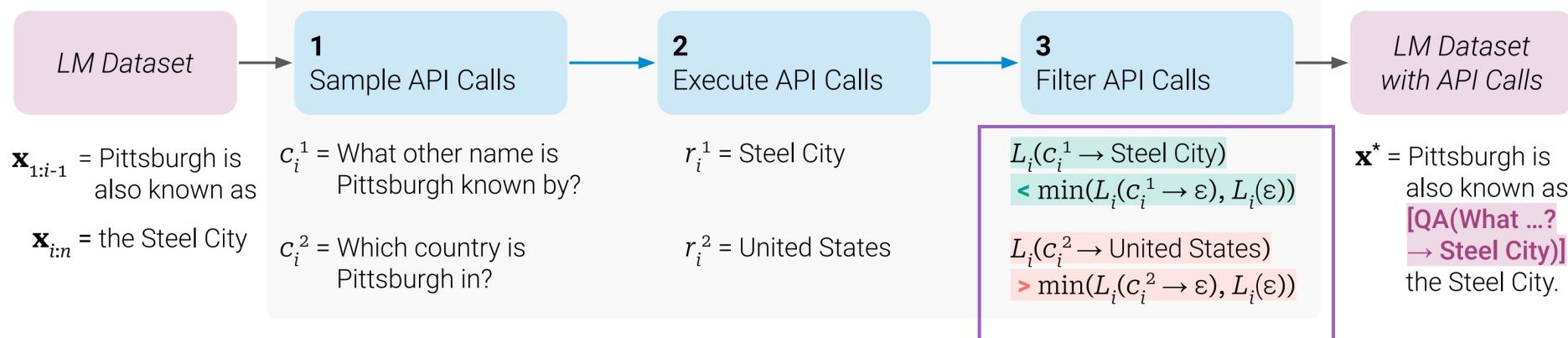


Sequence of items required to craft a crafting table, labeled with the median time it takes proficient humans to reach each step



Toolformer

- Self-supervised Tool Learning
 - Pre-defined tool APIs
 - Encourage models to call and execute tool APIs
 - Design self-supervised loss to see if the tool execution can help language modeling

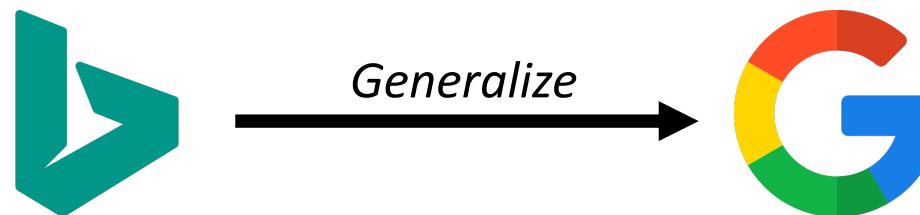
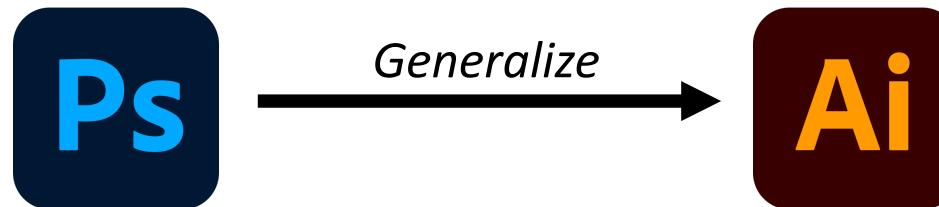


If the tool execution reduces LM loss, save the instances as training data



Generalizable Tool Learning

- Generalization of tool use is a key characteristic of human intelligence
- Generalizable tool learning highlights the process of identifying the **essential features** of a tool, which involves recognizing **commonalities** and **patterns** of tools





Generalizable Tool Learning

- Strategies for Generalizable Tool Learning
- Meta Tool Learning
 - Learn metacognition in tool learning
 - Identify common underlying principles or patterns
- Curriculum Tool Learning
 - Start with simple tools, then move on to complex tools
 - Allow the model to learn how complex tools are built upon simple tools



Tool Creation

- From Tool User to Tool Creator 
- Humans are the primary agents that create and use tools from Stone Age to 21st century
- Most tools are created for humans, not AI
- Tools Made for Models
 - Modularized: compose tools into smaller units
 - New input and output formats: more computable and suitable for AI



Tool Creation

Prompt: You have access to a function in Python: `forecast_weather(city, N)`, which will return the weather condition of a city after N days. The returned information is only about a single day and is a dictionary containing keys including `temperature`. Please wrap it into a new function, that can return the average temperature over the next N days in a city.

Response: Certainly! Here's an example code to wrap the `forecast_weather` function into a new function that calculates the average temperature of the next N days in a given city:

```
def average_temperature(city, N):
    total_temperature = 0
    for i in range(N):
        weather_data = forecast_weather(city, i)
        temperature = weather_data['temperature']
        total_temperature += temperature
    return total_temperature / N
```

In this code, we define a new function called `average_temperature` that takes in a city and N as input parameters. Inside the function, we loop over the range of N days, calling the `forecast_weather` function for each day and extracting the temperature data from the returned dictionary. We then add the daily temperature to a running total. Finally, we calculate the average temperature by dividing the total temperature by N and return it.

Note that this code assumes that the `forecast_weather` function returns a dictionary with a key `temperature` that contains the temperature for a given day. If the actual function returns a different format, you may need to adjust the code accordingly.



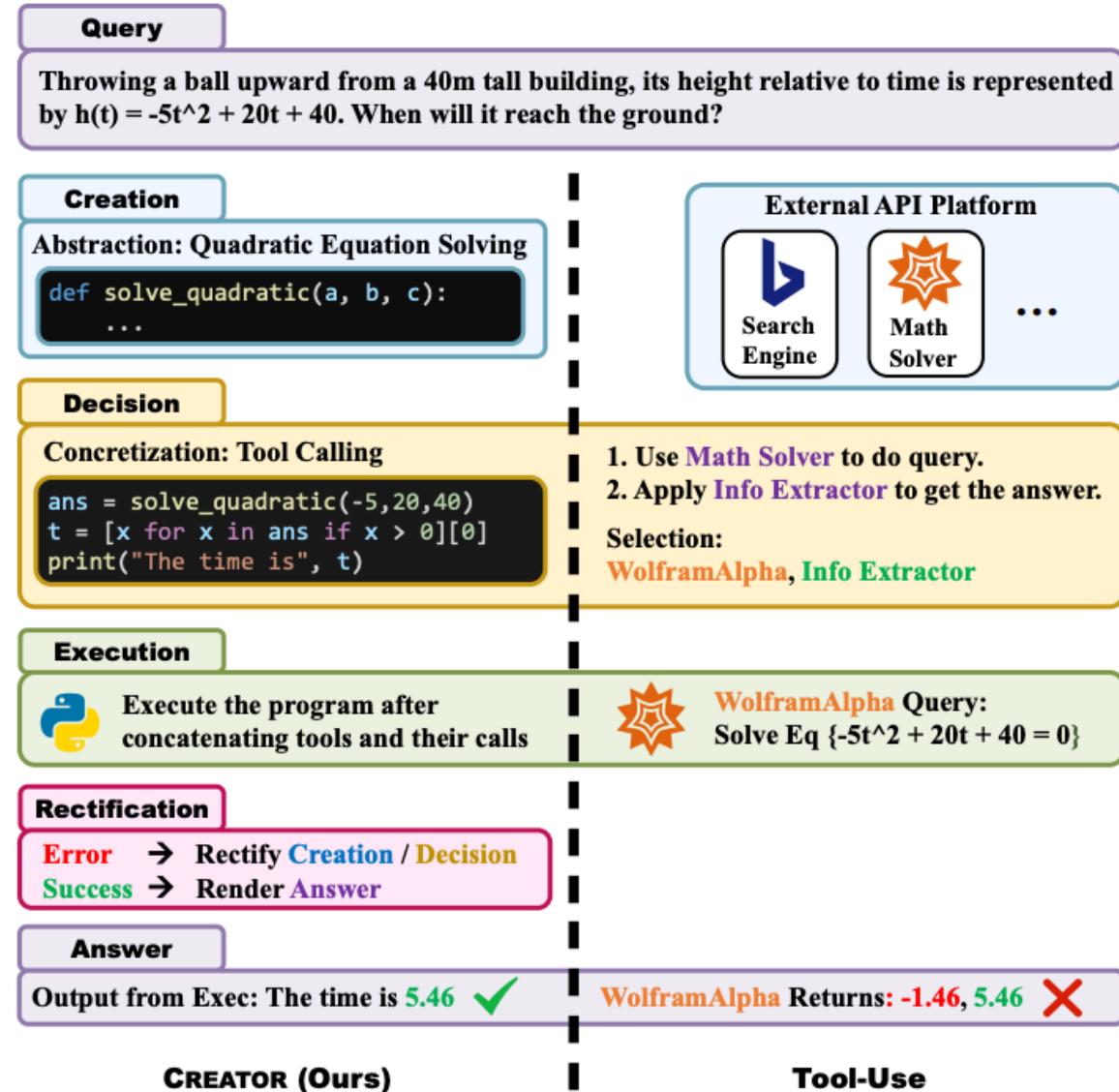
Tool Creation

- Limitations of Existing Works
 - Most existing work tends to concentrate on a limited number of tools
 - The reasoning process employed by models for determining the optimal utilization of tools is inherently complex
 - The current pipelines lack a error-handling mechanism after retrieving execution results
- Instead of letting LLMs act as the users of tools, we enable them to be the *creators* [1]



Tool Creation

- Four Procedures
 - Creation
 - Decision
 - Execution
 - Rectification





Tool Creation

- Experiments
 - Datasets: MATH, TabMWP
 - Significant improvements over PoT and pure CoT

Method	Setting	Algebra	Counting & Probability	Geometry	Itmd. Algebra	Number Theory	Pre-Algebra	Pre-Calculus	Average (weighted)
Standard	w/o CoT	25.7	25.8	22.4	13.9	18.5	40.9	21.8	25.3
	w/ CoT	50.9	36.1	24.5	17.5	23.2	58.6	16.7	37.9
PoT (w/o Rectify)	w/o CoT	58.2	48.5	35.4	25.8	53.1	66.8	25.0	49.8
	w/ CoT	54.0	47.8	32.5	22.3	48.9	64.5	19.9	46.5
PoT (w/ Rectify)	w/o CoT	63.8	51.9	35.9	28.6	59.2	70.0	28.2	53.9
	w/ CoT	61.4	48.8	34.6	23.7	54.5	67.6	34.6	51.2
Tool Use	w/o CoT	47.3	35.1	27.0	20.5	30.8	56.8	31.4	39.0
	w/ CoT	55.3	37.8	28.7	20.5	34.8	61.8	26.9	43.0
Tool Create (whole)	w/o Demo	58.0	53.3	34.2	21.8	55.7	63.4	33.3	49.6
	w/o CoT	64.1	55.7	35.9	42.7	61.6	69.0	37.2	57.2
	w/ CoT	62.7	50.9	33.8	31.4	61.4	68.7	31.4	54.0
CREATOR (ours)	w/o Demo	66.6	53.6	33.8	29.4	59.8	68.7	34.6	54.9
	w/o CoT	71.5	55.3	41.4	41.9	60.4	71.7	35.3	59.7
	w/ CoT	63.1	58.1	34.6	35.0	61.8	69.7	32.1	55.7



Application

THUNLP



ChatGPT Plugins

- OpenAI's official tool library
 - Empower ChatGPT with broader applications
 - By simply providing APIs with descriptions, ChatGPT is enabled to call applications and complete more complex tasks



Expedia

Bring your trip plans to life—get there, stay there, find things to see and do.



FiscalNote

Provides and enables access to select market-leading, real-time data sets for legal, political, and regulatory data and information.



Instacart

Order from your favorite local grocery stores.



Klarna Shopping

Search and compare prices from thousands of online shops.



Milo Family AI

Giving parents superpowers to turn the manic to magic, 20 minutes each day. Ask: Hey Milo, what's magic today?



OpenTable

Provides restaurant recommendations, with a direct link to book.



Speak

Learn how to say anything in another language with Speak, your AI-powered language tutor.



Wolfram

Access computation, math, curated knowledge & real-time data through Wolfram|Alpha and Wolfram Language.



Zapier

Interact with over 5,000+ apps like Google Sheets, Trello, Gmail, HubSpot, Salesforce, and more.



ChatGPT Plugins

- Plugin: web browsing



Can you tell me what person/movie won the oscar for these categories?

- Best Actor
- Best soundtrack
- Best picture
- Best supporting actor

And then come up with a poem linking them together



Finished browsing ^

Q Searched: "**Oscar winners Best Actor Best Soundtrack Best Picture Best Supporting Actor**"

↳ Clicked on: Oscar winners 2023: See the full list | CNN ↗

↳ Going back to last page

↳ Clicked on: Oscar winners 2023: See the full list | CNN ↗

↳ Going back to last page

↳ Clicked on: List of 2023 Oscar Winners - ABC News ↗

≡ Reading content

⌚ Finished browsing

FROM NOW, a soundtrack that's truly a treat.



ChatGPT Plugins

- Plugin: code interpreter



a brick weighs 30% of a brick plus five GPUs
there are 100 bricks and 200 GPUs in a metric ton
how much does a brick weigh?



Let's call the weight of a brick "B" and the weight of a GPU "G". We can set up an equation based on the information given:

```
from sympy import symbols, Eq, solve
B, G = symbols('B G')
eq1 = Eq(B, 0.3 * B + 5 * G)
eq2 = Eq(100 * B + 200 * G, 1000)
solution = solve((eq1, eq2), (B, G))
solution[B]
```

```
# Result
7.812500000000000
```

Finished calculating ^

on the total
ual to 1

I the
(G).

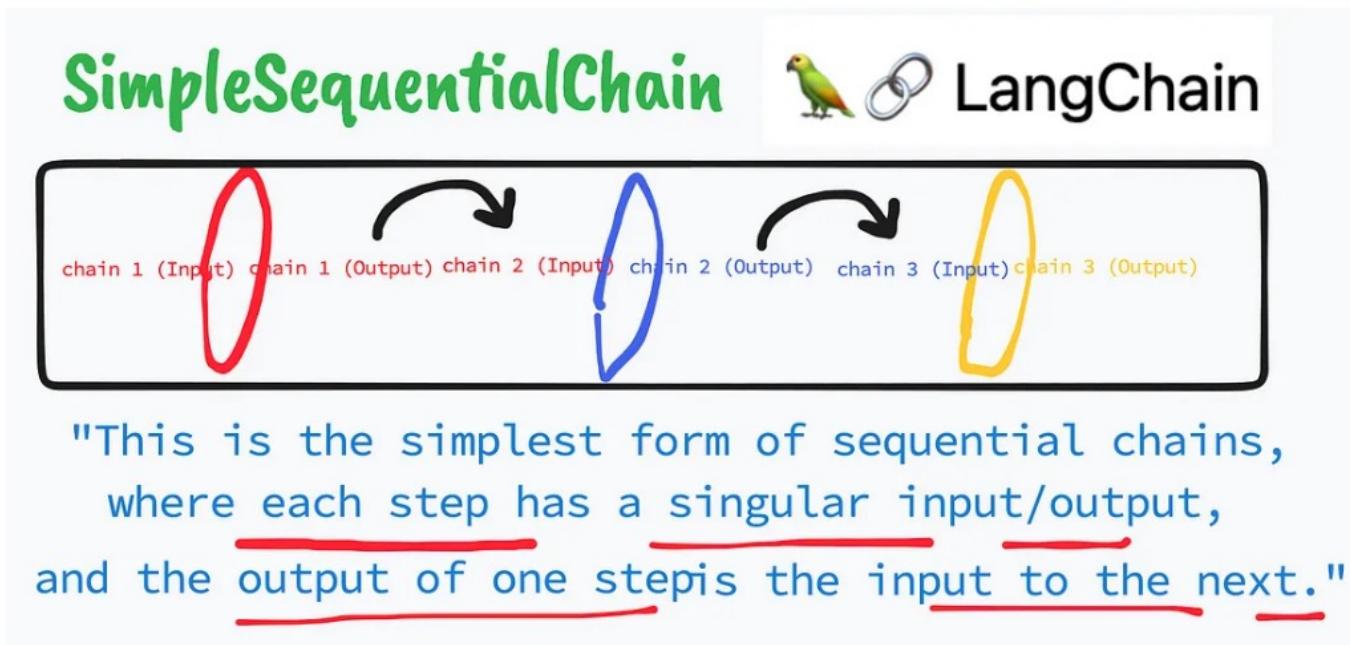
The weight of a brick is 7.8125 kg.



Open-source Solutions

- LangChain A green parrot emoji standing next to two interlocking silver rings.

- Integrated library to “chain” language models
- Also the first library to leverage tools



<https://langchain.readthedocs.io/>



Open-source Solutions

- BabyAGI

- Pull the first task from the task list
- Send the task to the execution agent, which uses ChatGPT to complete the task based on the context
- Enrich the result and stores it in Pinecone
- Create new tasks and reprioritizes the task list based on the objective and the result of the previous task

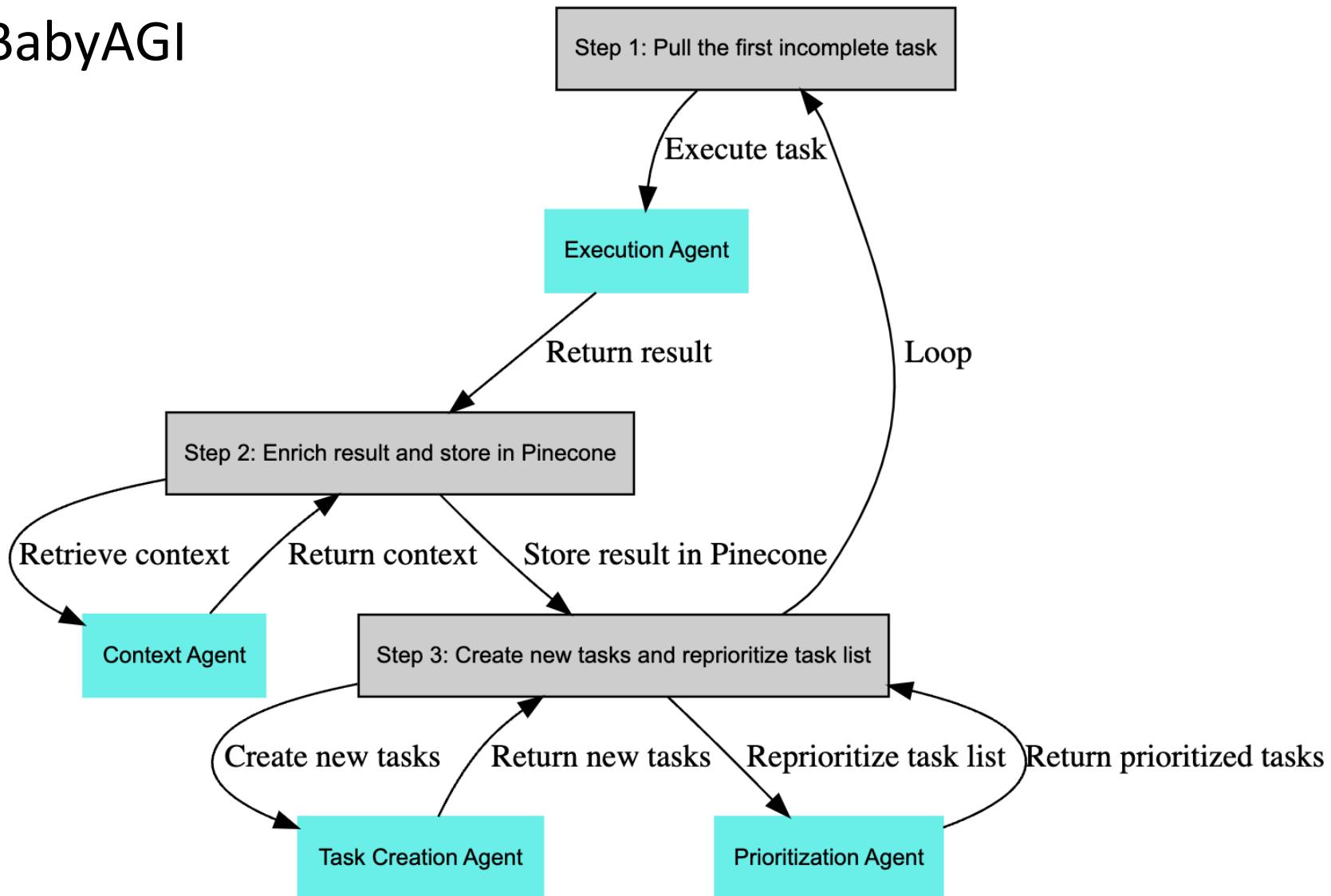


<https://github.com/yoheinakajima/babyagi>



Open-source Solutions

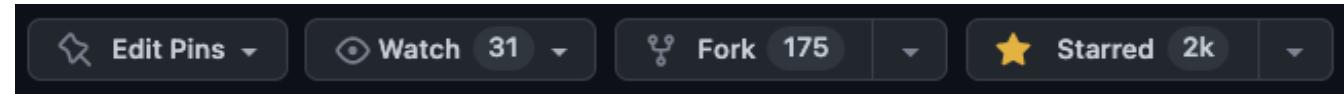
- BabyAGI



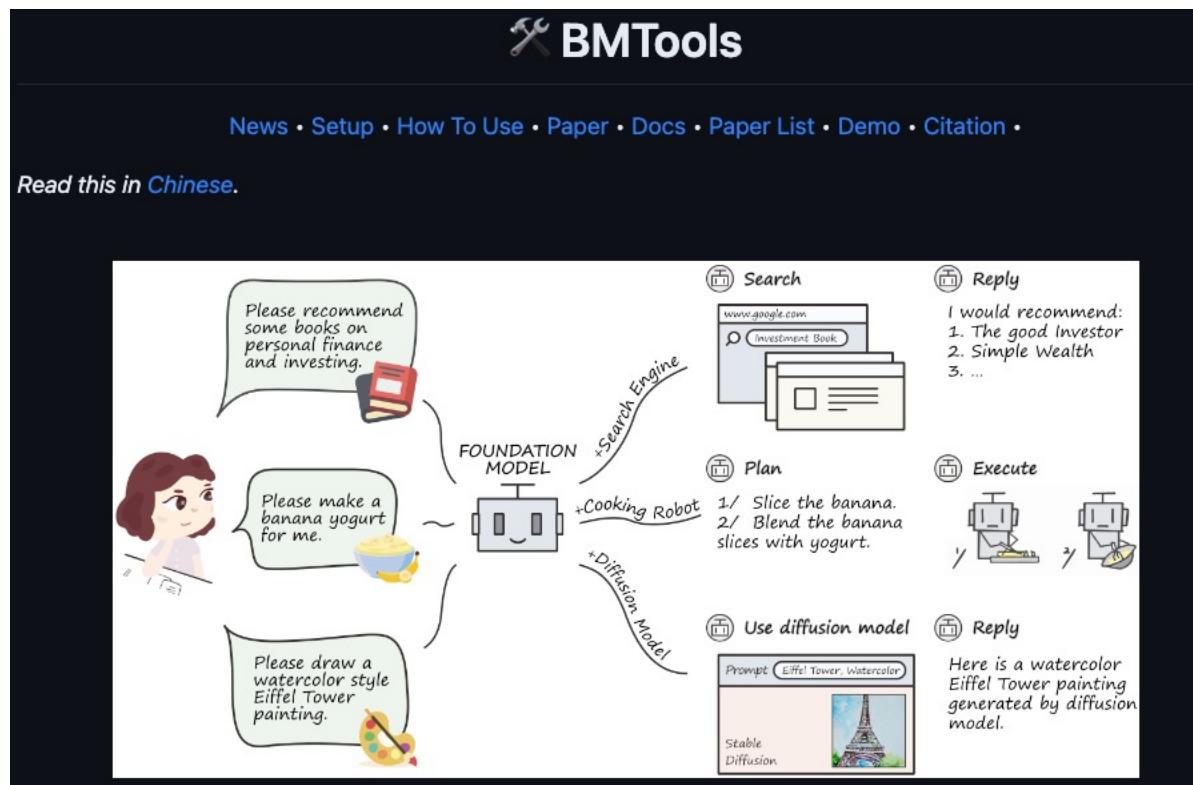


Open-source Solutions

- **BMTools**



- An open-source repository that extends language models to use tools and serves as a platform for the community to build and share tools





Open-source Solutions

- Features:
 - Users can easily build a **new** plugin by writing python functions and use external ChatGPT-Plugins
 - Users can host their **local models** (e.g., LLaMA, CPM) to use tools

Stanford
Alpaca





Open-source Solutions

- Features:
 - 30+ tools supported, welcome contributing!



database



Weather API



PPT

Google 學術搜尋



不限語言 搜尋所有中文網頁 搜尋繁體中文網頁

Google Scholar

🤗 Hugging Face

Huggingface Models



Image Generation



Open-source Solutions

- Features:
 - Support BabyAGI and AutoGPT
 - 100k+ tool-use SFT data on the way!





Open-source Solutions

A screenshot of a terminal window titled "Terminalizer". The window has a dark background and three colored window control buttons (red, yellow, green) in the top-left corner. The title bar "Terminalizer" is located at the top right. The main area of the terminal shows a command line prompt: "Meta-Analysis\$ |".

```
Meta-Analysis$ |
```



Open-source Solutions

BMTools

电影《龙马精神》是一部什么样的电影

Clear History

Thought: I need to find information about the “龙马精神” movie

Action: print_detail

Action Input: {"args": "龙马精神"}

Action output:

“龙马精神”是一部中国大陆的剧情、喜剧、动作电影，由杨子导演，成龙、刘浩存、郭麒麟等人主演。剧情简介：生活落魄的武行老罗（成龙饰）有一匹爱马“赤兔”，他一直想把它培养成片场的动作明星，不料却深陷官司，只能求助多年未见的女儿小宝（刘浩存饰）和她的律师男友乃华（郭麒麟饰）。小宝一边帮老罗打官司，一边劝说他不要带着赤兔玩命做危险动作，老罗不顾女儿反对继续偷偷训练赤兔，同时又对准女婿乃华展开了各种考验……”

Answer: “龙马精神”是一部中国大陆的剧情、喜剧、动作电影，由杨子导演，成龙、刘浩存、郭麒麟等人主演。剧情简介是生活落魄的武行老罗（成龙饰）有一匹爱马“赤兔”，他一直想把它培养成片场的动作明星，不料却深陷官司，只能求助多年未见的女儿小宝（刘浩存饰）和她的律师男友乃华（郭麒麟饰）。小宝一边帮老罗打官司，一边劝说他不要带着赤兔玩命做危险动作，老罗不顾女儿反对继续偷偷训练赤兔，同时又对准女婿乃华展开了各种考验。



Tools Search

Please input some text to search tools.

电影

Clear

Tools provided

Choose the tools to solve your question.

douban-film

Model provided

Choose the model to solve your question, Default means ChatGPT.

ChatGPT

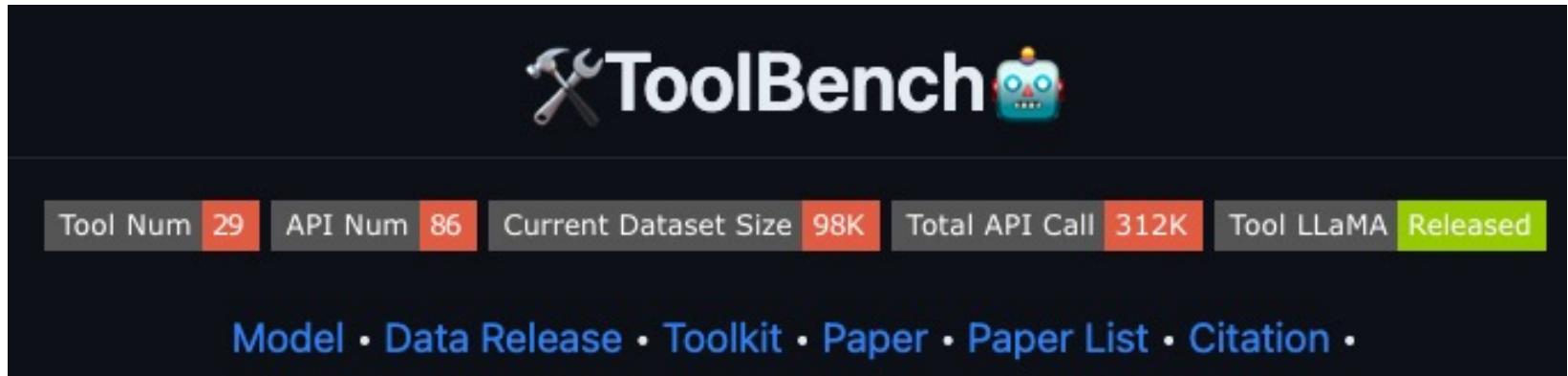
OpenAI API KEY:



Open-source Solutions

- ToolBench

- An open-source, large-scale, high-quality instruction tuning SFT data to facilitate general tool-use capability
- We provide the dataset, the corresponding training and evaluation scripts, and a capable model ToolLLaMA fine-tuned on ToolBench

A screenshot of the ToolBench website. The header features the "ToolBench" logo, which includes a wrench icon and a small robot head icon. Below the header, there is a navigation bar with several items: "Tool Num 29", "API Num 86", "Current Dataset Size 98K", "Total API Call 312K", "Tool LLaMA", and "Released". At the bottom of the page, there is a footer with links: "Model", "Data Release", "Toolkit", "Paper", "Paper List", and "Citation".

Tool Num 29 API Num 86 Current Dataset Size 98K Total API Call 312K Tool LLaMA Released

Model • Data Release • Toolkit • Paper • Paper List • Citation •



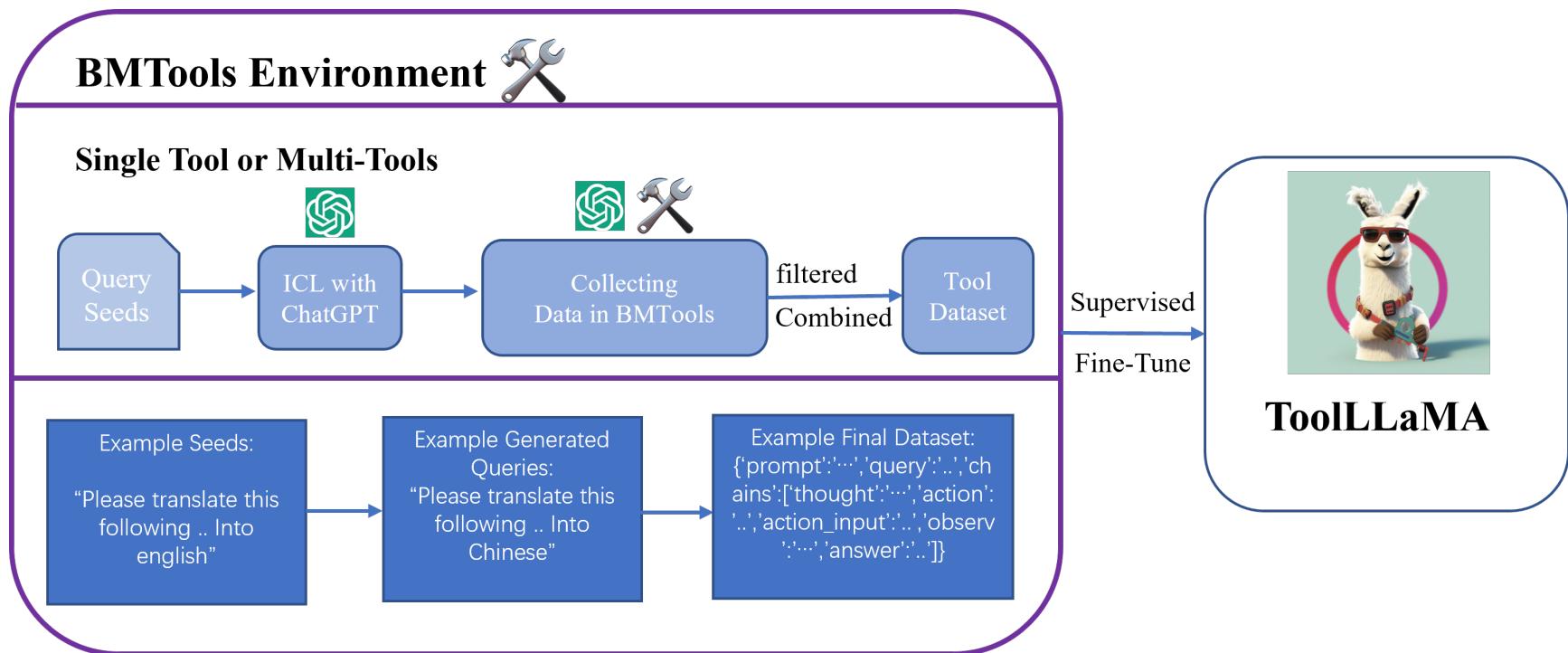
Open-source Solutions

- Features
 - Both **single-tool** and **multi-tool** scenarios are supported
 - ToolBench provides responses that not only include the final answer but also incorporate the **model's chain-of-thought process, tool execution, and tool execution results**
 - **Multi-step** decision making and tool execution
 - Another notable advantage is the **diversity** of our API, which is designed for real-world scenarios
 - **98k instances, 312k API calls**



Open-source Solutions

- Construction Process
- All the data is automatically generated by OpenAI API and then filtered, the whole data creation process is easy to scale up





Open-source Solutions

- Creation Process
 - We provide the dataset, the corresponding training and evaluation scripts, and a capable model ToolLLaMA

Tool	Query num	Step num	Steps per query
Weather	9827	23740	2.4
Chemical	8585	29916	3.5
Translation	10267	23011	2.2
Map	7305	23325	3.2
Stock	11805	32550	2.8
Meta analysis	2526	15725	6.2
Bing search	31089	102088	3.3
Wolfram	16130	56169	3.5
Database	1264	6347	5

Tool
LLaMA





Open-source Solutions

- Evaluation
 - ToolLLaMA matches ChatGPT's capabilities in tool use
 - Auto-evaluated by ChatGPT (higher is better)

Tool	ToolLLaMA Score	ChatGPT Score
baidu-translation	8.0	8.0
chemical-prop	7.93	7.53
bing-map	7.93	7.64
stock	4.87	4.4
weather	7.20	7.47
wolframalpha	7.67	7.80

Tool
LLaMA





Open-source Solutions

- AgentVerse
- From **individual** intelligence to **collective** intelligence
- Provide a flexible framework that simplifies the process of building custom multi-agent environments for LLMs
- Will support **multi-agent collaboration** for tool learning



<https://github.com/OpenBMB/AgentVerse>



Open-source Solutions

- AgentVerse

 AgentVerse框架
+
 一份YAML配置文件
+
 几行Python代码

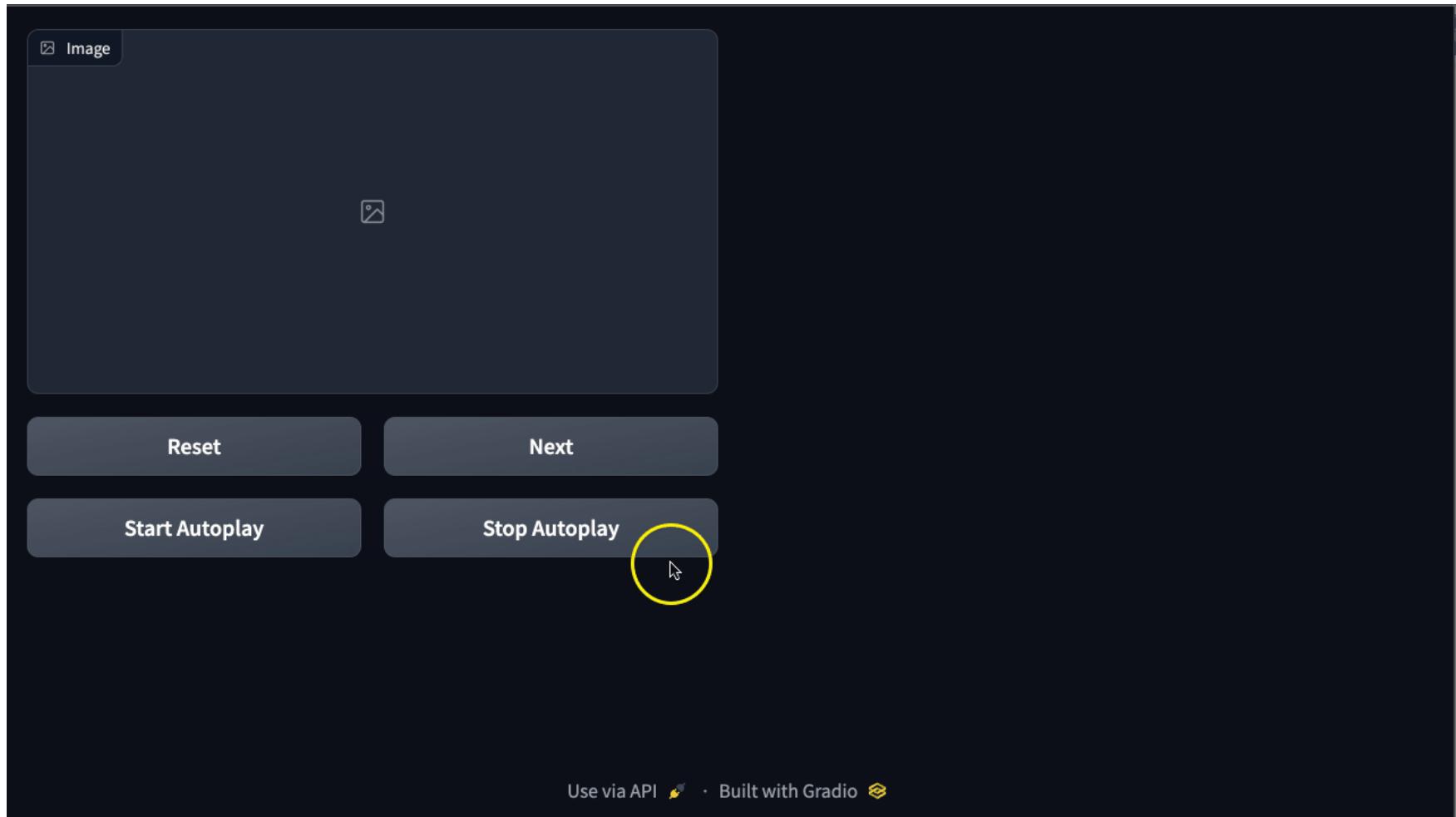


<https://github.com/OpenBMB/AgentVerse>



Open-source Solutions

- A demo case of classroom



A screenshot of a user interface for a classroom demo. At the top left, there is a placeholder labeled "Image" with a small camera icon. Below this is a large dark rectangular area with a small camera icon in its center. At the bottom of the screen, there are four buttons arranged in two rows of two. The top row contains "Reset" on the left and "Next" on the right. The bottom row contains "Start Autoplay" on the left and "Stop Autoplay" on the right. The "Stop Autoplay" button is highlighted with a yellow circle and a cursor arrow pointing to it. At the very bottom of the screen, there is a footer bar with the text "Use via API" and "Built with Gradio".



Summary

- Traditional language tasks are (almost) well solved
 - Syntactic parsing, entity recognition, sentiment analysis...
- **We are facing more challenging tasks!**
- Foundation models can be leveraged in complex scenarios by using language, and the performance may largely rely on LLMs' effectiveness
- Theoretical issues still exist
- Practical issues still exist
- Explore leveraging tool learning in complex scenarios



Tool Learning Paper List

<https://github.com/thunlp/ToolLearningPapers>

Screenshot of the GitHub repository page for `ToolLearningPapers`.

Repository Summary:

- Owner: `thuqinyj16`
- Repository name: `ToolLearningPapers`
- Status: Public
- Branches: master (1 branch)
- Tags: 0 tags
- Last commit: 695e1e0 1 hour ago (17 commits)
- Code navigation buttons: Go to file, Add file, Code

Commits:

File	Commit Message	Date
assets	initial commit	last month
.DS_Store	update readme	2 weeks ago
LICENSE	initial commit	last month
README.md	Update README.md	1 hour ago

README.md Content:

🛠 Tool Learning Papers

Must-read papers on [tool learning](#) with foundation models.

Content

- Why Tool Learning?
- Keywords Convention
- Papers
 - Overview
 - Tool-augmented Learning

About:

No description, website, or topics provided.

Statistics:

- Readme
- Apache-2.0 license
- 271 stars
- 7 watching
- 13 forks

[Report repository](#)

Releases:

No releases published
[Create a new release](#)

Packages:

No packages published
[Publish your first package](#)

Contributors: 5



Thanks

秦禹嘉

qyj20@mails.tsinghua.edu.cn

THUNLP