

salesforce

# Language-based AI Agents and Large Action Models (LAMs)

CVPR 2024 Tutorial “Generalist Agent AI”

Juan Carlos Niebles, Research Director  
[@jcniebles](mailto:@jcniebles) | [www.niebles.net](http://www.niebles.net)  
He/Him



# Conversational AI Assistants



## Work Agent



Hello I'm Einstein  
Copilot your trusted AI  
assistant

Can you help route my  
case for approval?



I have modified this  
case status to Escalated  
and created an  
escalation request with  
the subject "Modify  
deliver center to  
Portland, OR".

[Edit Case]

## Personal Agent



Let's start booking my  
summer vacation  
travel. Find and book  
family friendly hotel for  
my upcoming stay in  
France..



I found this nice hotel  
near the venues you  
are planning to visit. I  
booked 2 rooms for the  
full duration of your  
stay.

[View Booking]



I'm writing a fiction  
story about animals in  
the jungle. What are  
some adventures  
these animals might  
have? Give me some  
ideas and illustrate  
them with pictures.

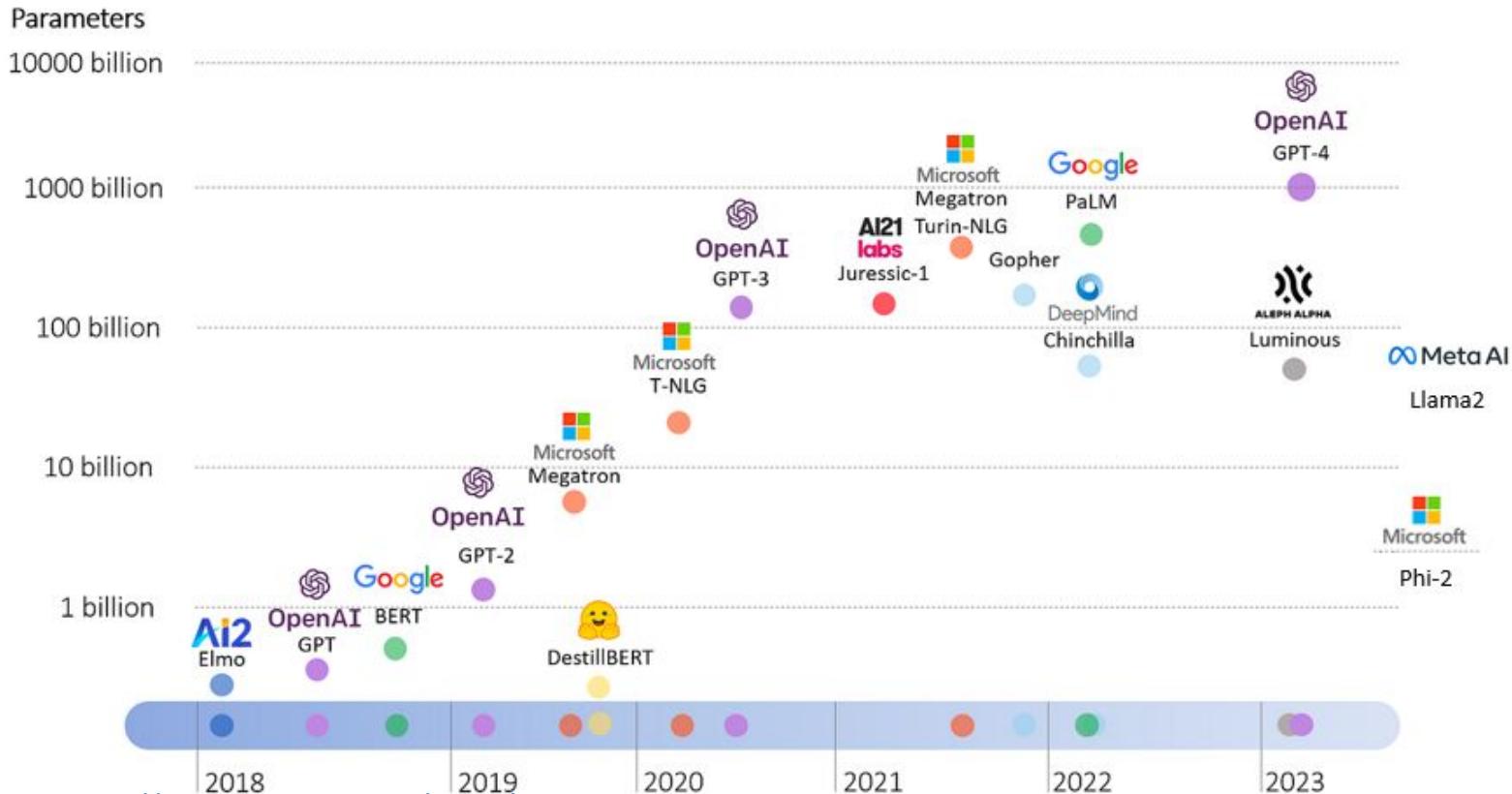
Sure, some ideas:  
1. The animals might  
be organizing a party.



2. The animals may  
need to solve a  
problem [...]



# LLM Parameter count



Source: <https://www.predli.com/post/llm-deep-dive-phi-2>

# Language-based Agents



Research  
Papers



open source

Huang et al, Zero-shot Planners, 2022

Yao et al, ReAct, 2022

Schick et al, Toolformer, 2023

Shen et al, HuggingGPT, 2023

Paul et al, Refiner, 2023

Shinn et al, Reflection, 2023

Madaan et al, Self-refine, 2023

Park et al, Generative Agents, 2023

...



**LangChain**



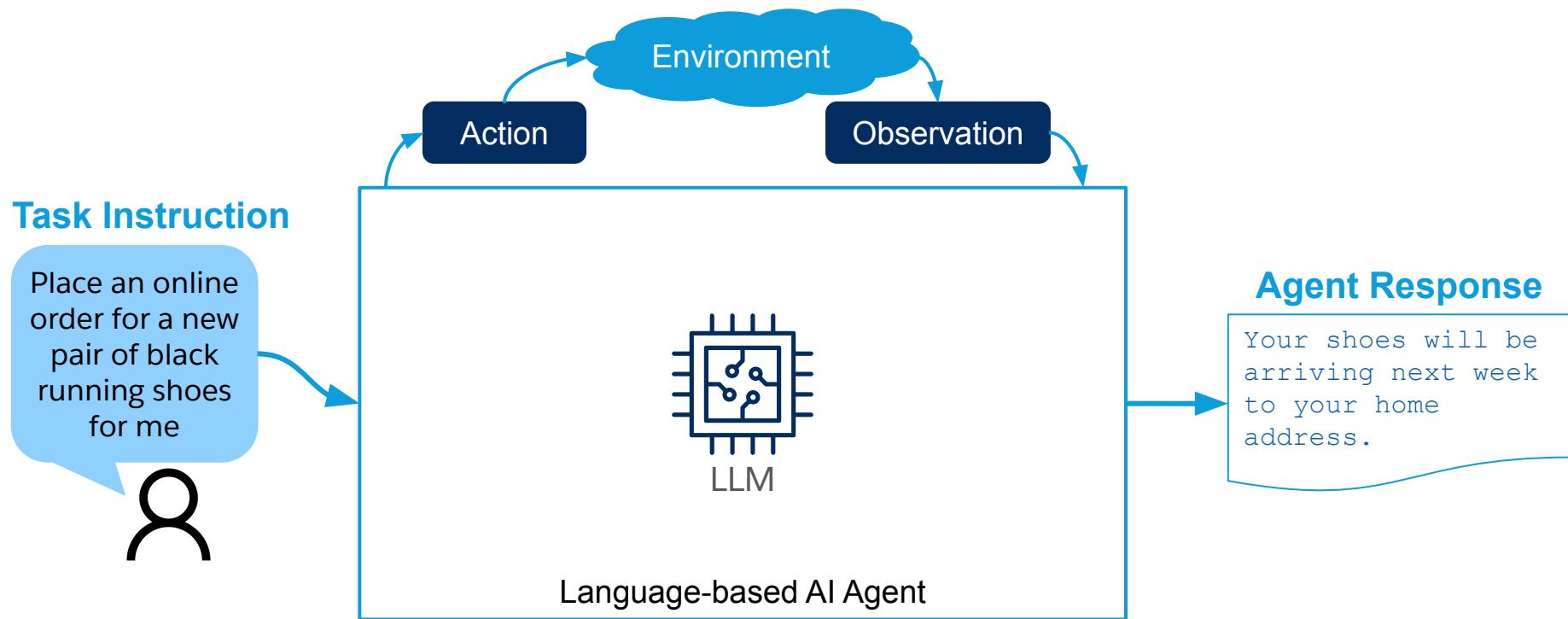
**Auto  
gpt**



**BabyAGI**

...

# High-level Language-based Agent framework





# Agent Benchmarking

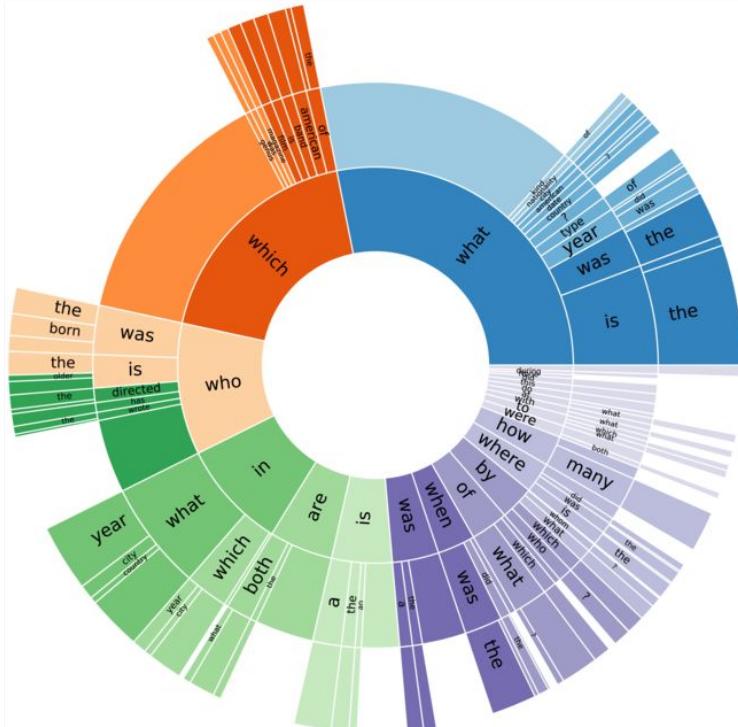
What tasks are agents solving today?



# ? HotPotQA - Knowledge Reasoning



<https://hotpotqa.github.io/>



[Yang et al. "HotPotQA: A Dataset for Diverse, Explainable Multi-hop Question Answering". EMNLP 2018]

- 113k question + answer pairs
- Require multiple steps of reasoning and actions (Wikipedia article search, string lookup, finish)

"User\_query":

"which magazine was started first: Arthur's Magazine or First for Women?",

"steps":

"content": "Thought: I need to Search[Arthur's Magazine] and then Search[First for Women] to collect their starting information.",  
"next observation": "OK."

"content": "Action: Search[Arthur's Magazine]",

"next observation": "Arthur's Magazine was published in 1844."

"content": "Action: Search[First for Women]",

"next observation": "First for Women is a woman's magazine published in 1989."

"content": "Action: Finish[Arthur's Magazine]",

"next observation": "Answer is CORRECT."



# WebShop - Decision Making

<https://webshop-pnlp.github.io/>



User gives natural language instruction



- Simplified e-commerce shopping environment containing **1.18M real-world products**
- **12k human instructions, ground truth items**
- Agent receives single instruction from user, then performs multiple actions to achieve the goal



# WebShop - Decision Making

<https://webshop-pnlp.github.io/>



- Simplified e-commerce shopping environment containing **1.18M real-world products**
- **12k human instructions, ground truth items**
- Agent receives single instruction from user, then performs multiple actions to achieve the goal

Current Action: `search[red faux fur coat winter jacket]`



# WebShop - Decision Making

<https://webshop-pnlp.github.io/>



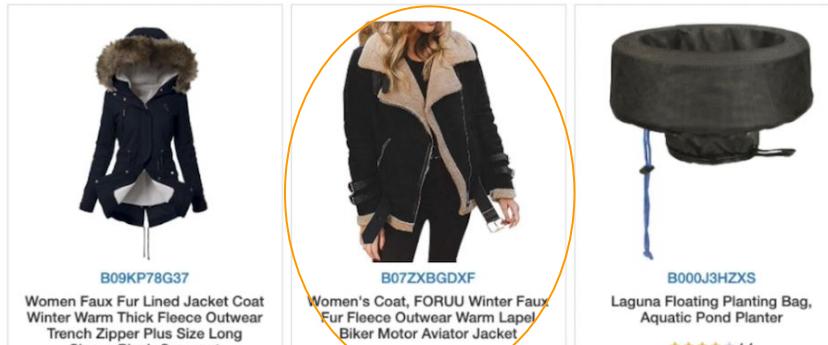
Instruction: i am looking for x-large, red color women faux fur lined winter warm jacket coat, and price lower than 70.00 dollars  
Current Query: red faux fur coat winter jacket

## Results

Page 1 (1-10) of 50 total results

[Back to Search](#)

[Next >](#)



Current Action: click [Women's Coat, FORUU Winter...]

- Simplified e-commerce shopping environment containing **1.18M real-world products**
- **12k human instructions, ground truth items**
- Agent receives single instruction from user, then performs multiple actions to achieve the goal



# WebShop - Decision Making

<https://webshop-pnlp.github.io/>



Instruction: i am looking for x-large, red color women faux fur lined winter warm jacket coat, and price lower than 70.00 dollars

Current Query: red faux fur coat winter jacket

[Back to Search](#) [< Back to Results](#)



Buy Now

Women's Coat, FORUU Winter Faux Fur Fleece Outwear Warm Lapel Biker Motor Aviator Jacket

Price: \$21.49 to \$24.99

Rating: 2.4

[Description](#) [Features](#) [Reviews](#) [Attributes](#)

size

small	medium	large	x-large
xx-large	3x-large	4x-large	

- Simplified e-commerce shopping environment containing **1.18M real-world products**
- **12k human instructions, ground truth items**
- Agent receives single instruction from user, then performs multiple actions to achieve the goal

Current Action: click[x-large]

gray red black



# WebShop - Decision Making

<https://webshop-pnlp.github.io/>



Instruction: i am looking for x-large, red color women faux fur lined winter warm jacket coat, and price lower than 70.00 dollars

Current Query: red faux fur coat winter jacket

[Back to Search](#) [< Back to Results](#)



Buy Now

Women's Coat, FORUU Winter Faux Fur Fleece Outwear Warm Lapel Biker Motor Aviator Jacket

Price: \$21.49 to \$24.99

Rating: 2.4

[Description](#) [Features](#) [Reviews](#) [Attributes](#)

size

small	medium	large	x-large
xx-large	3x-large	4x-large	

Current Action: click [red]



- Simplified e-commerce shopping environment containing **1.18M real-world products**
- **12k human instructions, ground truth items**
- Agent receives single instruction from user, then performs multiple actions to achieve the goal



# WebShop - Decision Making

<https://webshop-pnlp.github.io/>



Instruction: i am looking for x-large, red color women faux fur lined winter warm jacket coat, and price lower than 70.00 dollars

Current Query: red faux fur coat winter jacket

[Back to Search](#) [Back to Results](#)

Women's Coat, FORUU Winter Faux Fur Fleece Outwear Warm Lapel Biker Motor Aviator Jacket

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[Description](#) [Features](#) [Reviews](#) [Attributes](#)

size

small	medium	large	x-large
xx-large	3x-large	4x-large	

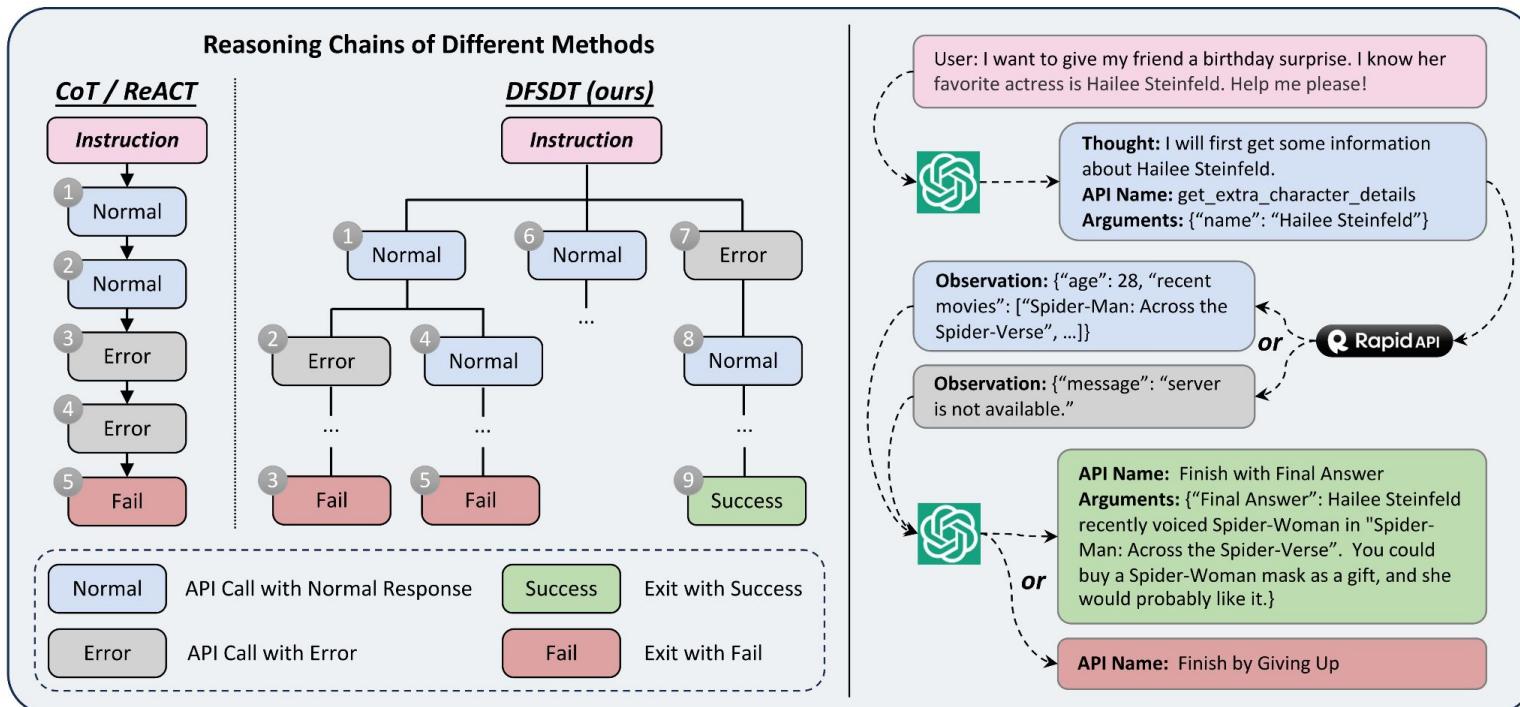
Current Action: click [buy now]

- Simplified e-commerce shopping environment containing **1.18M real-world products**
- **12k human instructions, ground truth items**
- Agent receives single instruction from user, then performs multiple actions to achieve the goal
- **Interaction is purely text-based**

# ToolBench - Tool-use capability



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





# ToolBench – Tool-use capability

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

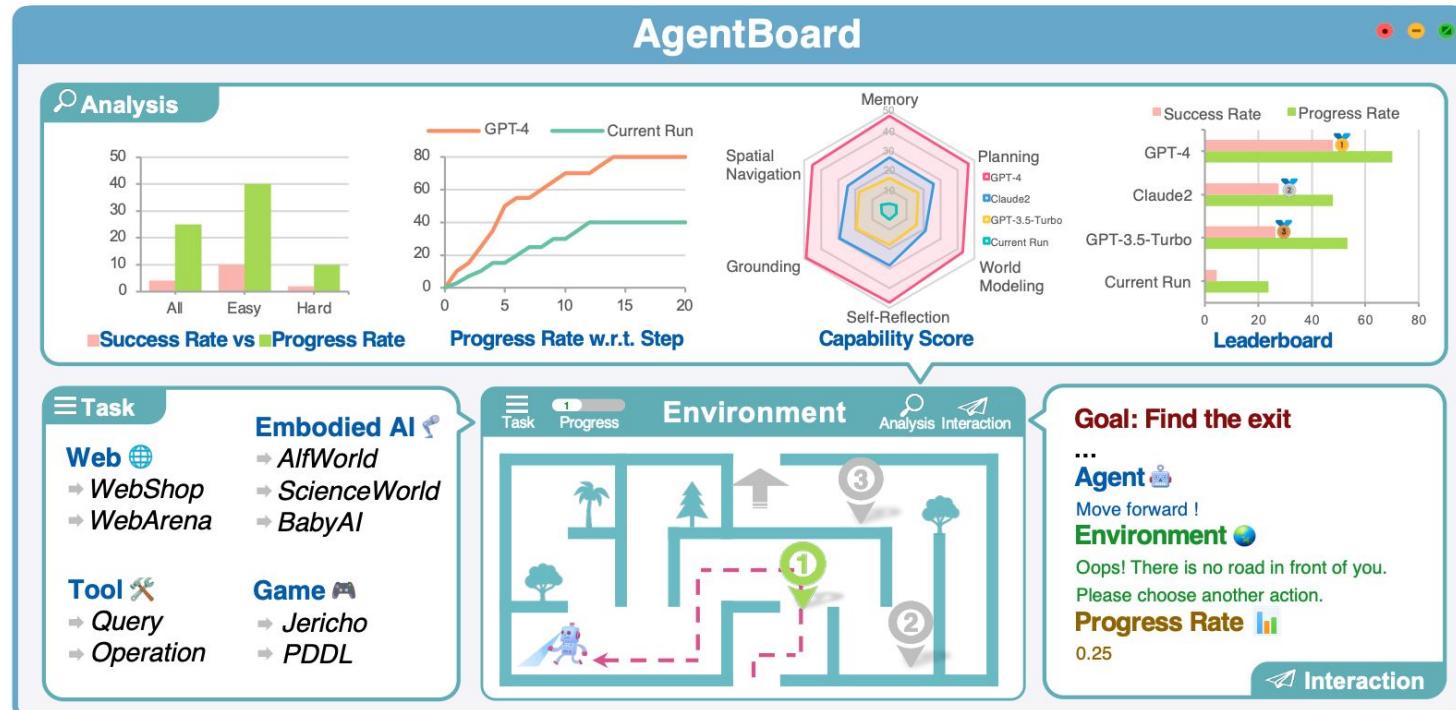


Resources	ToolBench
Number of tools	3,451
Number of APIs	16,461
Avg. Reasoning Traces	4
Number of evaluation queries	1,100
Evaluation metrics	<ul style="list-style-type: none"><li>- Pass Rate</li><li>- Win Rate</li></ul>



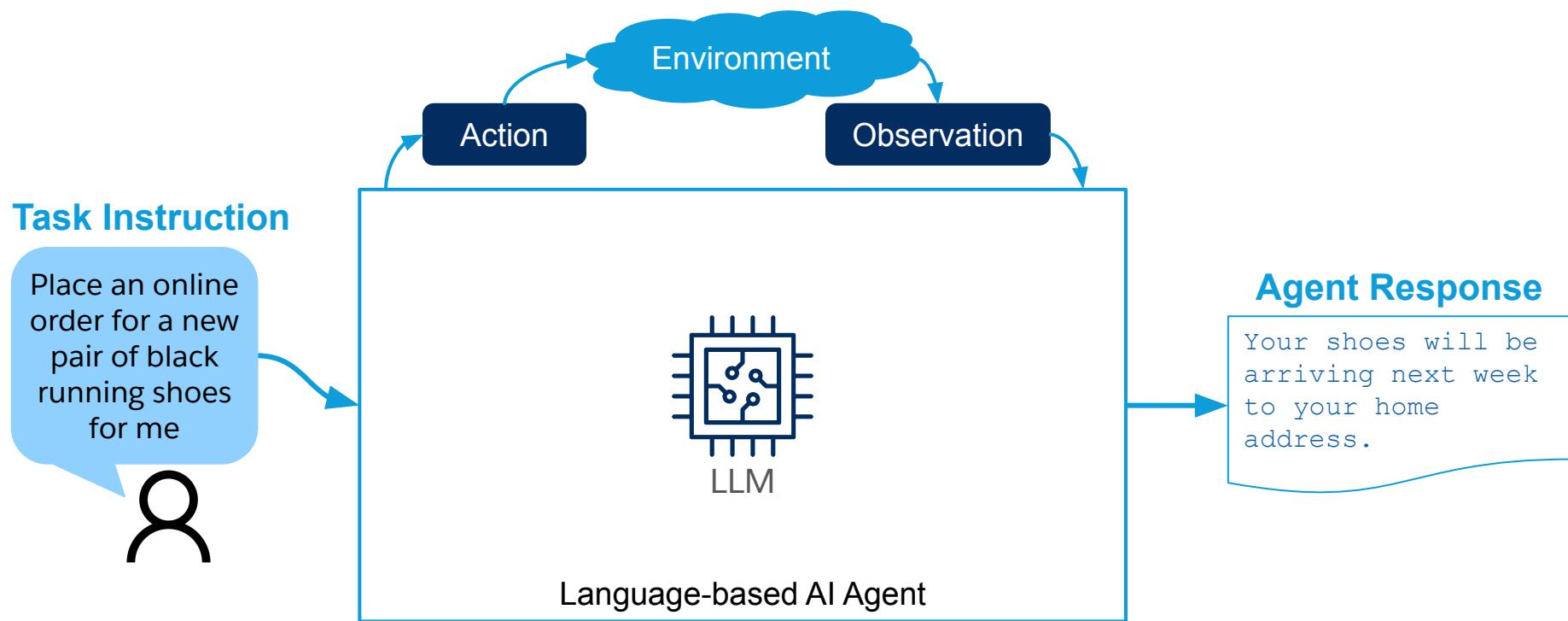
# AgentBoard: evaluation framework

<https://github.com/hkust-nlp/AgentBoard>



[Ma et al “AgentBoard: An Analytical Evaluation Board of Multi-turn LLM Agents”, 2023]

# High-level Language-based Agent framework



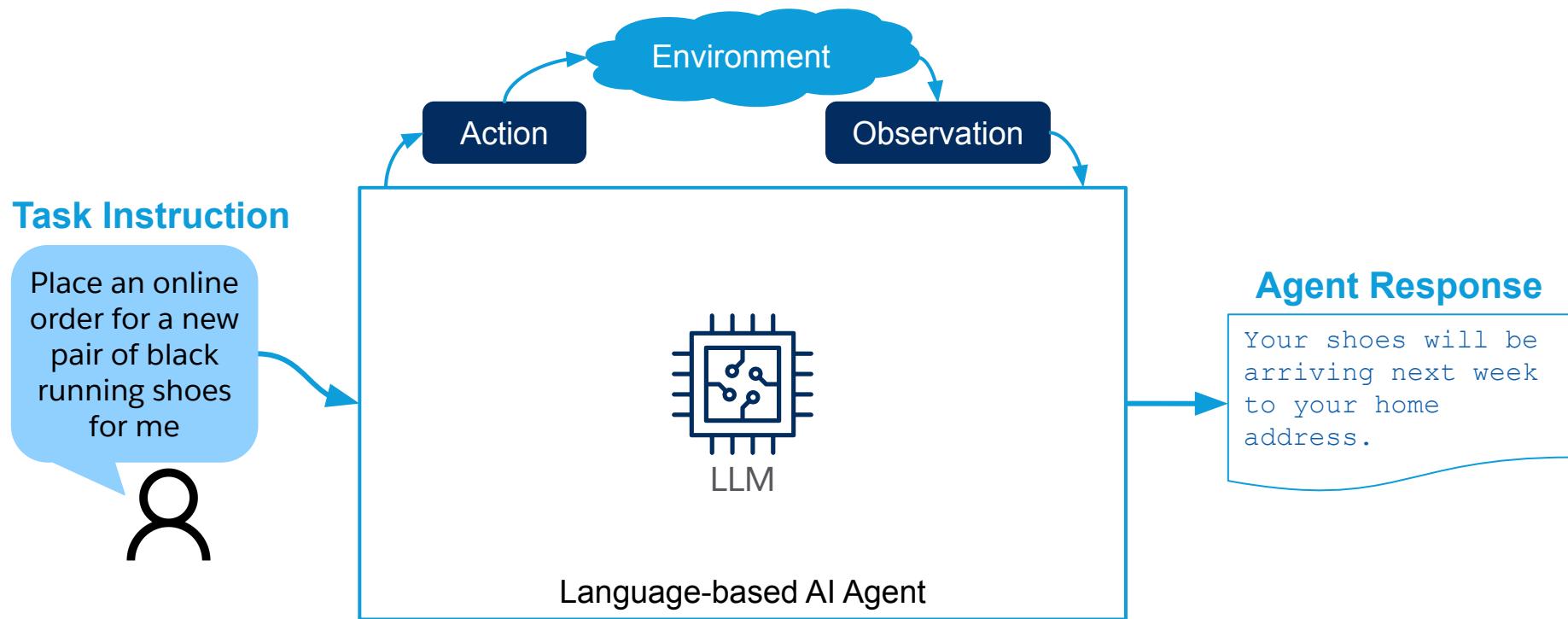


# Agent Architectures

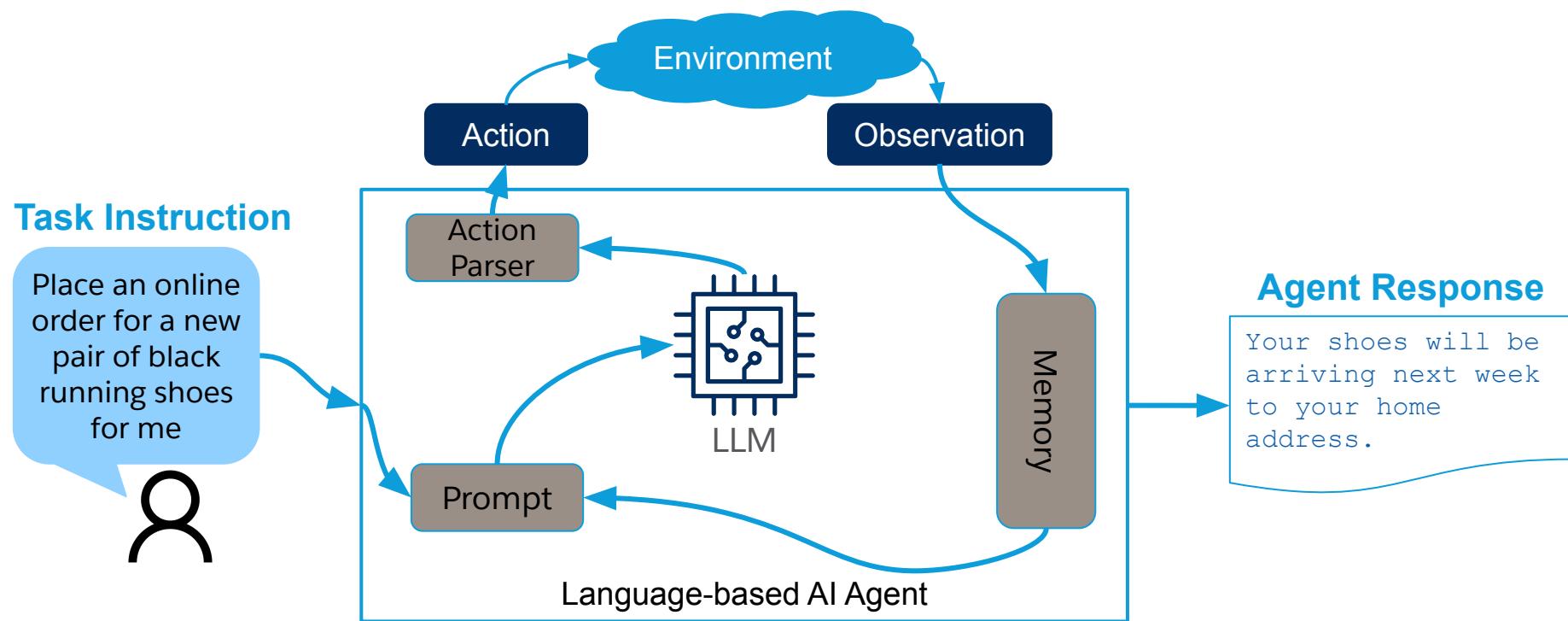
How are we building Agents today?



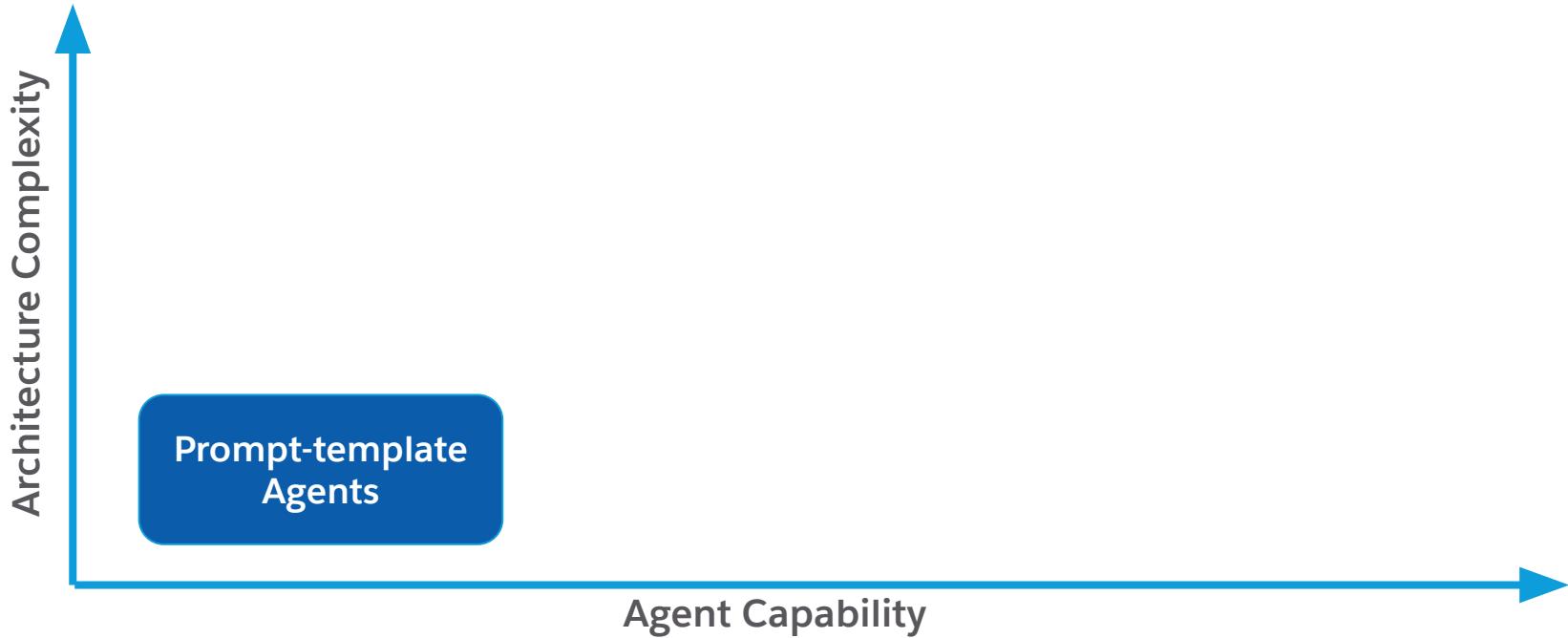
# High-level Language-based Agent framework



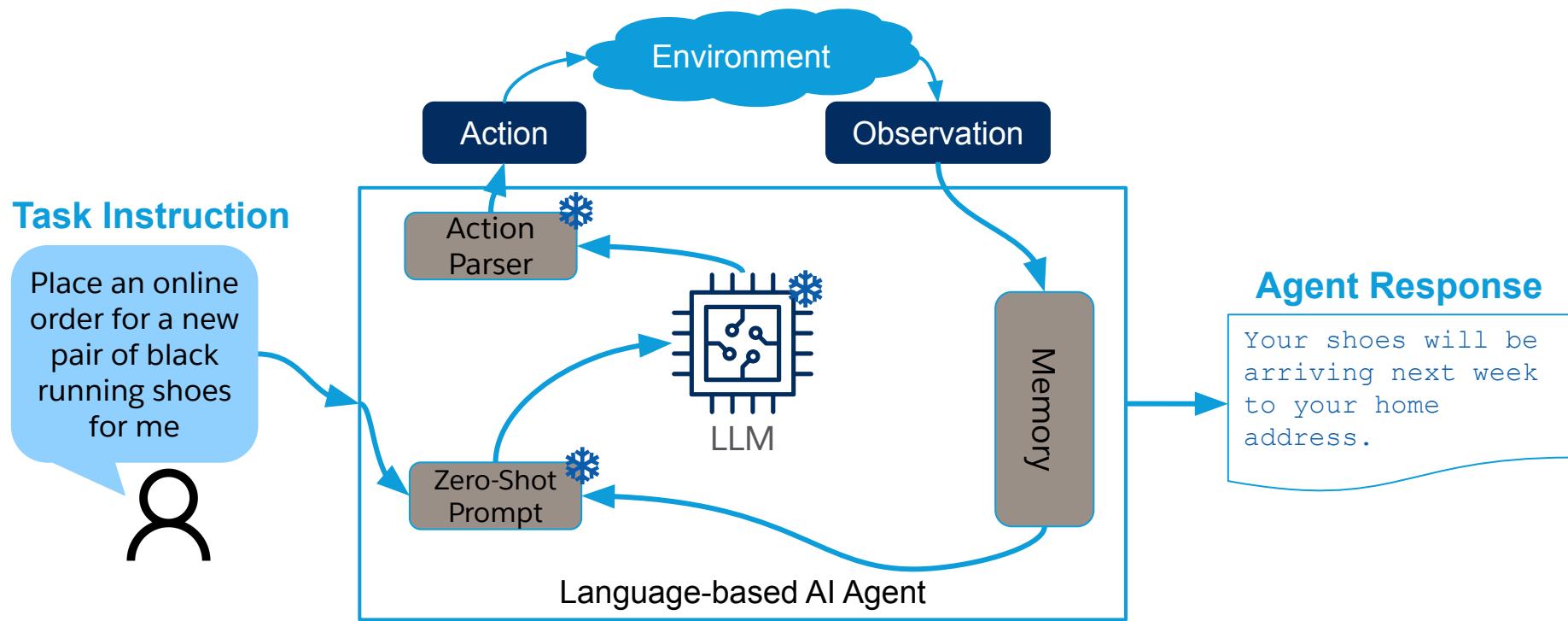
# High-level Language-based Agent framework



# Language-based AI Agents



# Zero-shot Language-based Agent





# Zero-shot Agent Example

## System Prompt

You are an intelligent agent. You should follow your [Role], [Action\_Doc] to take actions. Your generation should follow the example format. Finish the task as best as you can.

[Role] You can interact with the webshop. [End of Role]

[Constraint] Your generation should be simple and clear. [End of Constraint]

[Action\_Doc] [{"name": "search", "description": "<fc\_description>", "parameters": {"product": "<param\_description>"}, {"name": "click", "description": "<fc\_description>", "parameters": {"button": "<param\_description>"}}, {"name": "Finish", "description": "<fc\_description>", "parameters": {"response": "<param\_description>"}}] [End of Action\_Doc]

Using the following action format example to generate well formatted actions.

## ActionFormatExample

Action:search[{"product": "the name of the product to search for"}]

Action:Finish[{"response": "this is the finish action response. Respond towards the task instruction."}]

Action:click[{"button": "the name of the button to click"}]

[End of ActionFormatExample]

# Zero-shot Agent Example



**Task Instruction:** I need a long clip-in hair extension which is natural looking, and price lower than 40.00 dollars

## [Execution]

**Action:** search[{"product": "long clip-in hair extension"}]

**Action:** click[{"button": "B09C337K8S"}]

**Action:**  
Finish[{"response": "I found a long clip-in hair extension that is natural looking and priced lower than \$40.00. It is the Hair Clip Extensions for Women Natural Looking Hair Extensions Clip in Hairpieces Black Synthetic Hair Extensions, priced at \$29.99."}]

## [Environment]

**Observation:** WEB PAGE: {  
[Back to Search] Page 1 (Total results: 15)  
[Next >]  
[B09C337K8S]

Hair Clip Extensions for Women Natural Looking Hair Extensions clip in Hairpieces Black Synthetic Hair Extensions  
\$29.99  
[B099K9Z9L2]  
Clip in Hair Extensions 20" Double Weft 100% Remy Human Hair Grade 8A Quality 7pcs 16clips 70grams \$43.99  
}

**Observation:** WEB PAGE: {  
[Back to Search]  
[< Prev]  
Hair Clip Extensions for Women Natural Looking Hair Extensions Clip in Hairpieces Black Synthetic Hair Extensions Price: \$29.99  
Rating: N.A.  
[Buy Now]  
}

# Zero-shot Agent WebShop Results: Average Reward



LLM	Length	Zero-Shot
fastchat-t5-3b	2k	0.40
vicuna-7b	2k	0.00
vicuna-13b	2k	0.03
vicuna-33b	2k	0.14
llama-2-7b	4k	0.00
llama-2-13b	4k	0.07
llama-2-70b	4k	0.01
mpt-7b-instruct	8k	0.00
mpt-30b-instruct	8k	0.17
xgen-8k-7b-instruct	8k	0.00
longchat-7b-16k	16k	0.02
longchat-13b-16k	16k	0.00
text-davinci-003	4k	<b>0.53</b>
gpt-3.5-turbo	4k	0.51
gpt-3.5-turbo-16k	16k	<b>0.57</b>

- Bigger LLMs tend to achieve better agent performance out of the box
- Some LLMs struggle in Agent tasks in the zero-shot setting
- Big gap open source <-> GPT models

[Zhiwei Liu. “BOLAA: Benchmarking and orchestrating LLM-augmented autonomous agents”. ICLR 2024 Workshop on LLM Agents]

# Zero-shot Agent HotPotQA Results

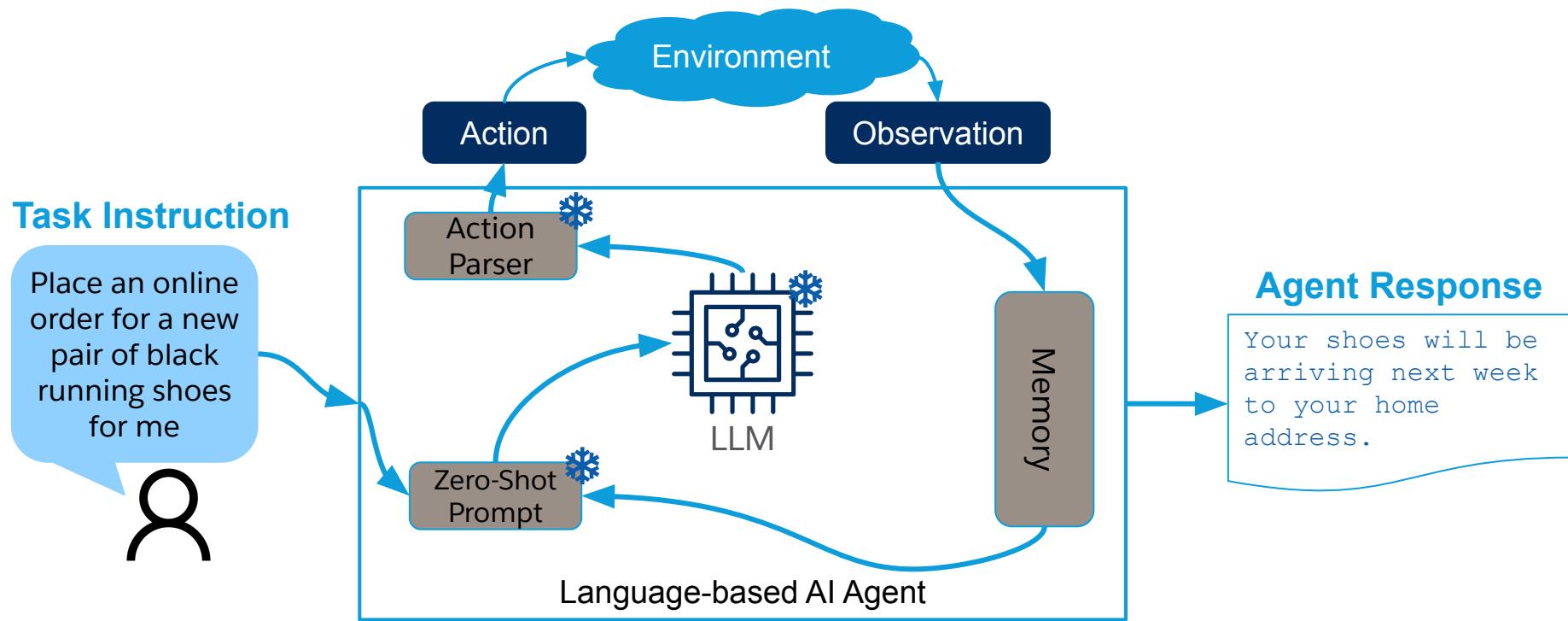


LLM	Length	Zero-Shot
fastchat-t5-3b	2k	0.03
vicuna-7b	2k	0.13
vicuna-13b	2k	0.15
vicuna-33b	2k	0.22
llama-2-7b	4k	0.04
llama-2-13b	4k	0.17
llama-2-70b	4k	<b>0.28</b>
mpt-7b-instruct	8k	0.10
mpt-30b-instruct	8k	0.16
xgen-8k-7b-instruct	8k	0.15
longchat-7b-16k	16k	0.08
longchat-13b-16k	16k	0.11
text-davinci-003	4k	<b>0.34</b>
gpt-3.5-turbo	4k	0.33
gpt-3.5-turbo-16k-0613	16k	0.30

- GPT models ahead again

[Zhiwei Liu. “BOLAA: Benchmarking and orchestrating LLM-augmented autonomous agents”. ICLR 2024 Workshop on LLM Agents]

# Zero-shot Language-based Agent



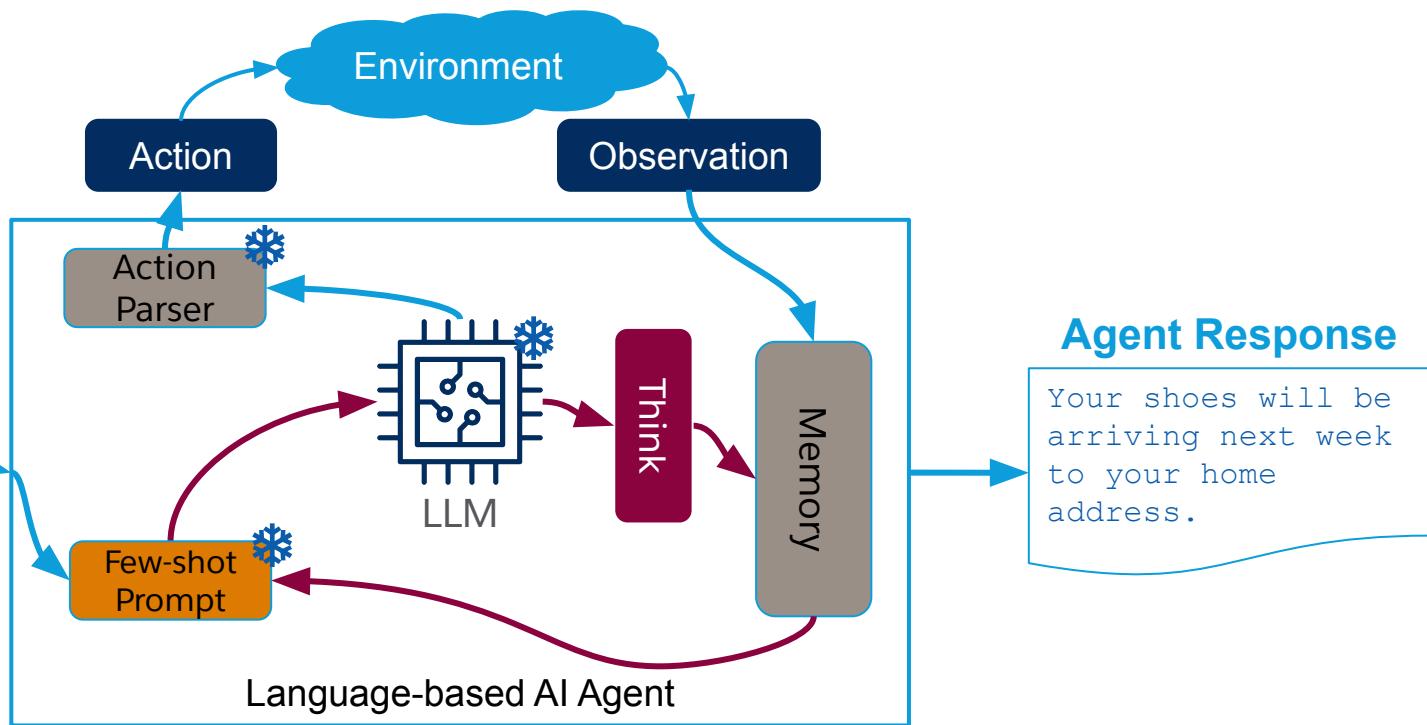
# ReAct Agent

<https://github.com/ysymyth/ReAct>



## Task Instruction

Place an online order for a new pair of black running shoes for me



## Agent Response

Your shoes will be arriving next week to your home address.

# ReAct Agent Example



## System Prompt

You are an intelligent agent. You should follow your [Role], [Action\_Doc] to take actions. Your generation should follow the example format. Finish the task as best as you can.

[Role] You can interact with the webshop. [End of Role]

[Constraint] You generation should be simple and clear. [End of Constraint]

[Action\_Doc] [{"name": "search", "description": "search for a product in the webshop", "parameters": {"product": "the name of the product to search for"}}, {"name": "Finish", "description": "Complete the task with a response.", "parameters": {"response": "this is the finish action response. Respond towards the task instruction."}}, {"name": "click", "description": "click a button in the web page", "parameters": {"button": "the name of the button to click"}}, {"name": "Think", "description": "Conduct thinking and reasoning process for solving task.", "parameters": {"response": "this is your thinking response. Be specific and critical."}}] [End of Action\_Doc]

Using the following action format example to generate well formatted actions.

[ActionFormatExample]

Action:search[{"product": "the name of the product to search for"}]

Action:Finish[{"response": "this is the finish action response. Respond towards the task instruction."}]

Action:click[{"button": "the name of the button to click"}]

[End of ActionFormatExample]

# ReAct Agent Example



[Example]

**Task:** i would like a 3 ounce bottle of bright citrus deodorant for sensitive skin, and price lower than 50.00 dollars

**Action:** Think[{"response": "I should first use Search to search bright citrus deodorant for sensitive skin."}]

**Observation:** OK

**Action:** search[{"product": "bright citrus deodorant for sensitive skin"}]

**Observation:** WEB PAGE: {

[Back to Search]

[< Prev]

scent [assorted scents][bright citrus][calming lavender] size [3 ounce (pack of 1)]}

**Action:** click[{"button": "bright citrus"}]

**Observation:** "You have clicked bright citrus."

**Action:** click[{"button": "3 ounce (pack of 1)"}]

**Observation:** "You have clicked 3 ounce (pack of 1)."

**Action:** click[{"button": "Buy Now"}]

# ReAct Agent Example



**Task Instruction:** I need a long clip-in hair extension which is natural looking, and price lower than 40.00 dollars

**Action:** Think[{"response": "I should first use Search to search for a long clip-in hair extension."}]

**Observation:** OK

**Action:** search[{"product": "long clip-in hair extension"}]

**Observation:** WEB PAGE:

[Back to Search] Page 1 (Total results: 15) [Next >]  
[B09C337K8S]

Hair Clip Extensions for Women Natural Looking Hair Extensions Clip in Hairpieces Black Synthetic Hair Extensions \$29.99

[B093BKWHFK]

MJMOJO Hair Extensions Clip in Human Hair Extensions 120g 7pcs Straight Natural Black Hair Clip in (16 inches #NST) \$63.99

**Action:** Think[{"response": "The first product is most relevant to the requirements. I should click the first product."}]

**Observation:** OK

# ReAct Agent Example (continued)



**Action:** click[{"button": "B09C337K8S"}]

**Observation:** WEB PAGE:  
[Back to Search] [< Prev]  
Hair Clip Extensions for Women  
Natural Looking Hair Extensions Clip in  
Hairpieces Black Synthetic Hair  
Extensions Price: \$29.99 Rating: N.A.  
[Buy Now] }

**Action:** click[{"button": "Buy Now"}]

**Observation:** shopping is finished.

**Action:** Finish[{"response": "Task Finished."}]

**Observation:** Task Finished. Reward:  
1.0

# ReAct Agent WebShop Results



LLM	Length	Zero-Shot	ReAct
fastchat-t5-3b	2k	0.40	<b>0.31</b>
vicuna-7b	2k	0.00	0.10
vicuna-13b	2k	0.03	0.15
vicuna-33b	2k	0.14	0.19
llama-2-7b	4k	0.00	0.12
llama-2-13b	4k	0.07	0.26
llama-2-70b	4k	0.01	<b>0.44</b>
mpt-7b-instruct	8k	0.00	0.06
mpt-30b-instruct	8k	0.17	<b>0.31</b>
xgen-8k-7b-instruct	8k	0.00	0.07
longchat-7b-16k	16k	0.02	0.07
longchat-13b-16k	16k	0.00	0.24
text-davinci-003	4k	<b>0.53</b>	<b>0.55</b>
gpt-3.5-turbo	4k	0.51	<b>0.54</b>
gpt-3.5-turbo-16k	16k	<b>0.57</b>	0.49

- ReAct helps smaller models boost their performance.
- Big models/GPTs do not benefit much.

# ReAct Agent HotPotQA Results



LLM	Length	Zero-Shot	ReAct
fastchat-t5-3b	2k	0.03	0.07
vicuna-7b	2k	0.13	0.03
vicuna-13b	2k	0.15	0.26
vicuna-33b	2k	0.22	0.26
llama-2-7b	4k	0.04	0.26
llama-2-13b	4k	0.17	0.25
llama-2-70b	4k	<b>0.28</b>	<b>0.36</b>
mpt-7b-instruct	8k	0.10	0.17
mpt-30b-instruct	8k	0.16	0.33
xgen-8k-7b-instruct	8k	0.15	0.19
longchat-7b-16k	16k	0.08	0.22
longchat-13b-16k	16k	0.11	0.24
text-davinci-003	4k	<b>0.34</b>	<b>0.45</b>
gpt-3.5-turbo	4k	0.33	0.32
gpt-3.5-turbo-16k-0613	16k	0.30	0.19

- ReAct helps smaller models boost their performance.
- Big models/GPTs do not benefit much.
- Model size more important than context length

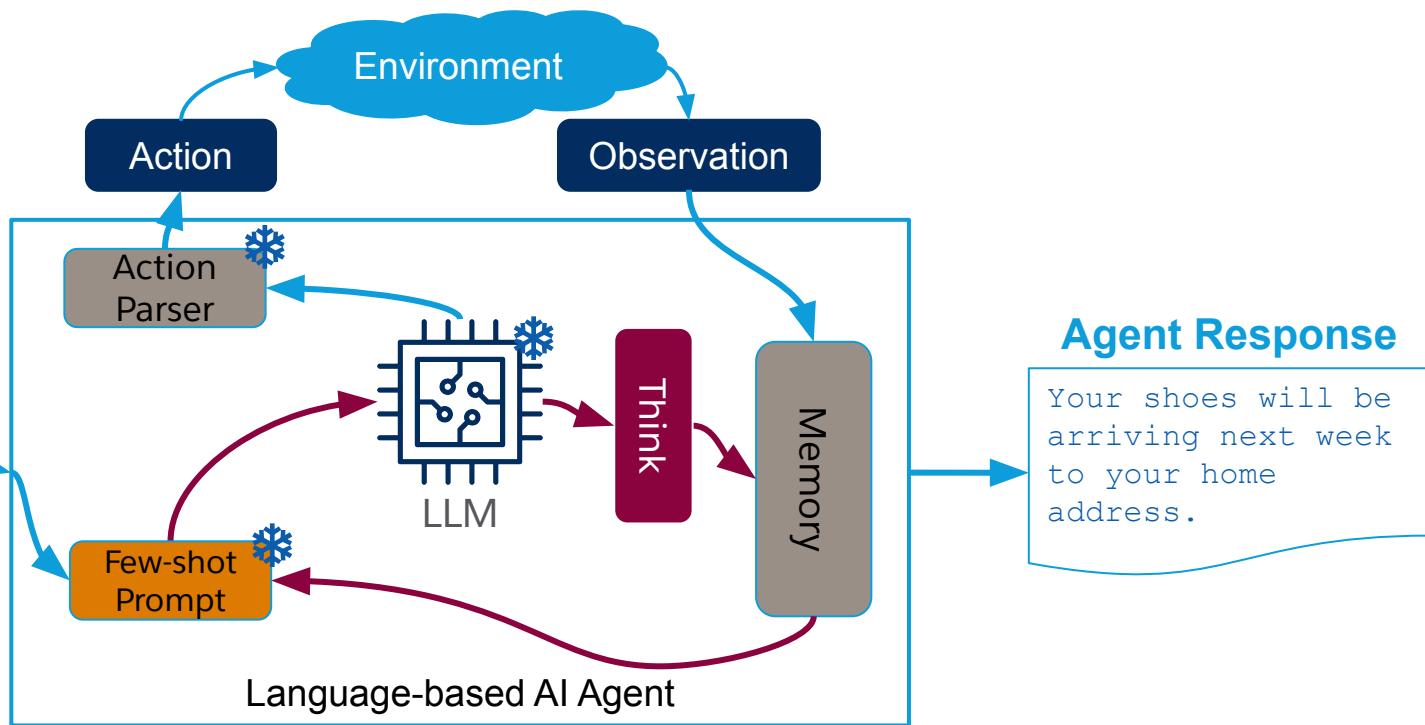
# ReAct Agent

<https://github.com/ysymyth/ReAct>



## Task Instruction

Place an online order for a new pair of black running shoes for me



# REX Agent Architecture



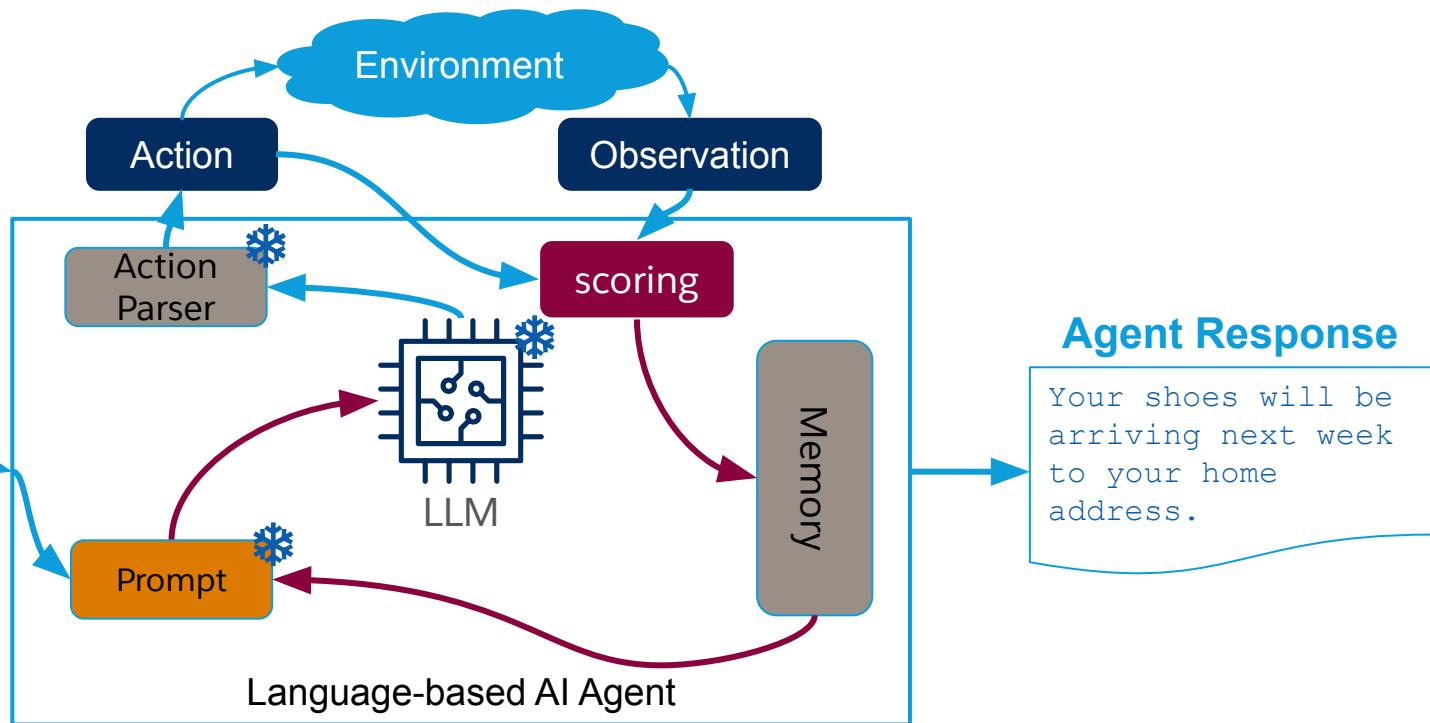
## Task Instruction

Place an online order for a new pair of black running shoes for me



## Agent Response

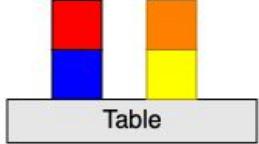
Your shoes will be arriving next week to your home address.



# Pass-1

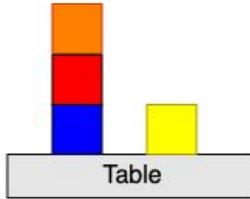
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



AI Agent

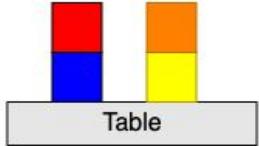
**REX:  
UCB-CoT**



# Pass-1

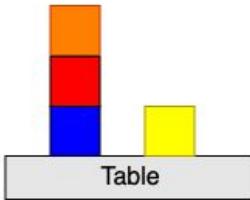
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



AI Agent



### Pass-1 Agent's Output:

**Step 1:** Unstack Orange block  
from on top of Yellow block

**Step 2:** Pick Red block



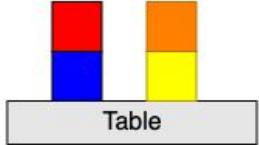
**REX:  
UCB-CoT**



# Pass-1

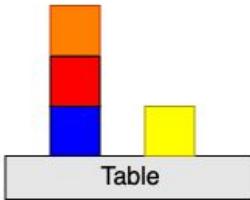
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



AI Agent



### Pass-1 Agent's Output:

**Step 1:** Unstack Orange block  
from on top of Yellow block

**Step 2:** Pick Red block

Step 1

Step 2

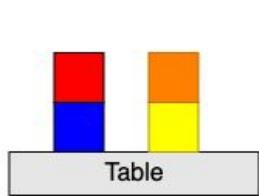
**REX:  
UCB-CoT**



# Pass-1

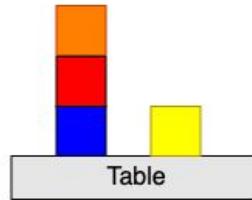
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free

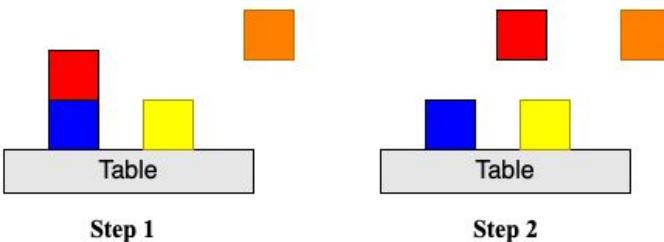


AI Agent



## Pass-1 Agent's Output:

- Step 1: Unstack Orange block from on top of Yellow block
- Step 2: Pick Red block



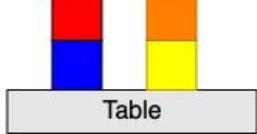
# REX: UCB-CoT



# Pass-1

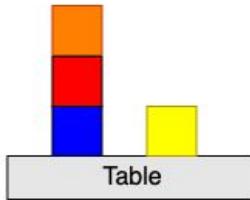
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free

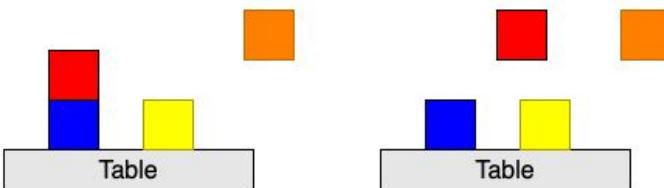


AI Agent



## Pass-1 Agent's Output:

- Step 1: Unstack Orange block from on top of Yellow block
- Step 2: Pick Red block



Step 1

Step 2

Final Config



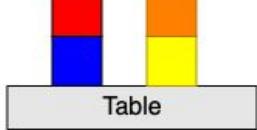
# REX: UCB-CoT



# Pass-1

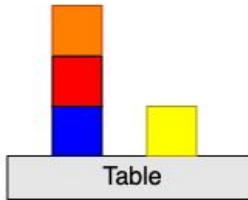
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free

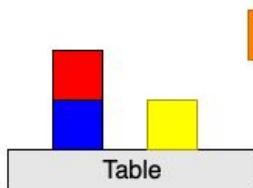


AI Agent

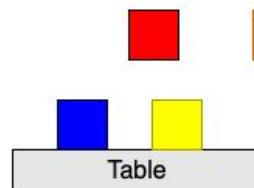


## Pass-1 Agent's Output:

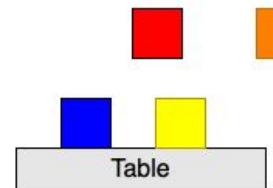
- Step 1: Unstack Orange block from on top of Yellow block
- Step 2: Pick Red block



Step 1



Step 2



Final Config



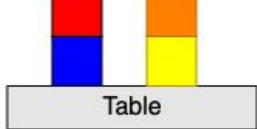
# REX: UCB-CoT



# Pass-1

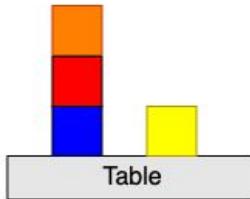
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



## REX: UCB-CoT

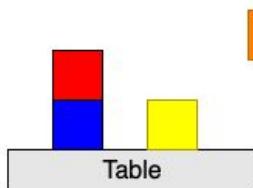


AI Agent

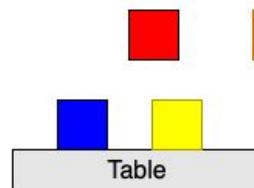


## Pass-1 Agent's Output:

- Step 1: Unstack Orange block from on top of Yellow block
- Step 2: Pick Red block

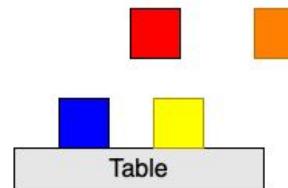


Step 1



Step 2

Correct Answer?



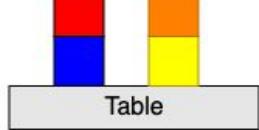
Final Config



# Pass-1

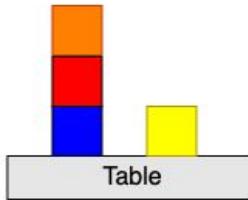
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free

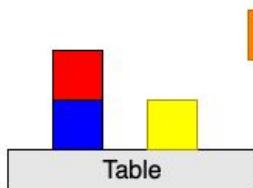


AI Agent

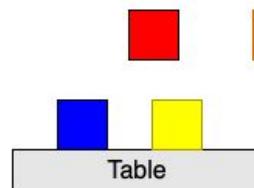


## Pass-1 Agent's Output:

- Step 1: Unstack Orange block from on top of Yellow block
- Step 2: Pick Red block

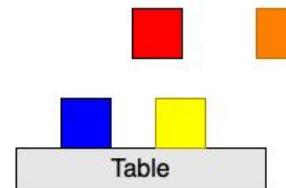


Step 1



Step 2

Correct Answer?



Final Config



# REX: UCB-CoT

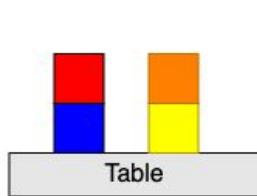


# Pass-1



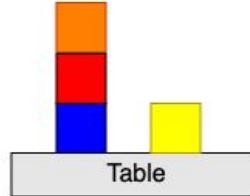
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



AI Agent

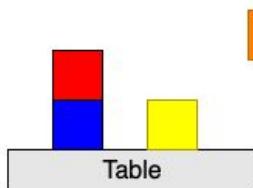
← Feedback →

Correct Answer?

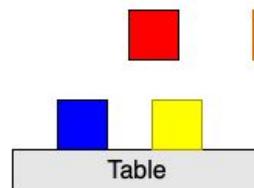


## Pass-1 Agent's Output:

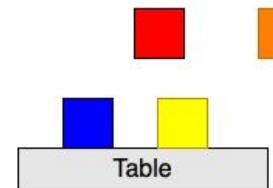
- Step 1: Unstack Orange block from on top of Yellow block
- Step 2: Pick Red block



Step 1



Step 2



Final Config

REX:  
UCB-CoT

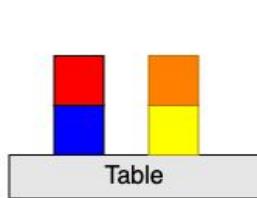


# Pass-1



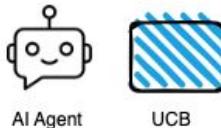
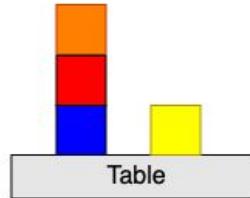
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free

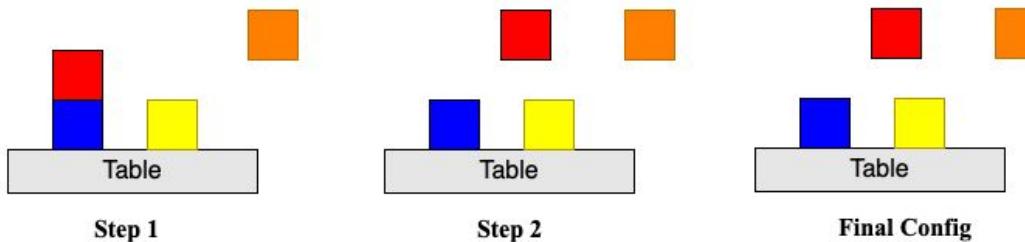


Correct Answer?



## Pass-1 Agent's Output:

- Step 1: Unstack Orange block from on top of Yellow block
- Step 2: Pick Red block



**REX:  
UCB-CoT**

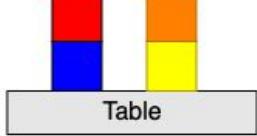


# Pass-2



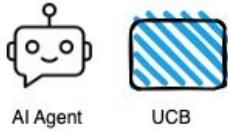
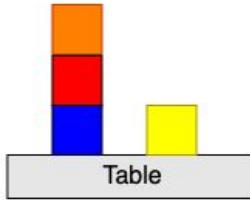
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



AI Agent

UCB

**REX:  
UCB-CoT**

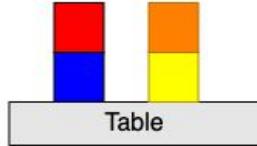


# Pass-2



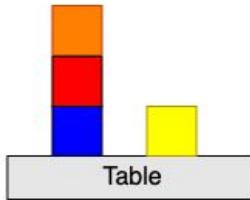
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



AI Agent

UCB



## Pass-2 Agent's Output:

### Step 1:

Pick Red block

### Step 2:

Stack Red block on top of Blue block

**REX:  
UCB-CoT**

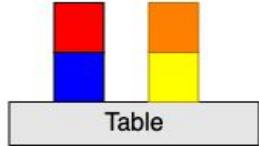


# Pass-2



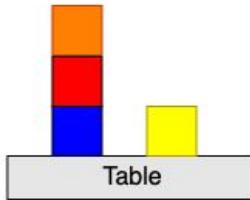
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



AI Agent

UCB



## Pass-2 Agent's Output:

### Step 1:

Pick Red block

### Step 2:

Stack Red block on top of Blue block

Step 1

Step 2

**REX:  
UCB-CoT**

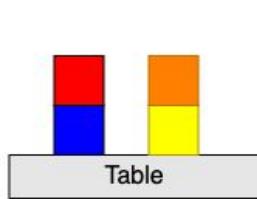


# Pass-2



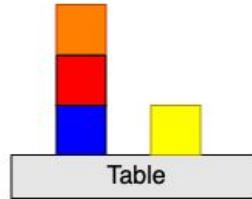
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

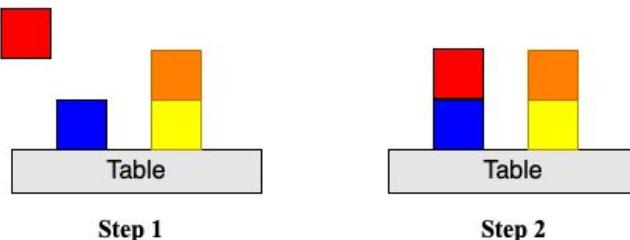
Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



## Pass-2 Agent's Output:

**Step 1:**  
Pick Red block

**Step 2:**  
Stack Red block on top of Blue block



# REX: UCB-CoT

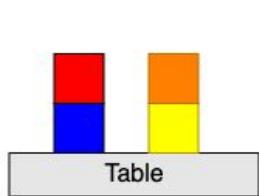


# Pass-2



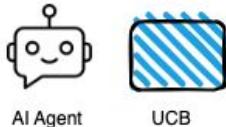
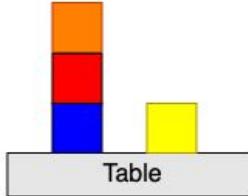
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



AI Agent

UCB



## Pass-2 Agent's Output:

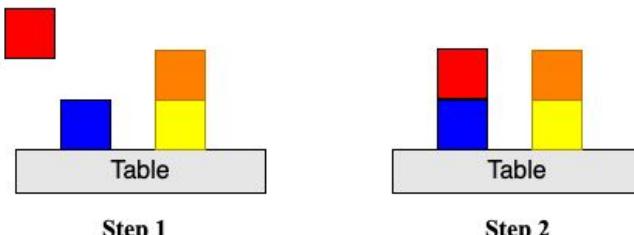
### Step 1:

Pick Red block

### Step 2:

Stack Red block on top of Blue block

blocks



Step 1

Step 2

Final Config

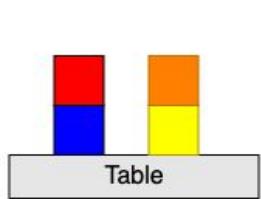
**REX:  
UCB-CoT**



# Pass-2

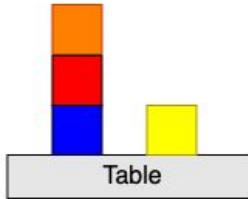
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



AI Agent

UCB



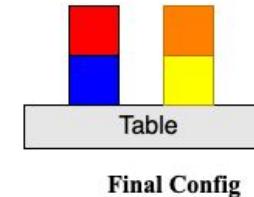
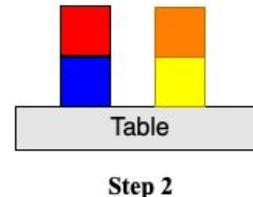
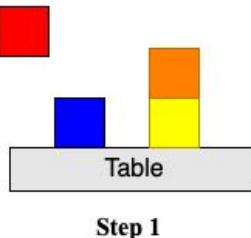
## Pass-2 Agent's Output:

### Step 1:

Pick Red block

### Step 2:

Stack Red block on top of Blue block



REX:  
UCB-CoT

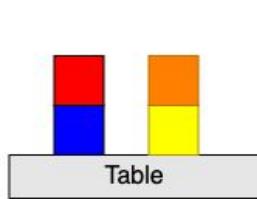


# Pass-2



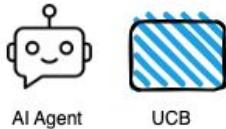
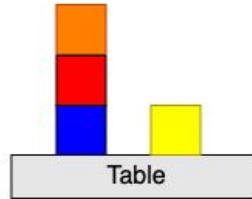
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



AI Agent

UCB



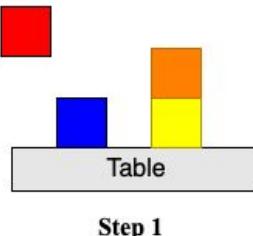
## Pass-2 Agent's Output:

### Step 1:

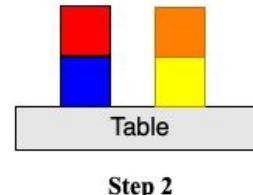
Pick Red block

### Step 2:

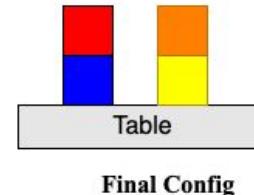
Stack Red block on top of Blue block



Step 1



Step 2



Final Config

Correct Answer?

**REX:  
UCB-CoT**

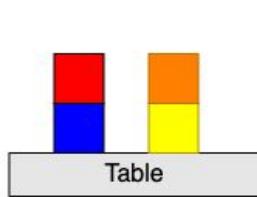


# Pass-2



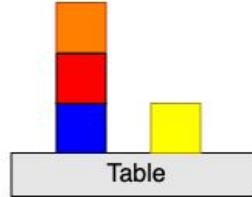
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



AI Agent

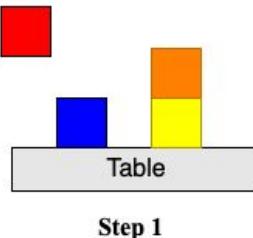
UCB



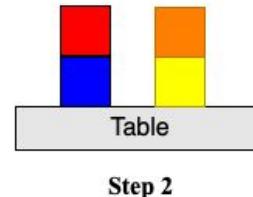
## Pass-2 Agent's Output:

**Step 1:**  
Pick Red block

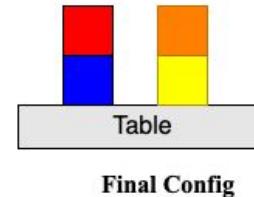
**Step 2:**  
Stack Red block on top of Blue block



Step 1



Step 2



Final Config

Correct Answer?



**REX:  
UCB-CoT**

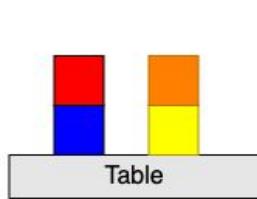


# Pass-2



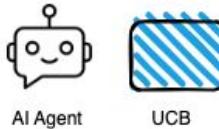
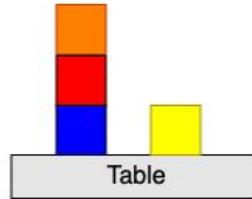
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



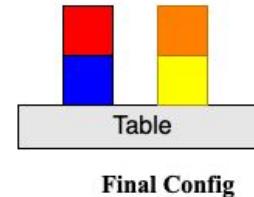
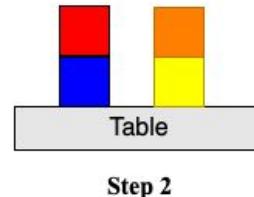
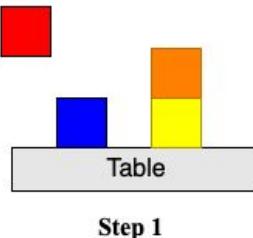
Correct Answer?



## Pass-2 Agent's Output:

**Step 1:**  
Pick Red block

**Step 2:**  
Stack Red block on top of Blue block



**REX:  
UCB-CoT**

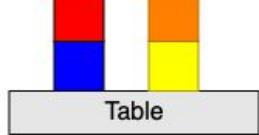


# Pass-7



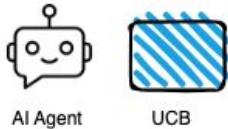
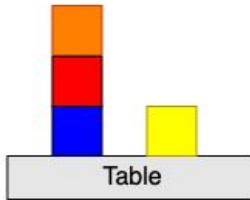
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



# REX: UCB-CoT

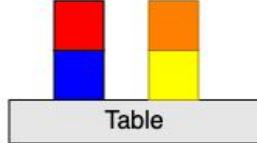


# Pass-7



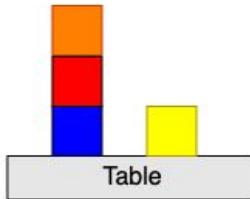
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



AI Agent

UCB



## Pass-7 Agent's Output:

**Step 1:** Unstack Orange block from on top of Yellow block

**Step 2:** Stack Orange block on top of Red block

**REX:  
UCB-CoT**

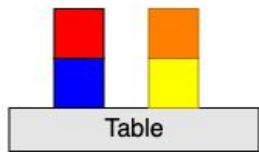


# Pass-7



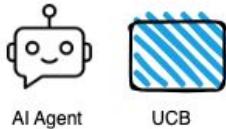
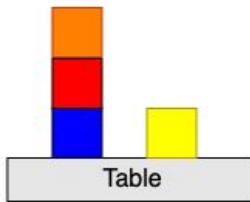
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



## Pass-7 Agent's Output:

**Step 1:** Unstack Orange block from on top of Yellow block

**Step 2:** Stack Orange block on top of Red block

**Step 1**

**Step 2**

**REX:  
UCB-CoT**

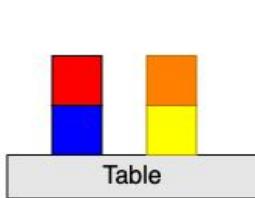


# Pass-7



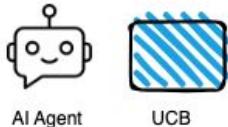
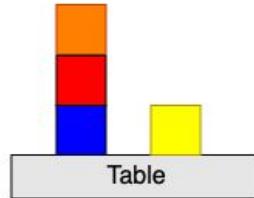
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



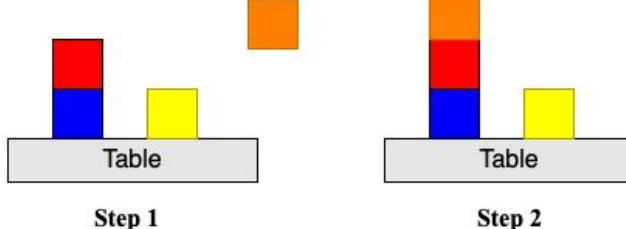
## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



## Pass-7 Agent's Output:

Step 1: Unstack Orange block from on top of Yellow block



Step 2: Stack Orange block on top of Red block

# REX: UCB-CoT

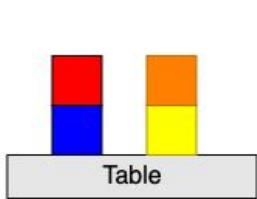


# Pass-7



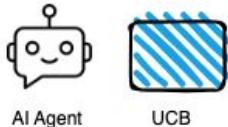
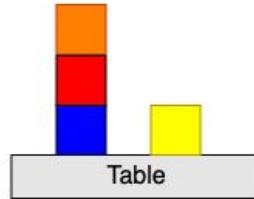
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



## Final Block Configuration

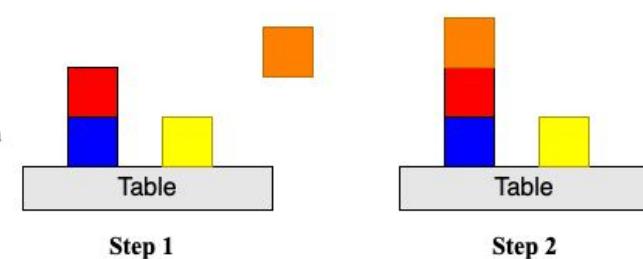
Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



## Pass-7 Agent's Output:

Step 1: Unstack Orange block from on top of Yellow block

Step 2: Stack Orange block on top of Red block



**REX:  
UCB-CoT**

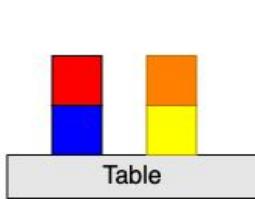


# Pass-7



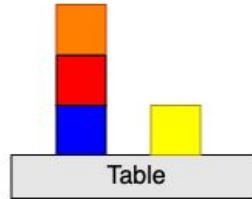
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



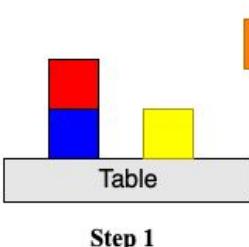
## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free

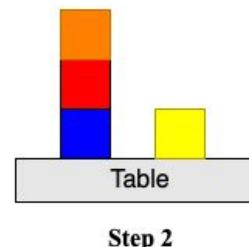


## Pass-7 Agent's Output:

Step 1: Unstack Orange block from on top of Yellow block



Step 2: Stack Orange block on top of Red block



Final Config

**REX:  
UCB-CoT**

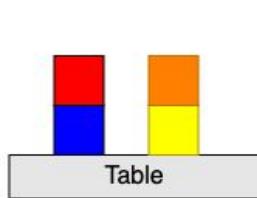


# Pass-7



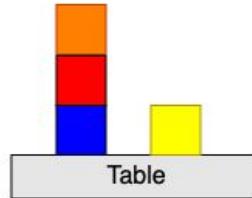
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



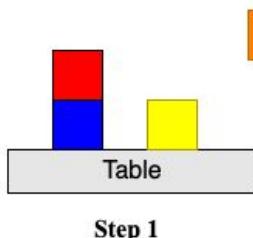
## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free

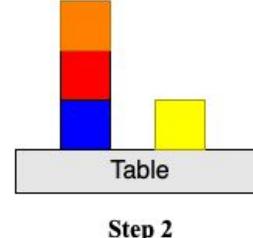


## Pass-7 Agent's Output:

Step 1: Unstack Orange block from on top of Yellow block



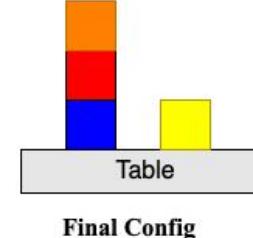
Step 2: Stack Orange block on top of Red block



Step 1

Step 2

Correct Answer?



Final Config

REX:  
UCB-CoT

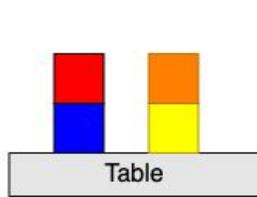


# Pass-7



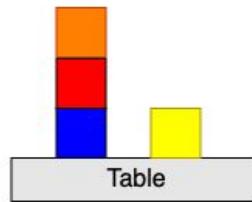
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



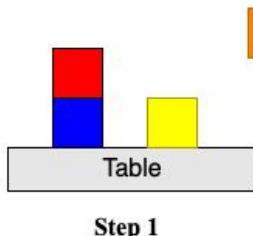
## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free



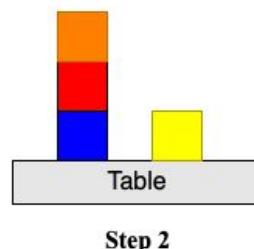
## Pass-7 Agent's Output:

Step 1: Unstack Orange block from on top of Yellow block



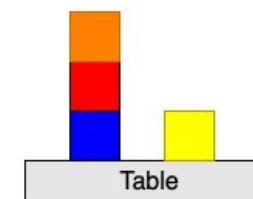
Step 1

Step 2: Stack Orange block on top of Red block



Step 2

Correct Answer?



Final Config

**REX:  
UCB-CoT**

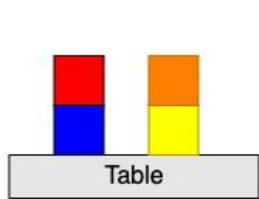


# Pass-7



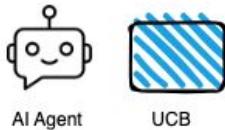
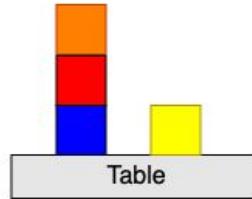
## Initial Block Configuration

Blue block is on the table. Red block is on top of Blue block and is free. Yellow block is on table. Orange block is on top of Yellow block and is free



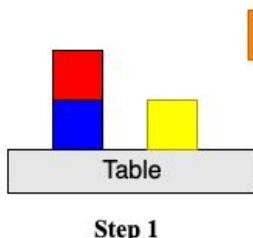
## Final Block Configuration

Blue block is on the table. Red block is on top of Blue block. Yellow block is on table and is free. Orange block is on top of Red block and is free

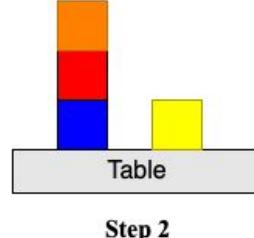


## Pass-7 Agent's Output:

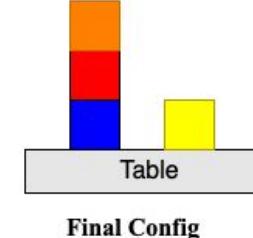
Step 1: Unstack Orange block from on top of Yellow block



Step 2: Stack Orange block on top of Red block



Correct Answer?



**REX:  
UCB-CoT**



# REX Results



REX {

Model	2-step (n=30)	4-step (n=56)	6-step (n=114)
CoT	40%	17.85%	8.77%
Reflexion (+ CoT)	41.67%	<u>41.96%</u>	<b>29.82%</b>
$\mathcal{R}$ -CoT	53.33%	37.5%	14.91%
UCB-CoT	<b>80%</b>	39.28%	<u>25.43%</u>
UCL-CoT	<u>60%</u>	<b>44.64%</b>	20.17%

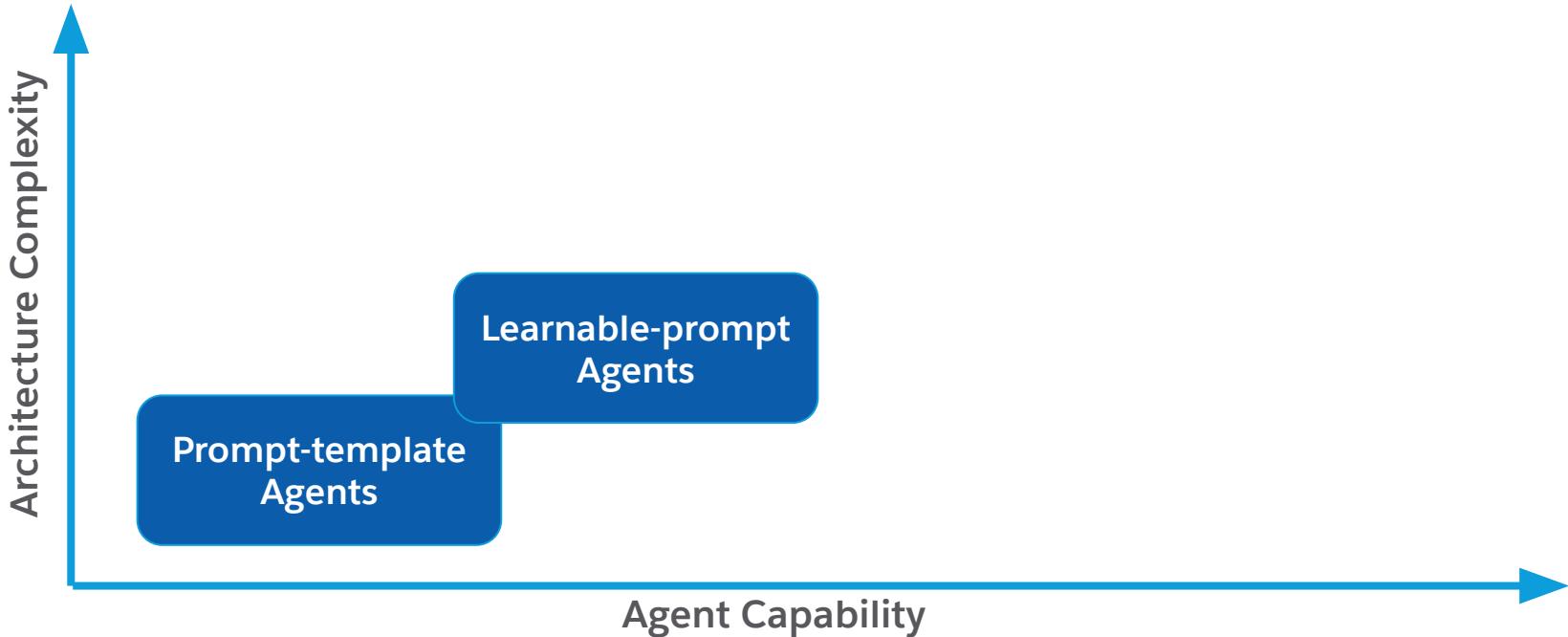
Table 2: Blocksworld; T=0

Model	GSM8K-test (n=1319)
CoT (1-pass)	76.95%
CoT	80.81%
Reflexion (+ CoT)	<b>88.85%</b>
$\mathcal{R}$ -CoT	81.34%
UCB-CoT	82.03%
UCL-CoT	<b>90.44%</b>

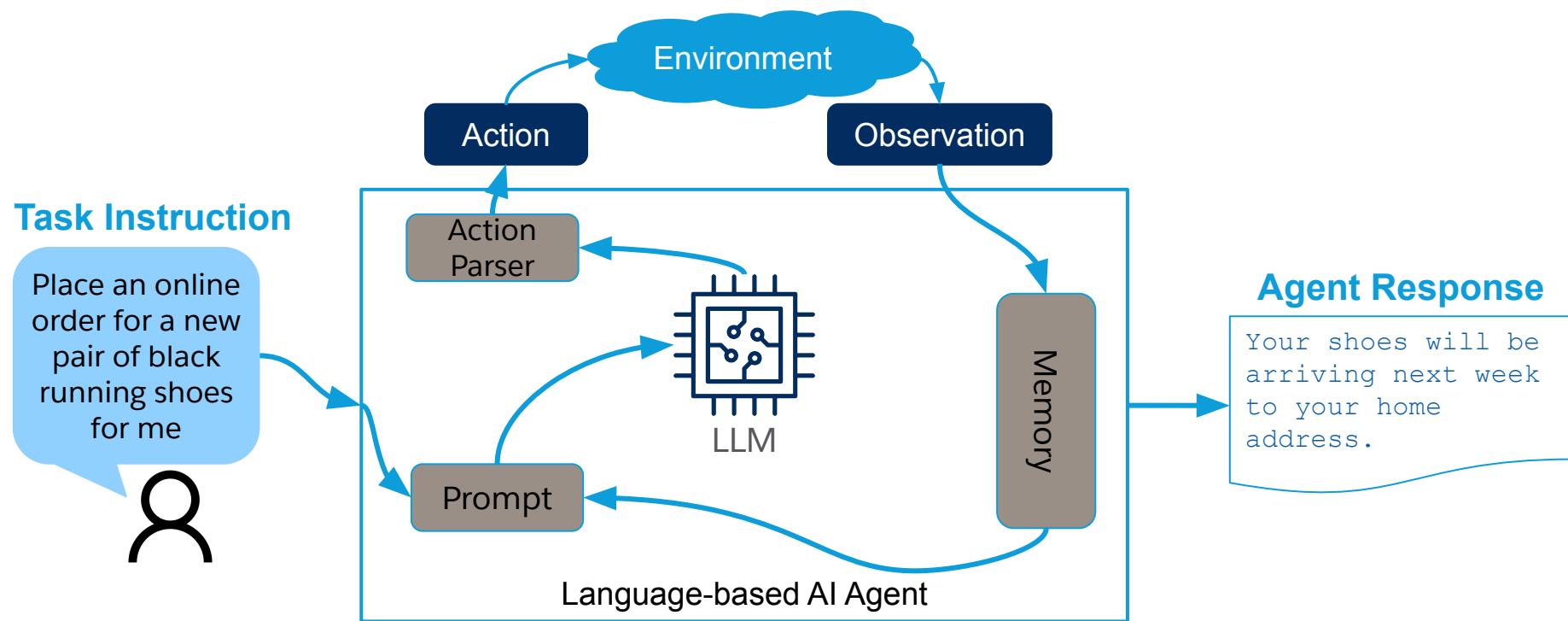
Table 4: GSM8K; T=0



# Language-based AI Agents



# High-level Language-based Agent framework



# Learnable-prompt Agents



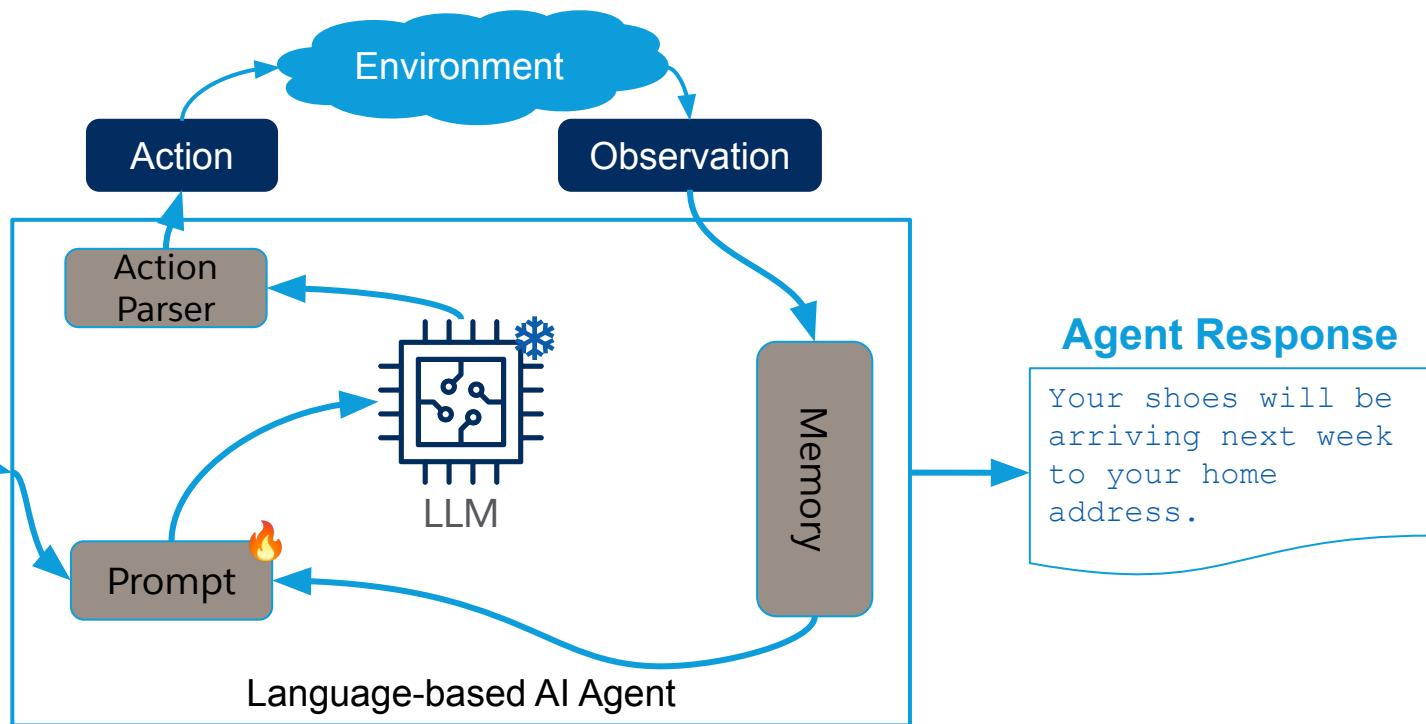
## Task Instruction

Place an online order for a new pair of black running shoes for me



## Agent Response

Your shoes will be arriving next week to your home address.



# Retroformer

<https://github.com/weirayao/Retroformer>



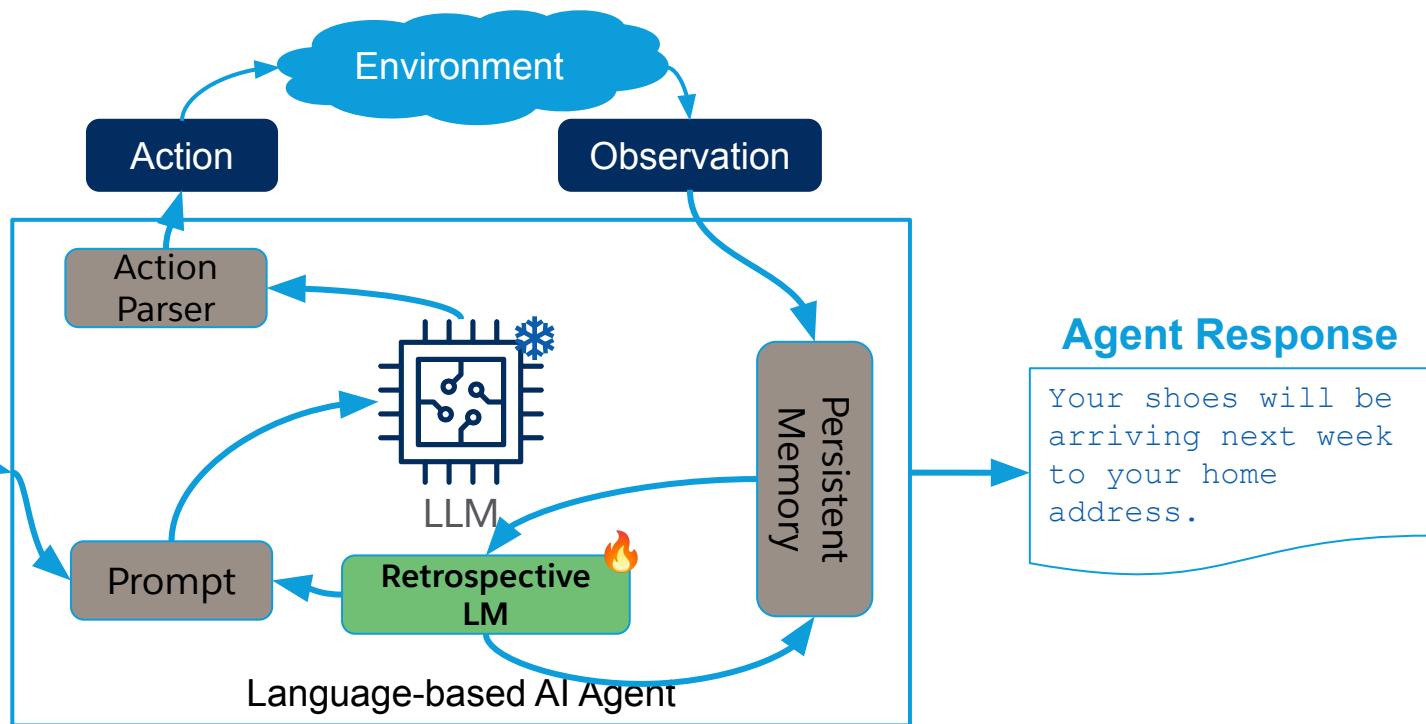
## Task Instruction

Place an online order for a new pair of black running shoes for me



## Agent Response

Your shoes will be arriving next week to your home address.



# Retroformer: Store useful reflections

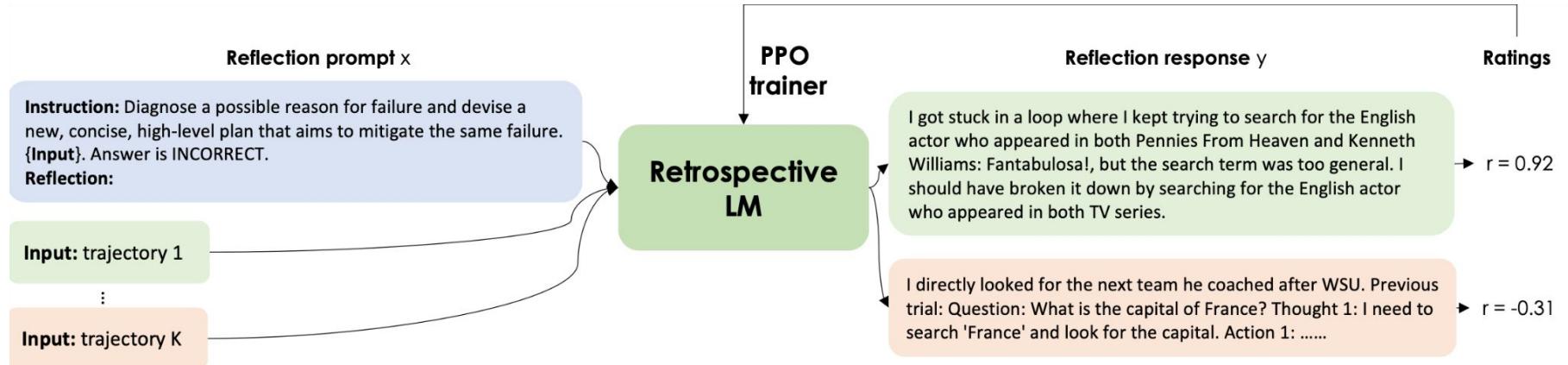


Question	Prior failed trial	Reflection (Green: Retroformer)
Lollipop Chainsaw featured Juliet Starling, who was voiced by a Canadian-American actress who has done voice roles for what Teen Titans spinoff series?	<p><b>Thought 1:</b> I need to search Juliet Starling and find the Canadian-American actress who voiced her, then find the Teen Titans spinoff series she has done voice roles for.</p> <p><b>Action 1:</b> Search[Juliet Starling]</p> <p><b>Observation 1:</b> Could not find [Juliet Starling]. ...</p> <p><b>Thought 2:</b> Juliet Starling is a character from Lollipop Chainsaw, so I can search Lollipop Chainsaw.</p> <p><b>Action 2:</b> Search[Lollipop Chainsaw]</p> <p><b>Observation 2:</b> Lollipop Chainsaw is a ...</p> <p><b>Thought 3:</b> Juliet Starling is voiced by Tara Strong, so I need to search Tara Strong and find the Teen Titans spinoff series she has done voice roles for.</p> <p><b>Action 3:</b> Search[Tara Strong]</p> <p><b>Observation 3:</b> Tara Lyn Strong...</p> <p><b>Thought 4:</b> Tara Strong has voiced characters in Teen Titans and Teen Titans Go!, so the answer is Teen Titans and Teen Titans Go!.</p> <p><b>Action 4:</b> Finish[Teen Titans and Teen Titans Go!]</p>	I failed to find the Teen Titans spinoff series that Tara Strong has done voice roles for. Instead, I found Lollipop Chainsaw, a video game that Juliet Starling appeared in. I should have searched Tara Strong and Teen Titans or Teen Titans Go! specifically in my previous action to find the correct answer.

# Retroformer: Policy Gradient Optimization



Use Proximal Policy Optimization (PPO) to fine-tune the retrospective LM



# Retroformer: HotPotQA Result

## Question Answering Task

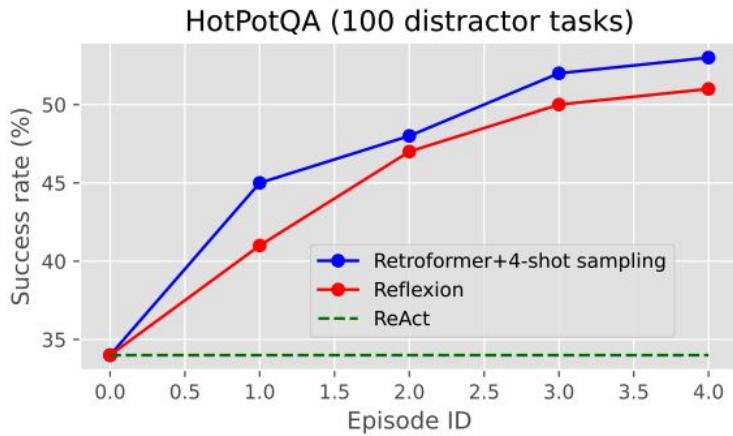
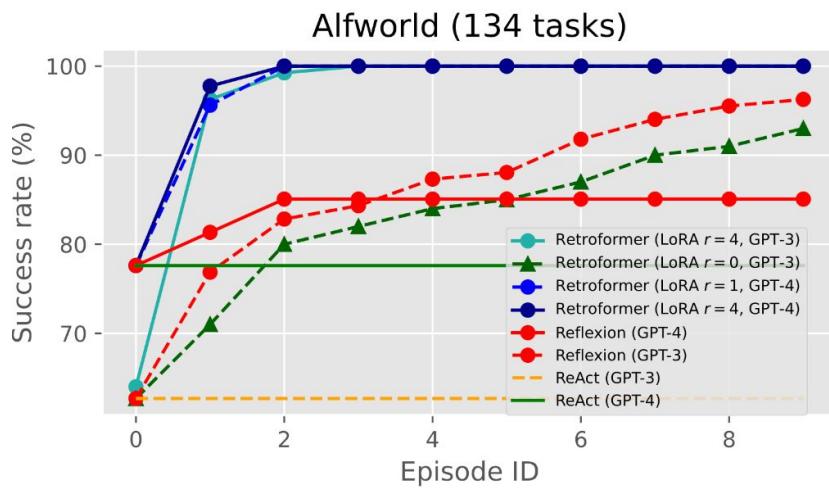


Figure 4: We compare **Retroformer** with baselines and observe consistent and faster performance improvement in terms of success rate.

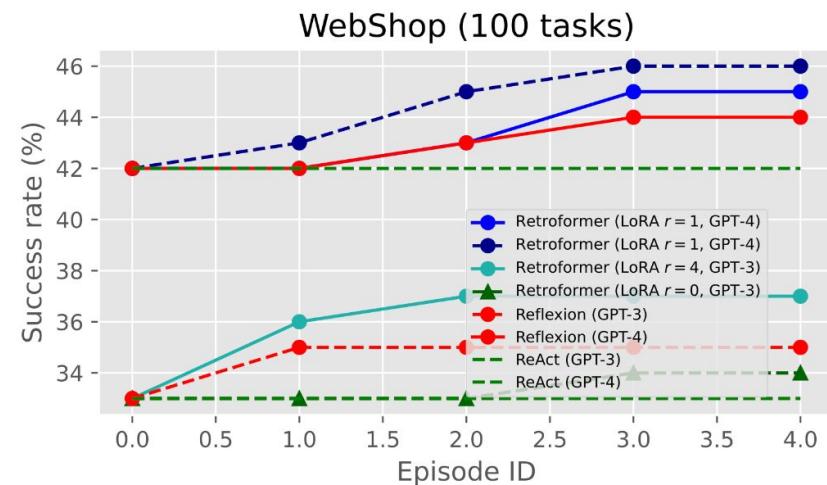
## Task Description

- Solve a question answering task by searching in Wikipedia pages.
- At each step, the agent is asked to choose from three action APIs:
  - Search [entity]
  - Lookup [keyword]
  - Finish [answer]
- Evaluation metric (success rate) measures if the answer and ground truth matches exactly or not, over all tasks.

# Retroformer: Alfworld & Webshop Results



(a) AlfWorld environment



(b) WebShop environment

# Retroformer takeaways: Refine prompts, decompose

<https://github.com/weirayao/Retroformer>



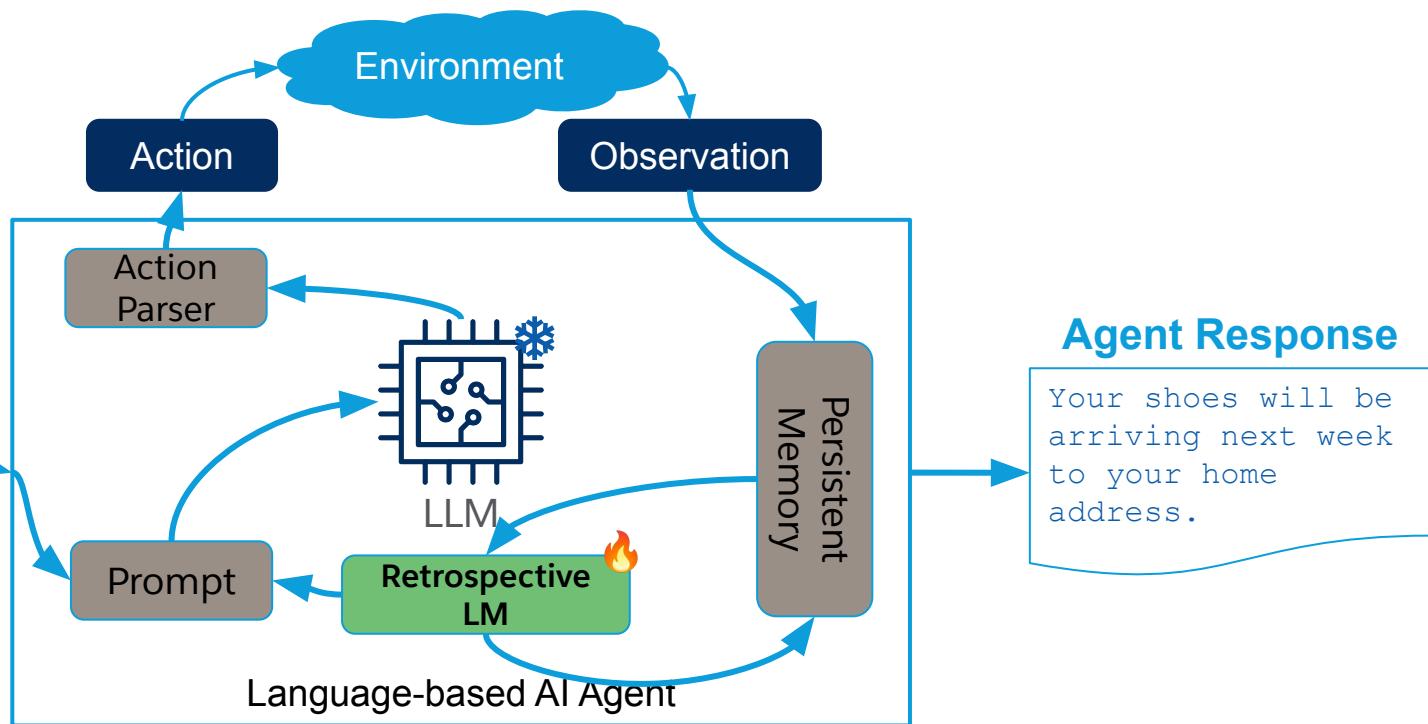
## Task Instruction

Place an online order for a new pair of black running shoes for me

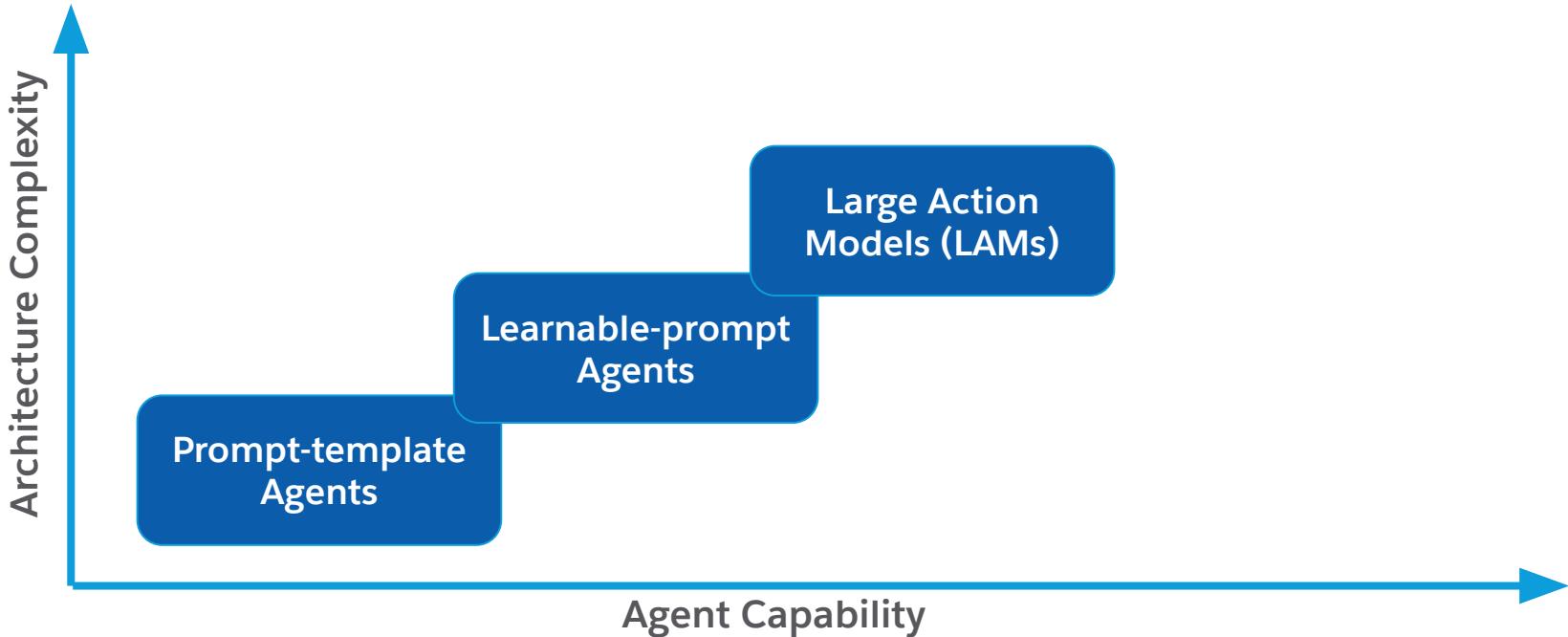


## Agent Response

Your shoes will be arriving next week to your home address.



# Language-based AI Agents



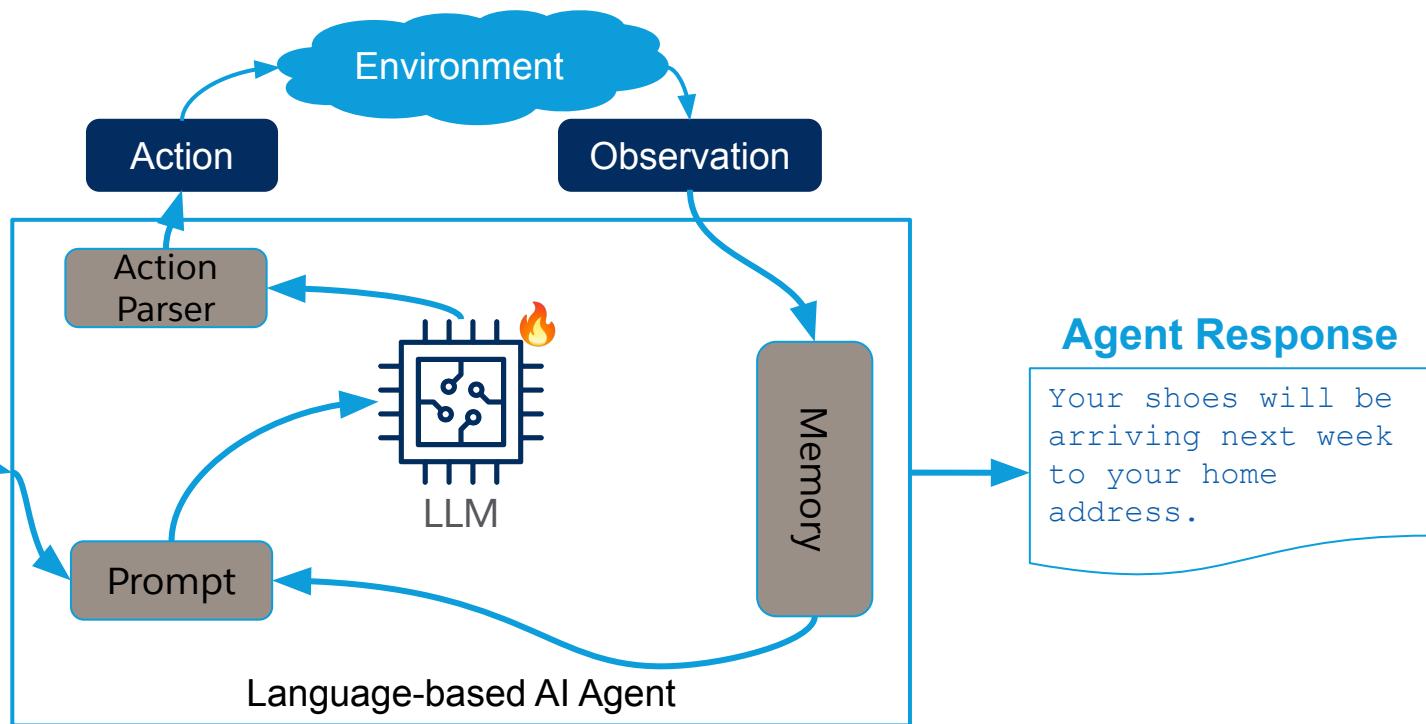
# Large Action Models (LAMs)

<https://github.com/SalesforceAIResearch/xLAM>



## Task Instruction

Place an online order for a new pair of black running shoes for me



# Agent Trajectory Data Example



## HotPotQA

```
{  
  "question": "Which magazine was started first Arthur's Magazine or First for Women?",  
  "answer": "Arthur's Magazine",  
  "correct": true,  
  "reward": 1.0,  
  "halted": false,  
  "error": false,  
  "prompt": "  
    Question: Which magazine was started first Arthur's Magazine or First for Women? Follow Action[param] format.\n    Thought: I need to Search[Arthur's Magazine] and then Search[First for Women] to collect their starting information.\n    Model Action 1: Search[Arthur's Magazine]\n    Env Observation 1: Arthur's Magazine was published in 1844.\n    Model Action 2: Search[First for Women]\n    Env Observation 2: First for Women is a woman's magazine published in 1989.\n    Model Action 3: Finish[Arthur's Magazine]\n    Env Observation 3: Answer is CORRECT"  
}
```

**Question:** Which magazine was started first Arthur's Magazine or First for Women? Follow Action[param] format.  
**Thought:** I need to Search[Arthur's Magazine] and then Search[First for Women] to collect their starting information.  
**Model Action 1:** Search[Arthur's Magazine]  
**Env Observation 1:** Arthur's Magazine was published in 1844.  
**Model Action 2:** Search[First for Women]  
**Env Observation 2:** First for Women is a woman's magazine published in 1989.  
**Model Action 3:** Finish[Arthur's Magazine]  
**Env Observation 3:** Answer is CORRECT

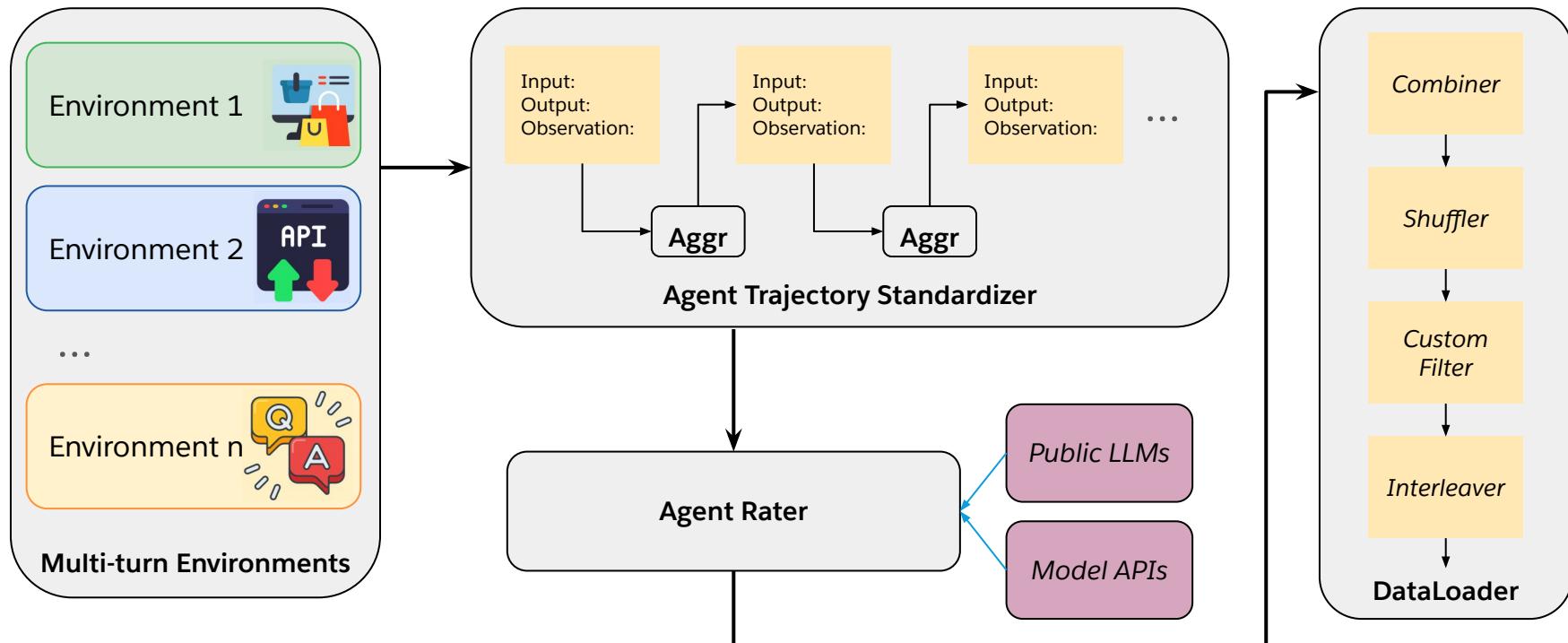
## WebShop

```
[  
  [{"  
    "Begin!\\n\\nUSER": "Can you send a GET request to link 1 and then retrieve the cookie by sending another GET request to link 2\\n Follow: Thought: xxx.\\n Action: name \\n Action Input:{param} format.",  
    "ASSISTANT Thought": "I need to send a request to set the cookie. \\nASSISTANT Action: sendHttpRequest\\nASSISTANT Action Input: {link1}\\nASSISTANT Observation: ",  
    "ASSISTANT Observation": "Status Code: 200.... Response 1\\n",  
    "ASSISTANT Thought": "The request was successful.\\nASSISTANT Action: getClientRequestData\\nASSISTANT Action Input: {link2}\\nASSISTANT Observation: ",  
    "ASSISTANT Observation": "Status Code: 200. ...\\nASSISTANT Thought: ",  
    "ASSISTANT Thought": "The cookie data was retrieved.\\nASSISTANT Response: The request was successful."  
  }],  
  [ false, true, false, true, false, true]  
]
```

# AgentOhana: Unified Diverse Training Data

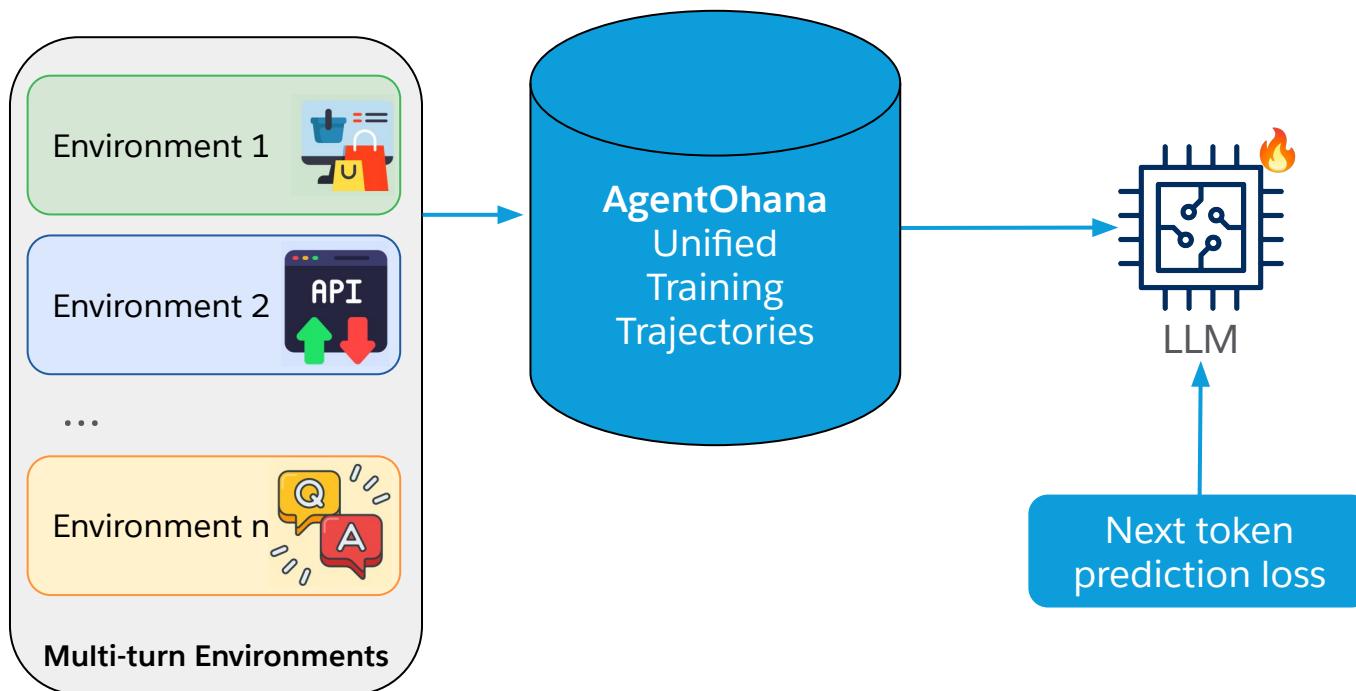


<https://github.com/SalesforceAIResearch/xLAM>



# Training xLAM (Large Action Model)

Supervised Fine-tuning (SFT)



[Zhang et al. The AgentOhana: Designing Unified Data and Training Pipeline for Effective Agent Learning. ICLR 2024 Workshop on LLM Agents]

# xLAM: Results

<https://github.com/SalesforceAIResearch/xLAM>

LLM	LAA Architecture					
	ZS	ZST	ReAct	PlanAct	PlanReAct	BOLAA
Llama-2-70b-chat (Touvron et al., 2023)	0.0089	0.0102	0.4273	0.2809	0.3966	0.4986
Vicuna-33b (Zheng et al., 2023b)	0.1527	0.2122	0.1971	0.3766	0.4032	0.5618
Mixtral-8x7B-Instruct-v0.1 (Jiang et al., 2024)	0.4634	0.4592	<u>0.5638</u>	0.4738	0.3339	0.5342
GPT-3.5-Turbo	<u>0.4851</u>	<u>0.5058</u>	0.5047	0.4930	<u>0.5436</u>	<u>0.6354</u>
GPT-3.5-Turbo-Instruct	0.3785	0.4195	0.4377	0.3604	0.4851	0.5811
GPT-4-0613	<u>0.5002</u>	0.4783	0.4616	<b>0.7950</b>	0.4635	0.6129
xLAM-v0.1	<b>0.5201</b>	<b>0.5268</b>	<b>0.6486</b>	<u>0.6573</u>	<b>0.6611</b>	<b>0.6556</b>

Table 2: Average reward on the WebShop environment. **Bold** and Underline results denote the best result and the second best result for each setting, respectively.

# xLAM: Results

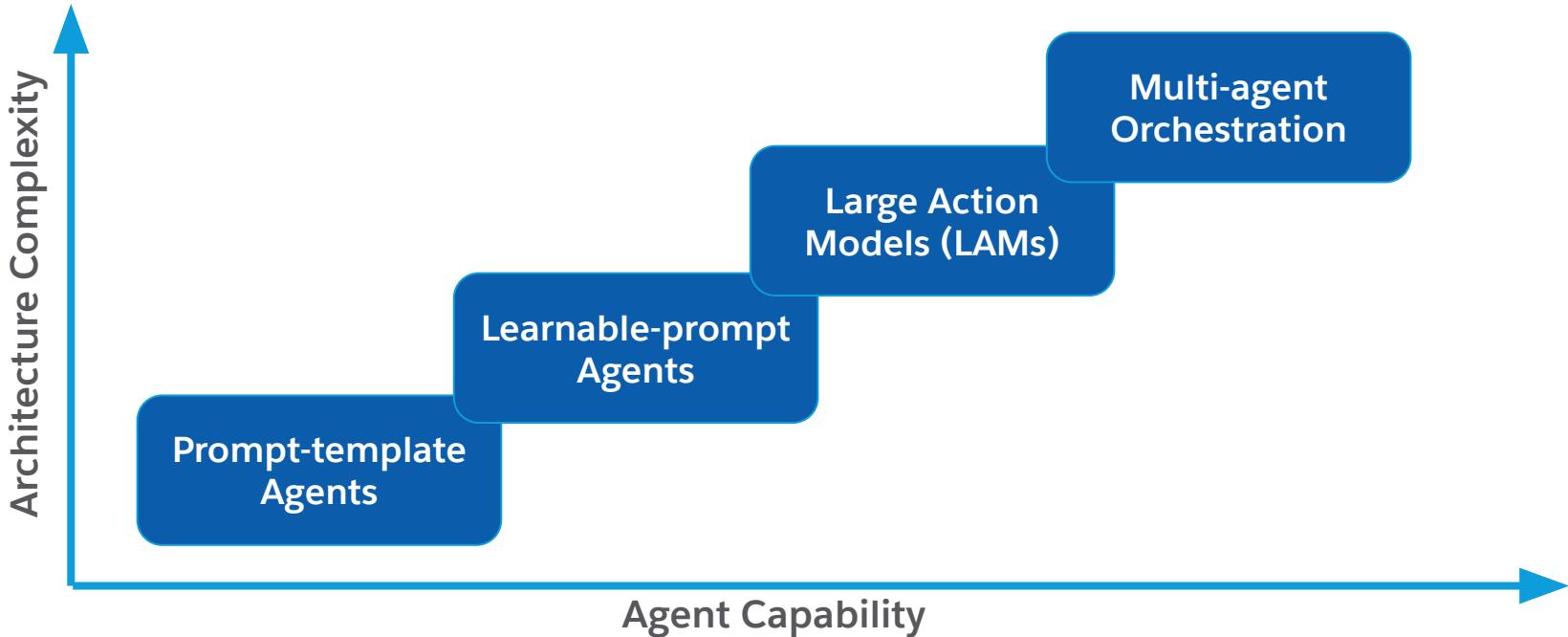
<https://github.com/SalesforceAIResearch/xLAM>



LLM	LAA Architecture				
	ZS	ZST	ReAct	PlanAct	PlanReAct
Mixtral-8x7B-Instruct-v0.1 (Jiang et al., 2024)	0.3912	0.3971	0.3714	0.3195	0.3039
GPT-3.5-Turbo	0.4196	0.3937	0.3868	0.4182	0.3960
GPT-4-0613	<b>0.5801</b>	<b>0.5709</b>	<b>0.6129</b>	<b>0.5778</b>	<b>0.5716</b>
xLAM-v0.1	<u>0.5492</u>	<u>0.4776</u>	<u>0.5020</u>	<u>0.5583</u>	<u>0.5030</u>

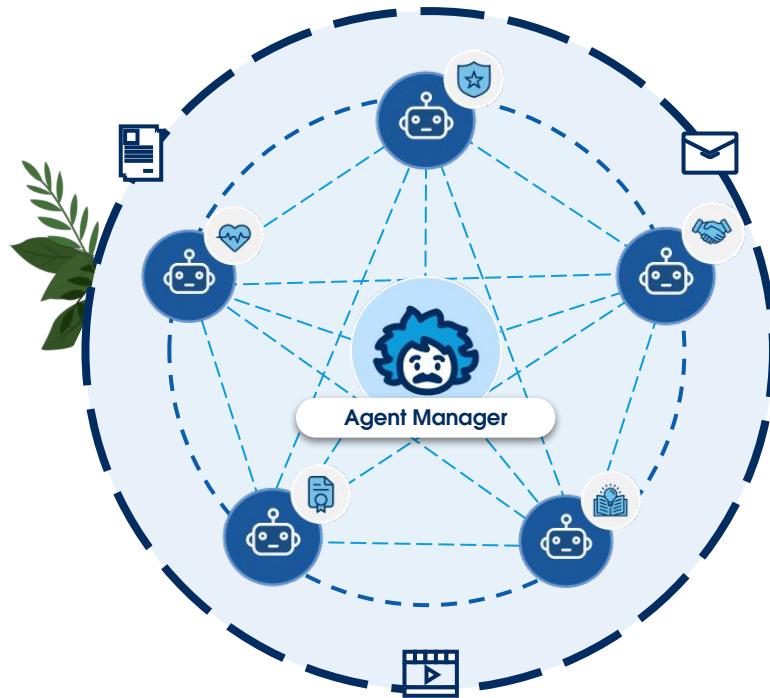
Table 3: Average reward on the HotpotQA environment. **Bold** and Underline results denote the best result and the second best result for each setting, respectively.

# Language-based AI Agents



# From Single Agents to Multiple Agents

<https://github.com/SalesforceAIResearch/AgentLite>



release v0.1.0 Python 3.9+ License Apache ⚡ Stars 244

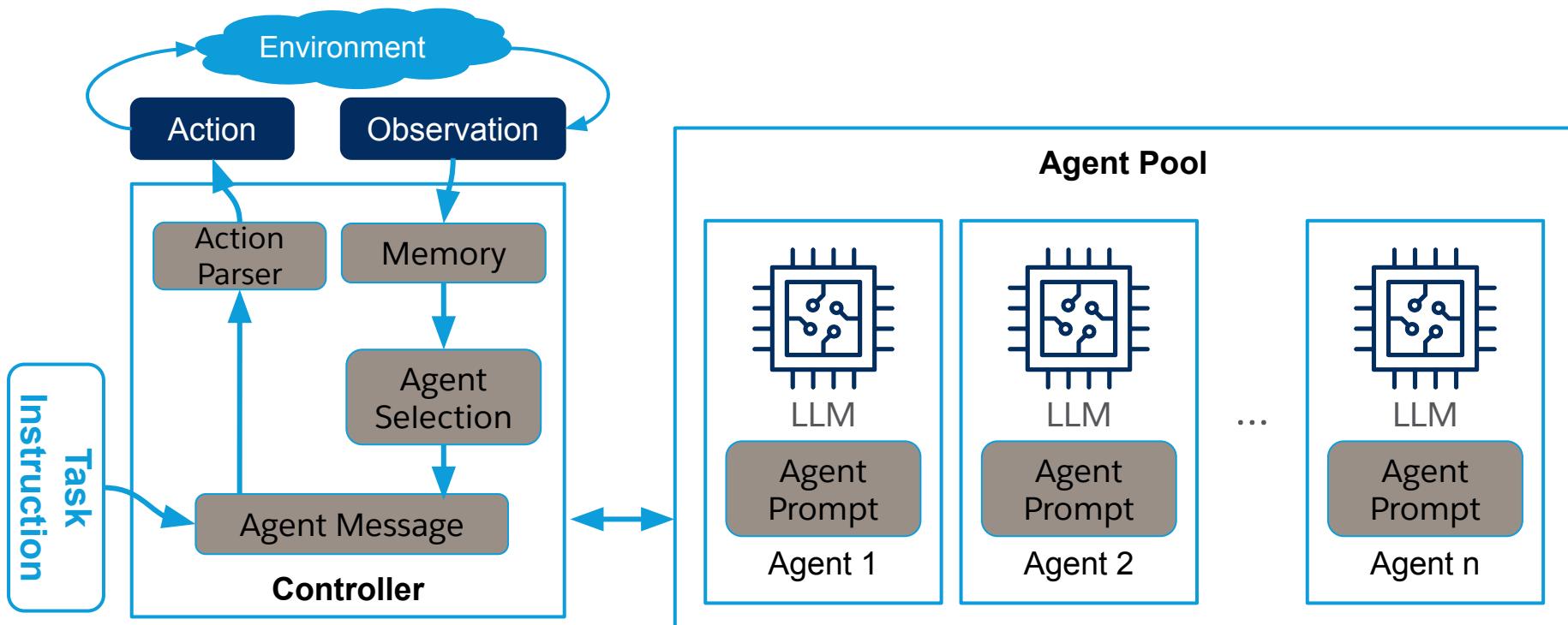
Equip agents with LLMs and Tools

Define agent hierarchy: managers and specialists

Lean implementation, easy-to-follow tutorials

# BOLAA: Orchestrating multiple agents

<https://github.com/salesforce/BOLAA>



# BOLAA Multi-Agent WebShop Results

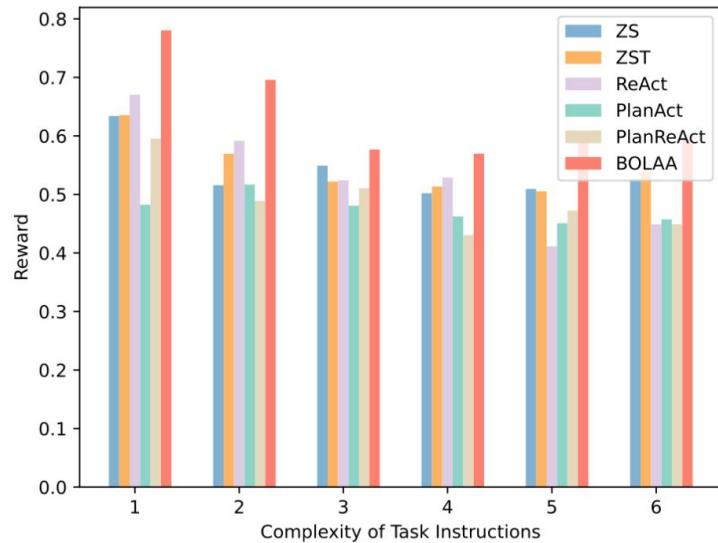


LLM	Length	Zero-Shot	ReAct	BOLAA
fastchat-t5-3b	2k	0.40	<b>0.31</b>	<b>0.52</b>
vicuna-7b	2k	0.00	0.10	0.06
vicuna-13b	2k	0.03	0.15	<b>0.54</b>
vicuna-33b	2k	0.14	0.19	<b>0.56</b>
llama-2-7b	4k	0.00	0.12	<b>0.46</b>
llama-2-13b	4k	0.07	0.26	<b>0.37</b>
llama-2-70b	4k	0.01	<b>0.44</b>	<b>0.50</b>
mpt-7b-instruct	8k	0.00	0.06	0.06
mpt-30b-instruct	8k	0.17	<b>0.31</b>	<b>0.44</b>
xgen-8k-7b-instruct	8k	0.00	0.07	<b>0.37</b>
longchat-7b-16k	16k	0.02	0.07	<b>0.20</b>
longchat-13b-16k	16k	0.00	0.24	<b>0.32</b>
text-davinci-003	4k	<b>0.53</b>	<b>0.55</b>	<b>0.63</b>
gpt-3.5-turbo	4k	0.51	<b>0.54</b>	<b>0.66</b>
gpt-3.5-turbo-16k	16k	<b>0.57</b>	0.49	<b>0.65</b>

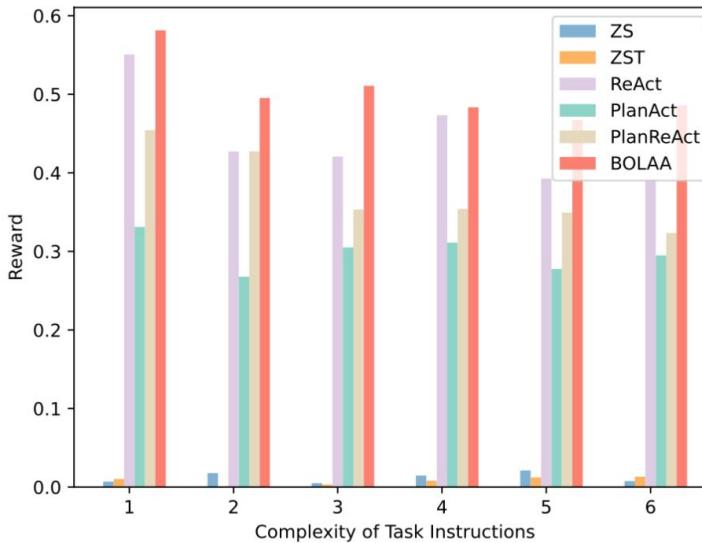
- The BOLAA multi-agent architecture significantly improves the performance of smaller models.
- GPT models also improve

[Zhiwei Liu. “BOLAA: Benchmarking and orchestrating LLM-augmented autonomous agents”. ICLR 2024 Workshop on LLM Agents]

# BOLAA: Task Instruction Complexity on WebShop



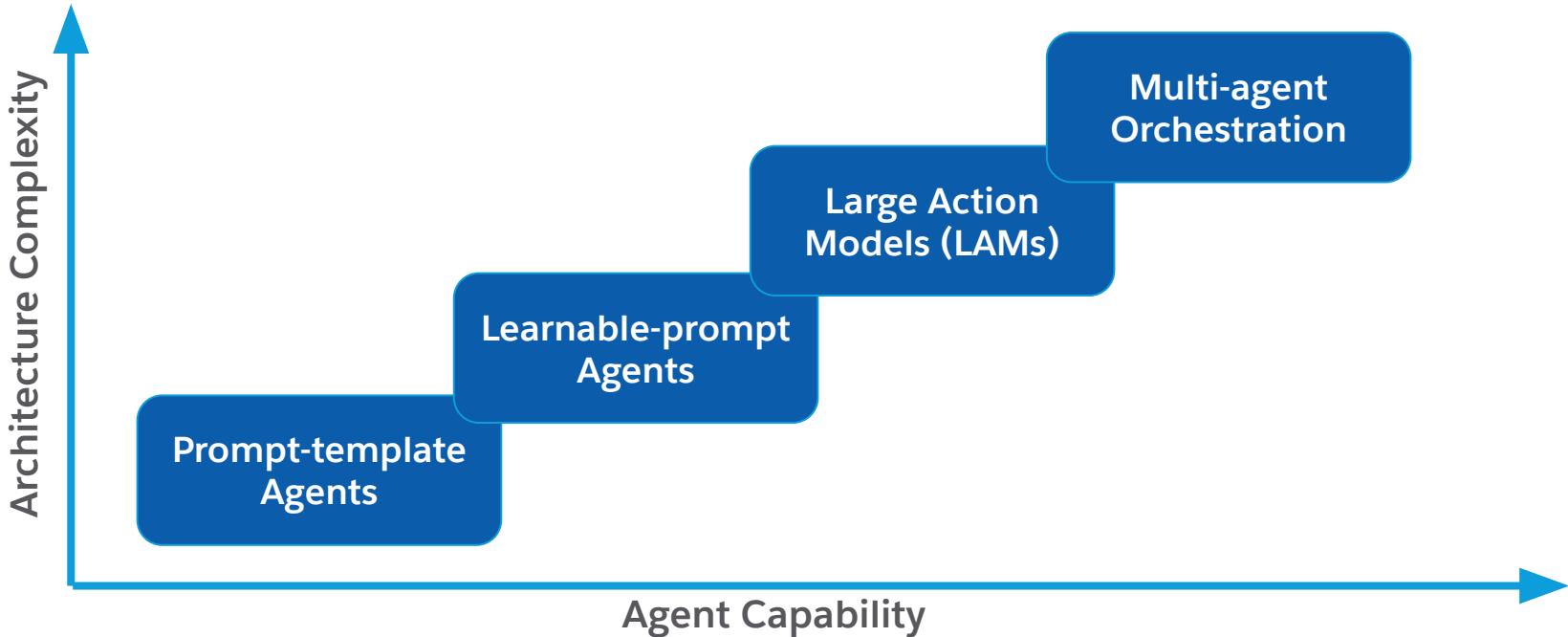
(a) text-davinci-003



(b) Llama-2-70b

- Task Complexity = number of attributes described in query

# Language-based AI Agents

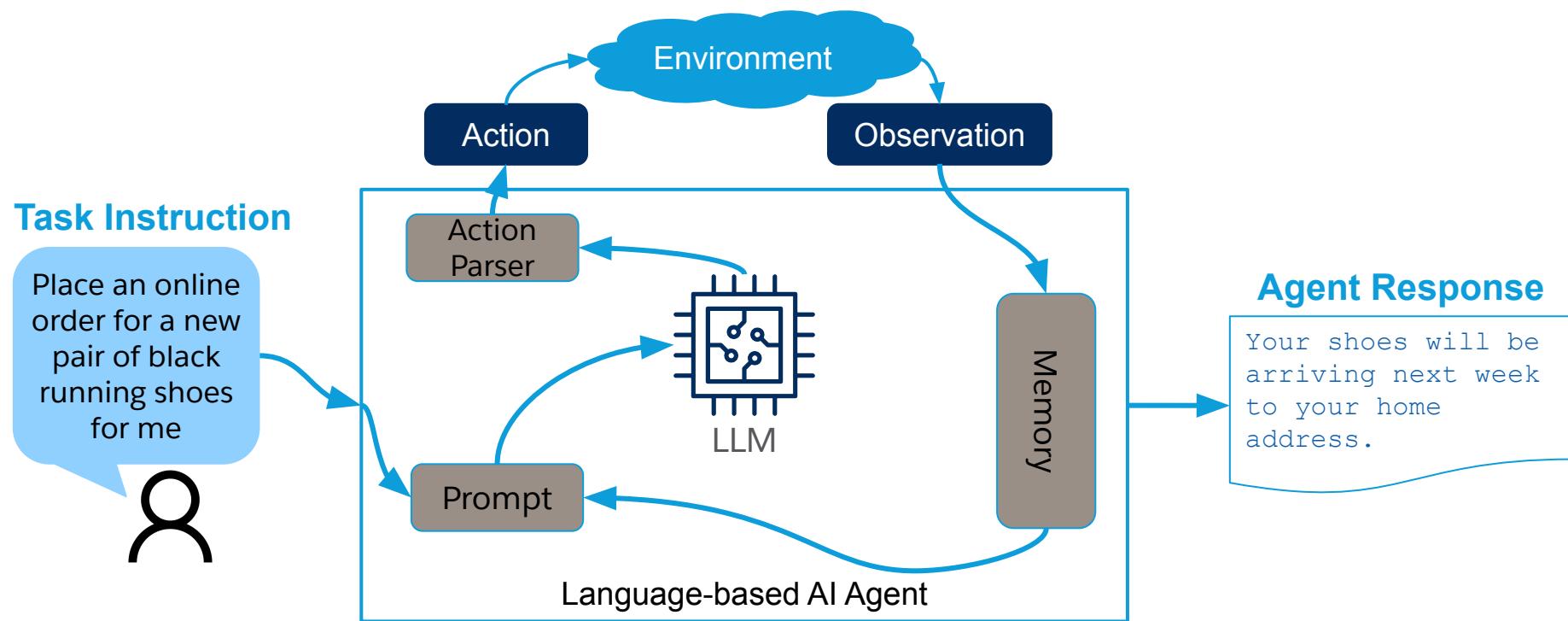


# What's next?

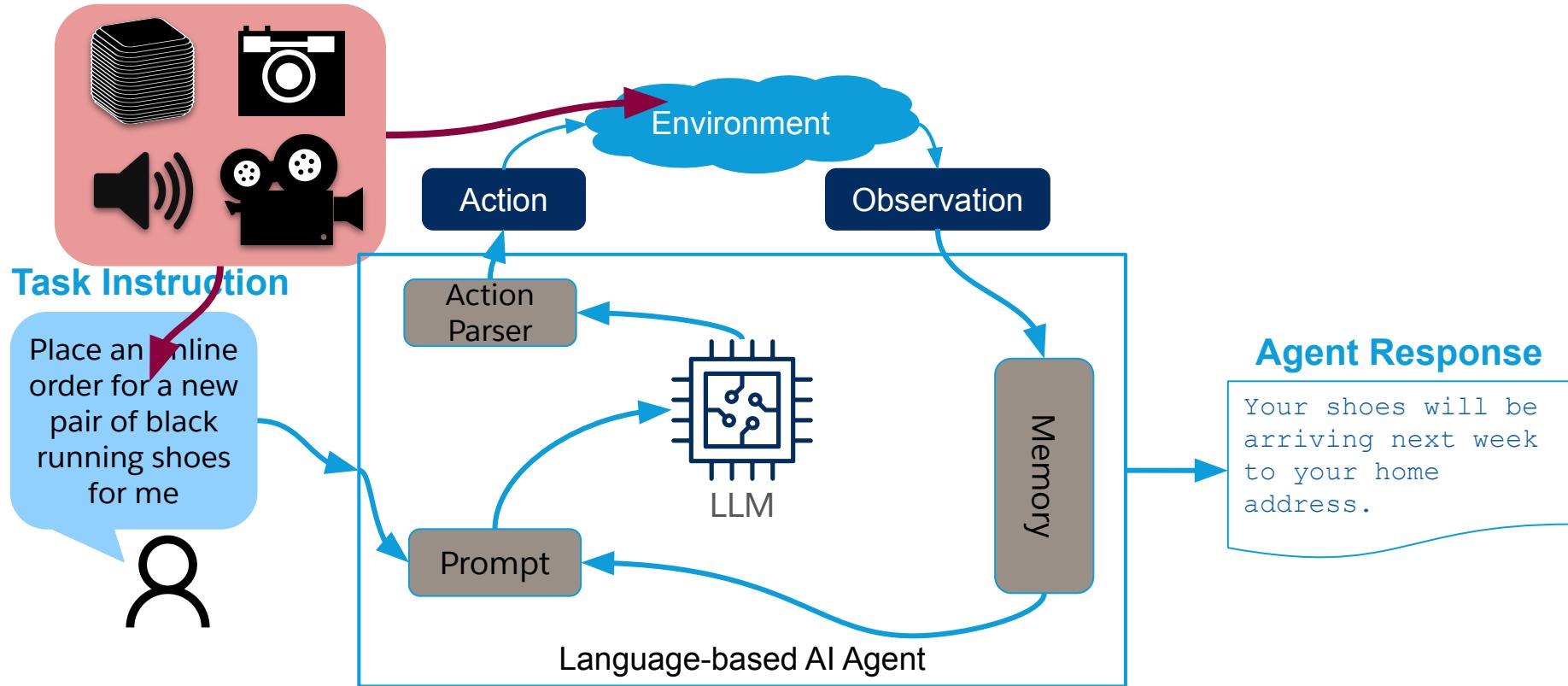
Interesting avenues to further explore



# High-level Language-based Agent framework



# Multimodality

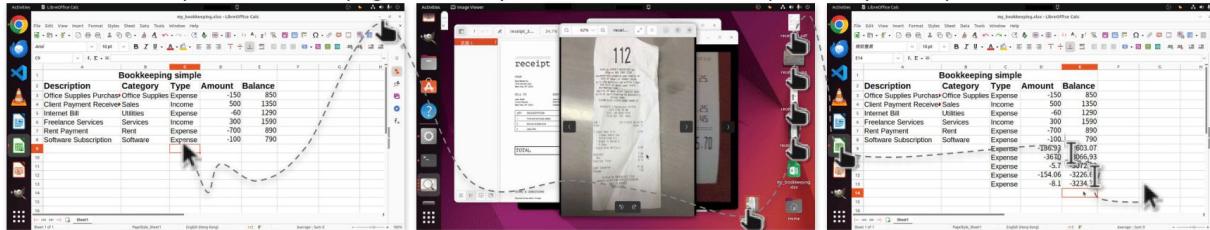


# OSWorld

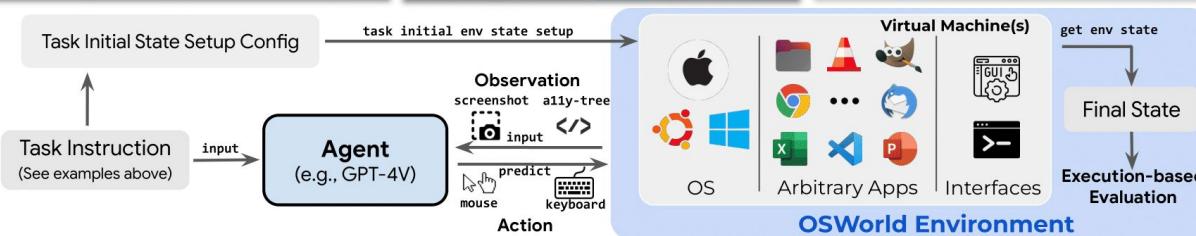
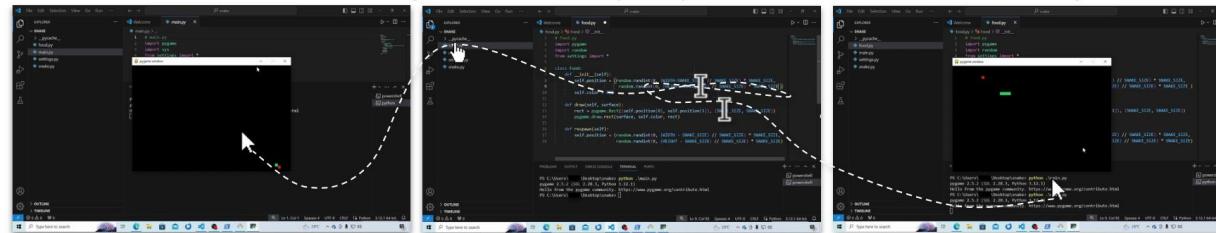
<https://github.com/xlang-ai/OSWorld>



Task instruction 1: Update the bookkeeping sheet with my recent transactions over the past few days in the provided folder.



Task instruction 2: ...some details about snake game omitted... Could you help me tweak the code so the snake can actually eat the food?



# Benchmarking & Environments



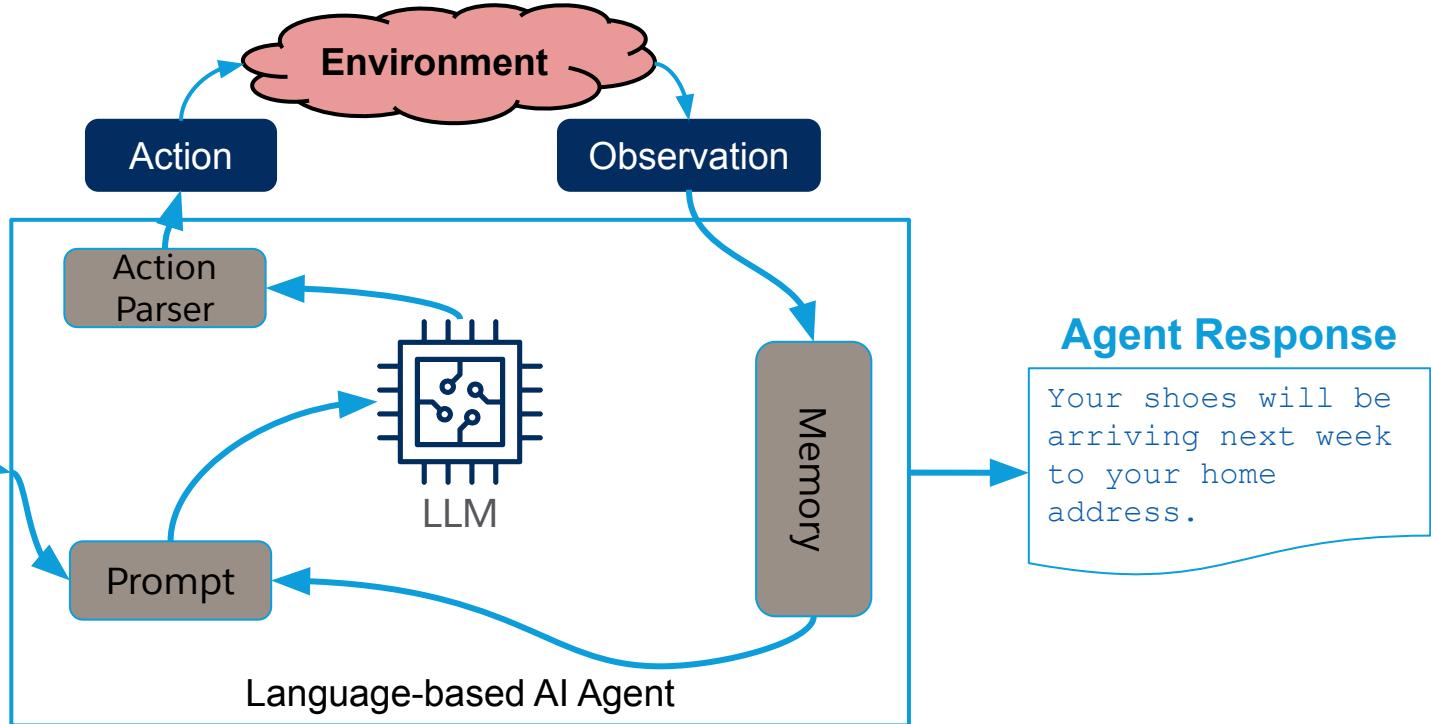
## Task Instruction

Place an online order for a new pair of black running shoes for me



## Agent Response

Your shoes will be arriving next week to your home address.

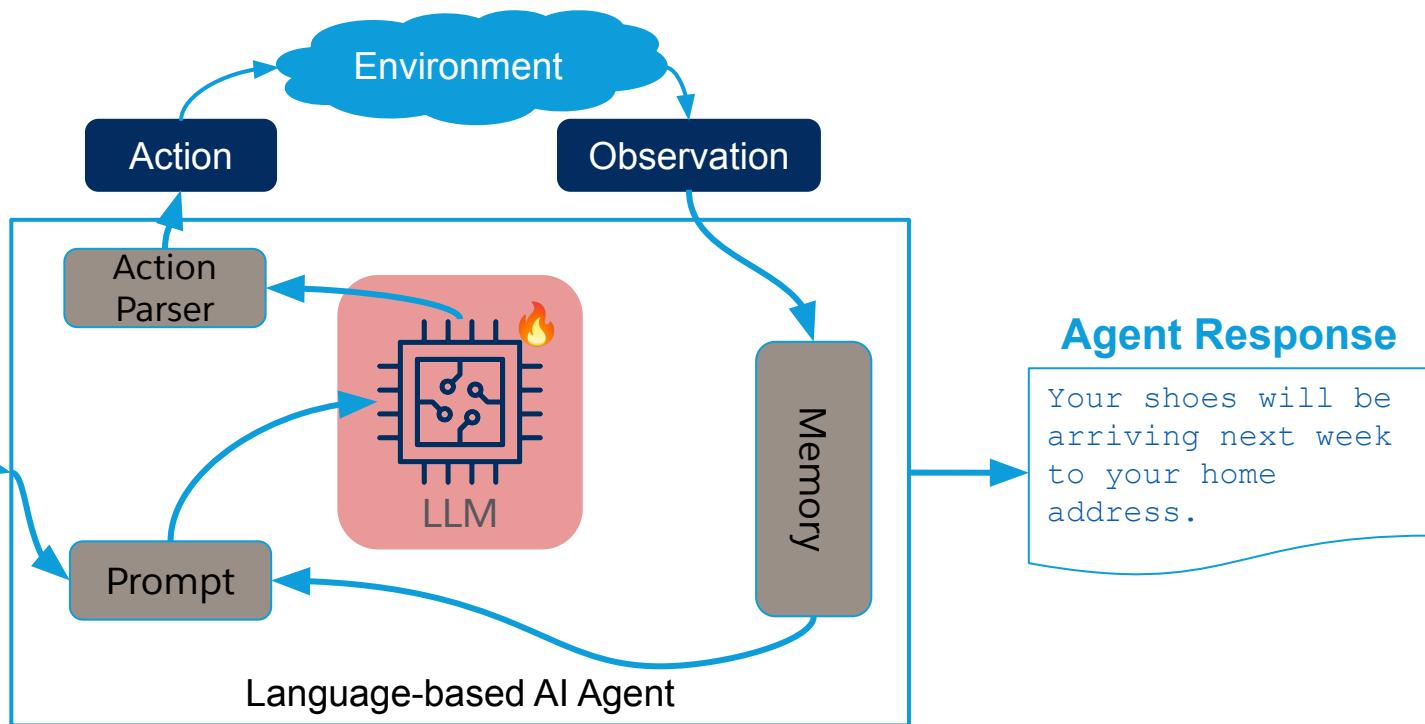


# Learning & Generalization



## Task Instruction

Place an online order for a new pair of black running shoes for me



## Agent Response

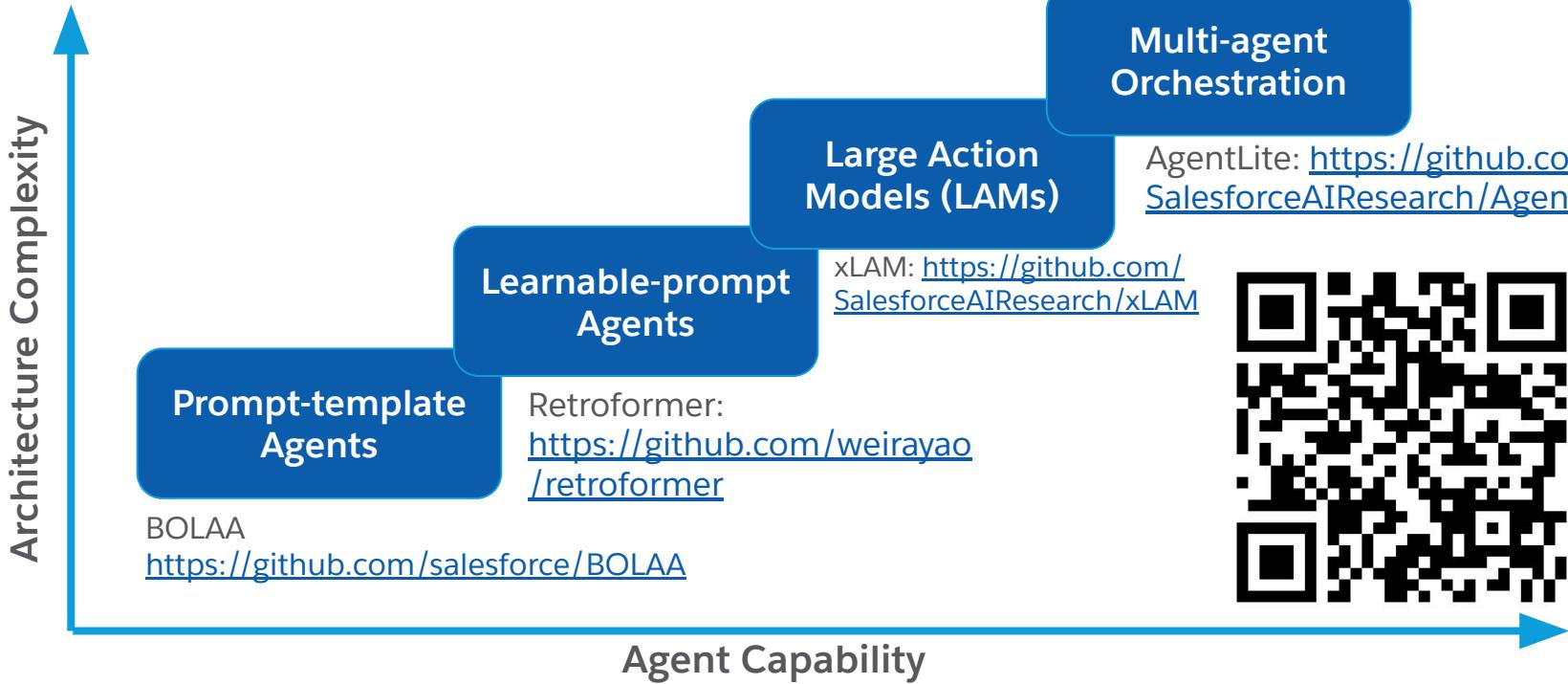
Your shoes will be arriving next week to your home address.

# Resources & References

Selected papers & open source  
implementations

# Resources to Get Started

Salesforce AI Research Open Source Ecosystem



# References



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# Thank you

