COMP 3361 Natural Language Processing

Lecture 19: Intro to Advanced Topics

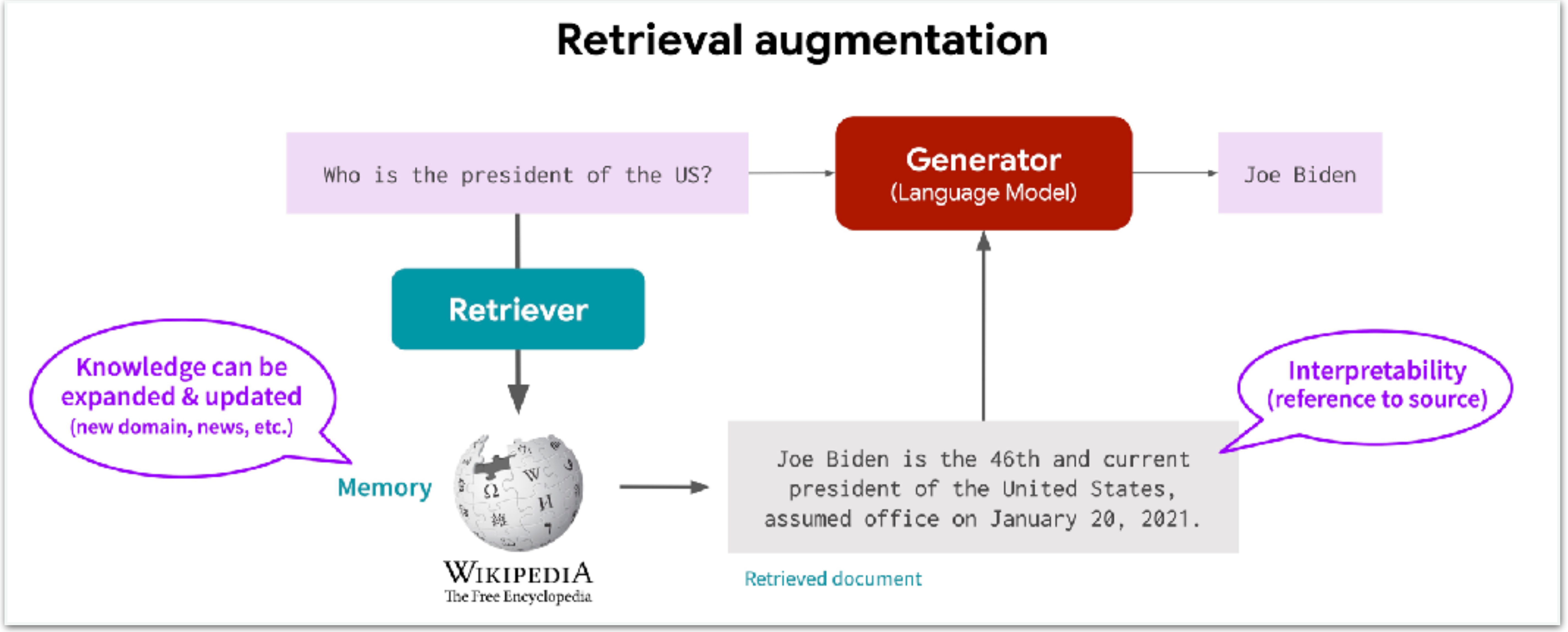
Spring 2025

Tentative schedule

- Participate in two for the class participation (2% for each) + 1 more for 1% extra credits.
  - Paper readings
  - Attend the talk in person (attendance will be taken)
  - Ask questions

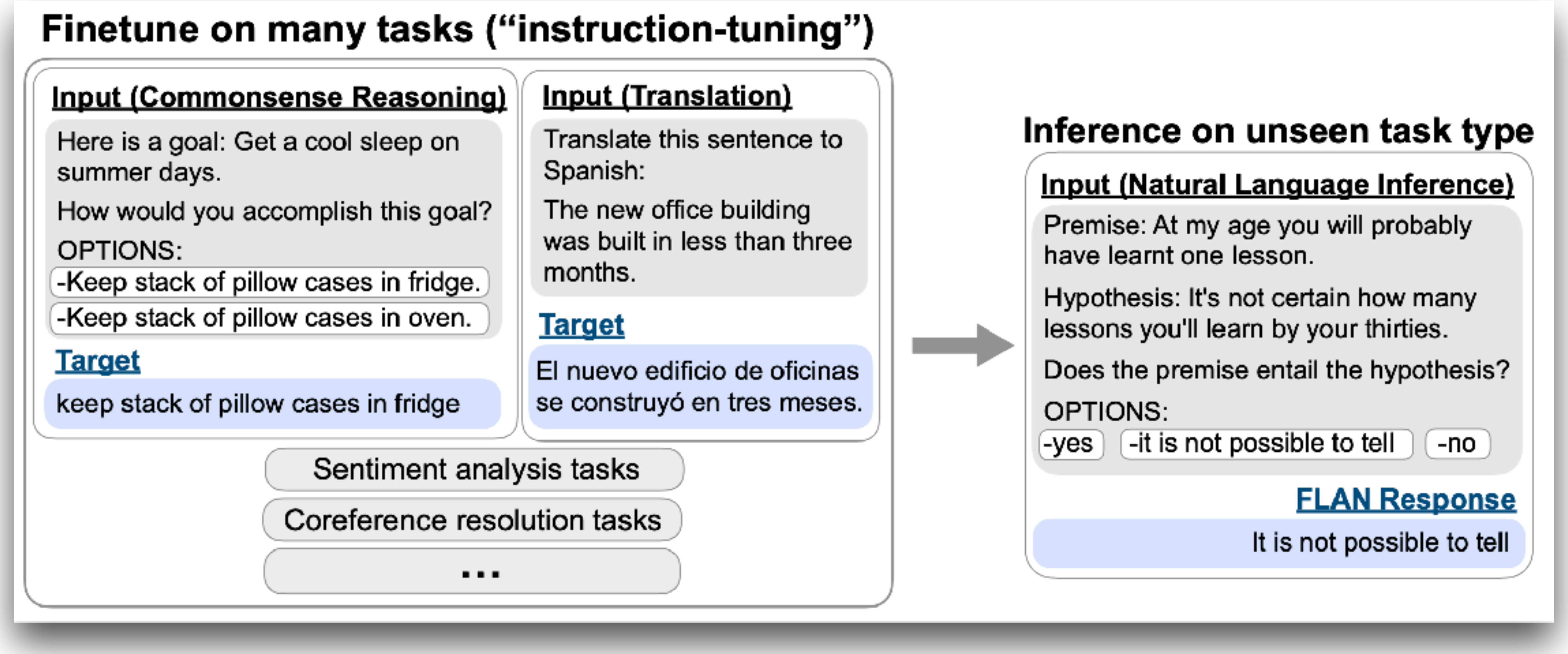
Retrieval-augmented LLMs

- How do we keep LLMs update-to-date without further training?
- Alleviate problems of hallucinations, lack of attributions, copyright in LLMs
- Smaller size, better performance?



Instruction tuning for LLMs

- How do we make LLMs more controllable by following specific instructions?
- Why following human instructions is important?
- That is the reason why you can prompt a single LLM to perform many tasks !!!



Finetune on many tasks ("instruction-tuning")

Input (Commonsense Reasoning)

Here is a goal: Get a cool sleep on summer days.

How would you accomplish this goal?

OPTIONS:

-Keep stack of pillow cases in fridge.

-Keep stack of pillow cases in oven.

Target

keep stack of pillow cases in fridge

Input (Translation)

Translate this sentence to Spanish:

The new office building was built in less than three months.

Target

El nuevo edificio de oficinas se construyó en tres meses.

Sentiment analysis tasks

Coreference resolution tasks

...

Inference on unseen task type

Input (Natural Language Inference)

Premise: At my age you will probably have learnt one lesson.

Hypothesis: It's not certain how many lessons you'll learn by your thirties.

Does the premise entail the hypothesis?

OPTIONS:

-yes -it is not possible to tell -no

FLAN Response

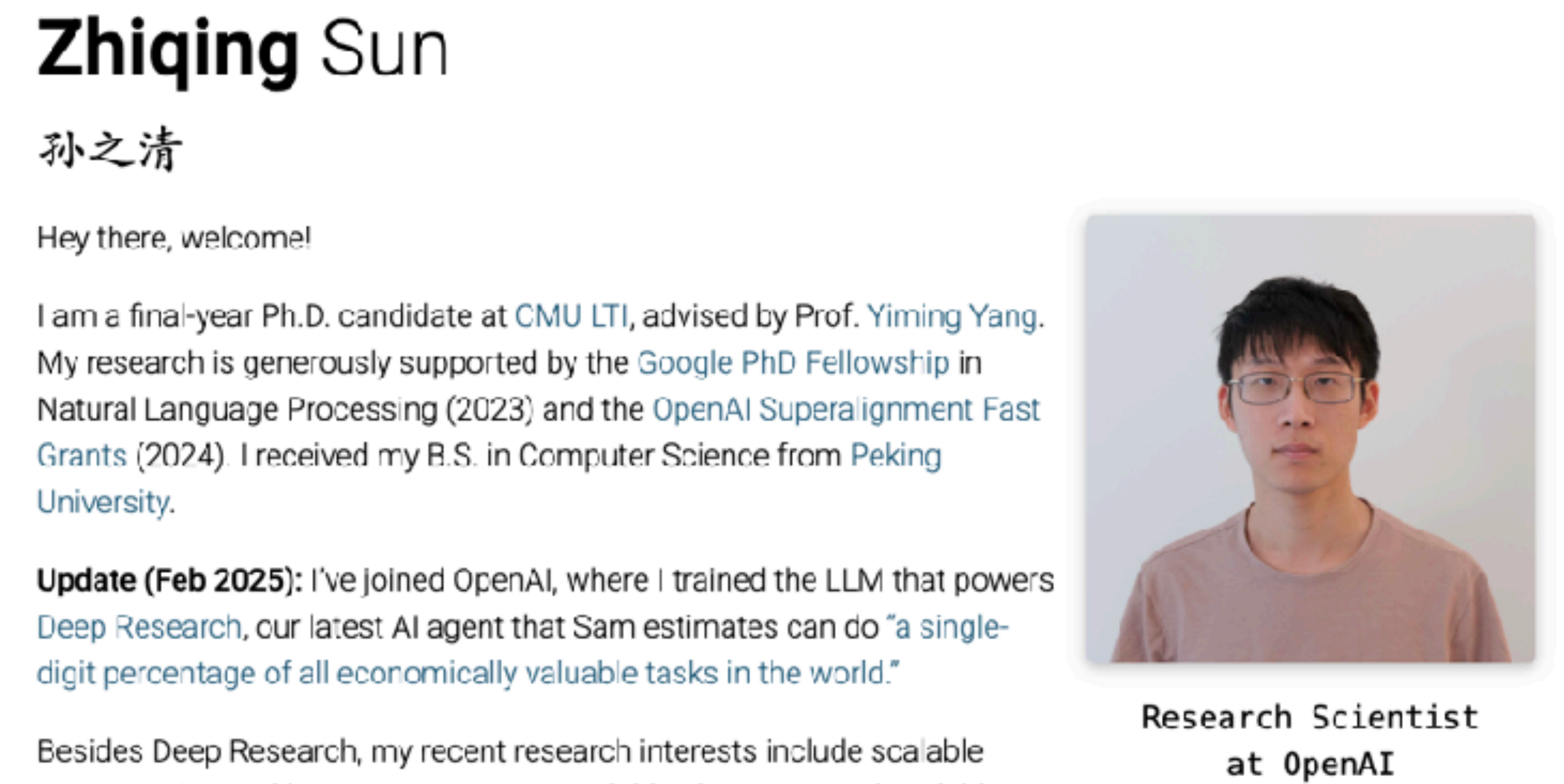
It is not possible to tell

Finetuned Language Models Are Zero-Shot Learners

Self-Instruct: Aligning Language Model with Self-Generated Instructions

LLM alignment

- How do we create LLMs that behaves in accordance with what a human wants?
- How can we ensure powerful AI systems remain aligned with human values and reliable in their reasoning?
- To build trustworthy and aligned AI systems as their capabilities continue to grow.



Zhiqing Sun

孙之清

Hey there, welcome!

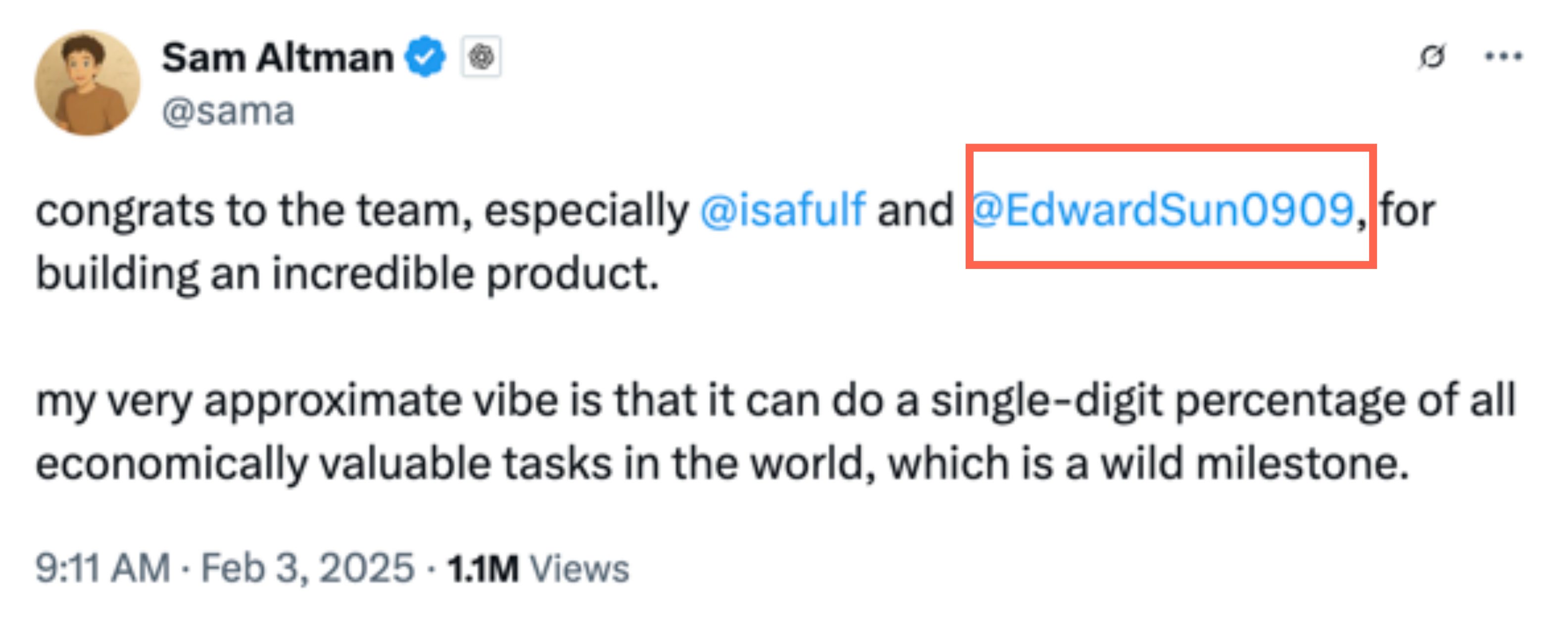
I am a final-year Ph.D. candidate at CMU LTI, advised by Prof. Yiming Yang. My research is generously supported by the Google PhD Fellowship in Natural Language Processing (2023) and the OpenAI Superalignment Fast Grants (2024). I received my B.S. in Computer Science from Peking University.

Update (Feb 2025): I've joined OpenAI, where I trained the LLM that powers Deep Research, our latest AI agent that Sam estimates can do "a single-digit percentage of all economically valuable tasks in the world."

Besides Deep Research, my recent research interests include scalable reasoning beyond human supervision, scalable alignment, and scalable training of more capable and trustworthy AI agents.

Research Scientist
at OpenAI
PhD Candidate at
CMU -> SCS -> LTI

https://www.cs.cmu.edu/~zhiqings



Sam Altman
@sama

congrats to the team, especially @isafulf and @EdwardSun0909, for building an incredible product.

my very approximate vibe is that it can do a single-digit percentage of all economically valuable tasks in the world, which is a wild milestone.

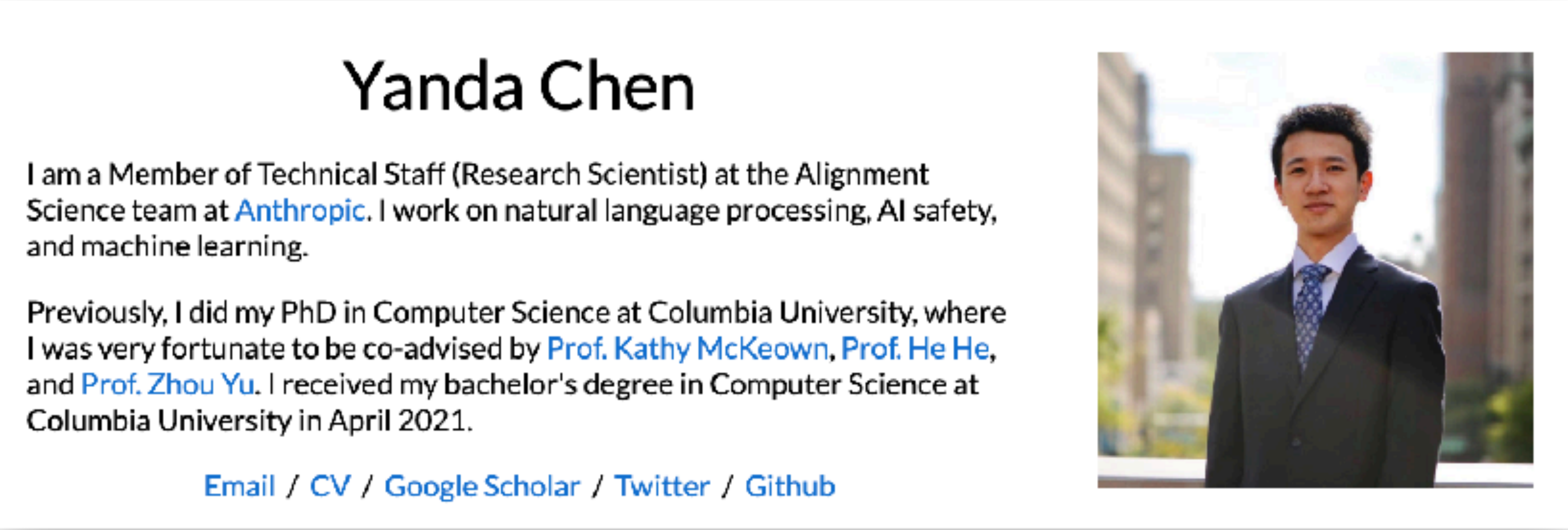
9:11 AM · Feb 3, 2025 · **1.1M** Views

Zhiqing is the lead of Deep Research agent at OpenAI

https://openai.com/index/introducing-deep-research

LLM explainability & reliability

- How can we build explainable AI systems to better understand the behavior of LLMs?
- What methods improve the calibration and reduce the sensitivity of LLMs to ensure reliable outputs?



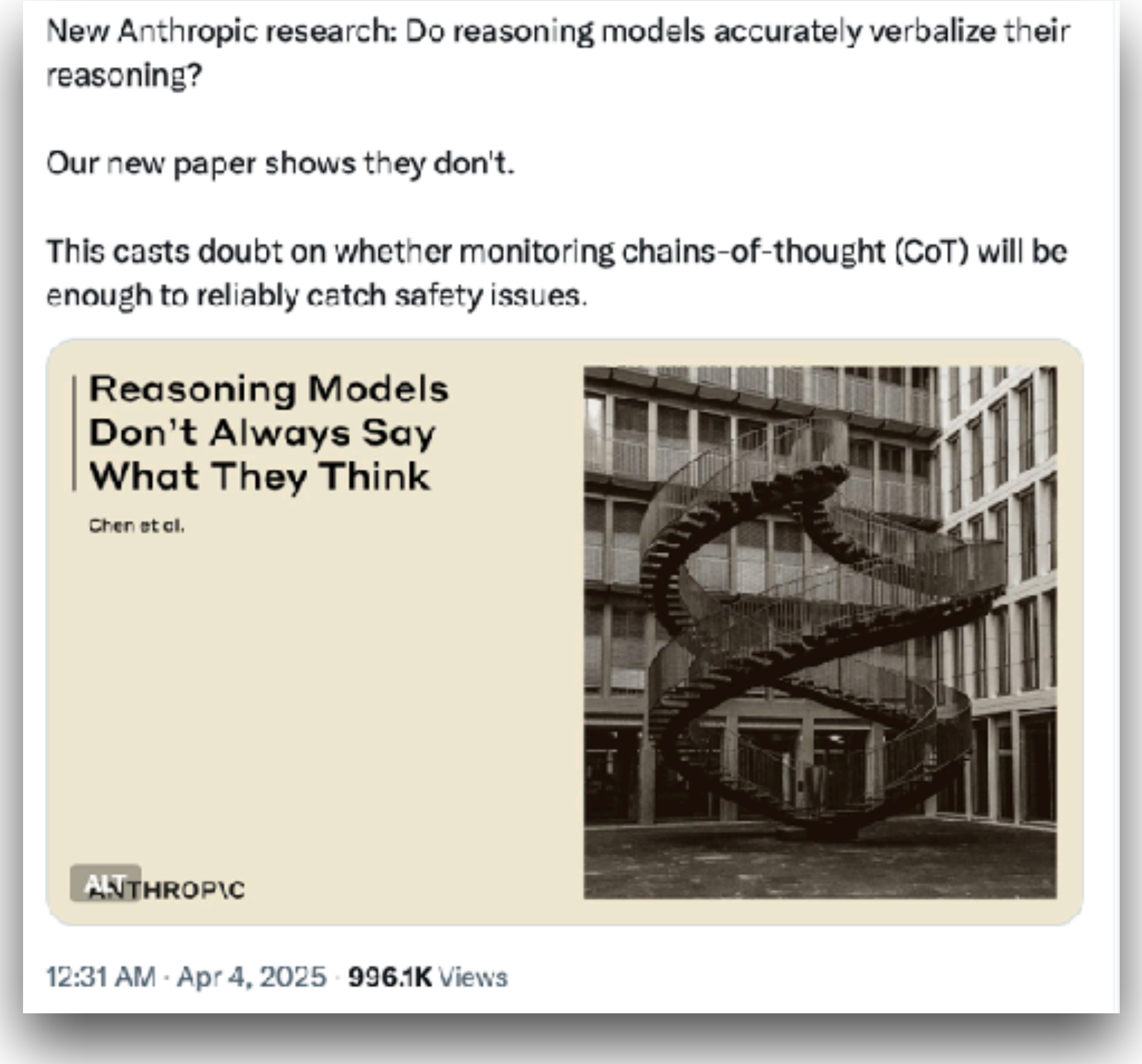
Yanda Chen

I am a Member of Technical Staff (Research Scientist) at the Alignment Science team at Anthropic. I work on natural language processing, AI safety, and machine learning.

Previously, I did my PhD in Computer Science at Columbia University, where I was very fortunate to be co-advised by Prof. Kathy McKeown, Prof. He He, and Prof. Zhou Yu. I received my bachelor's degree in Computer Science at Columbia University in April 2021.

Email / CV / Google Scholar / Twitter / Github

https://yandachen.github.io



New Anthropic research: Do reasoning models accurately verbalize their reasoning?

Our new paper shows they don't.

This casts doubt on whether monitoring chains-of-thought (CoT) will be enough to reliably catch safety issues.

Reasoning Models Don't Always Say What They Think

Chen et al.

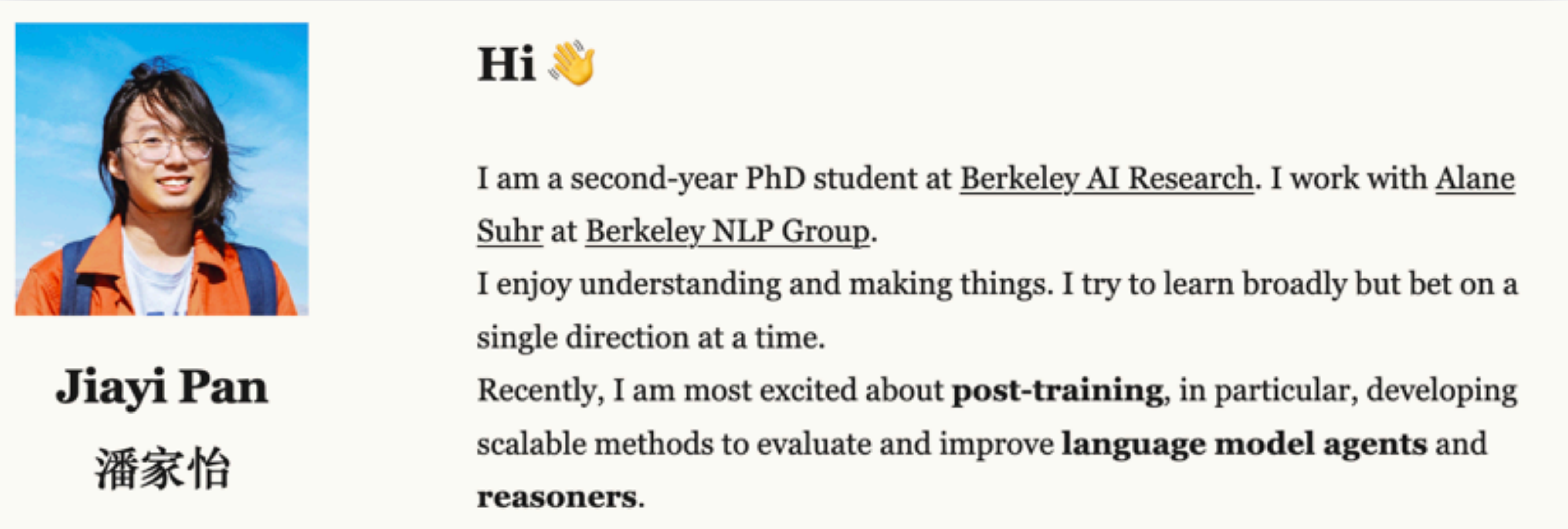
ALT

ANTHROPIC

12:31 AM · Apr 4, 2025 · 996.1K Views

Scaling RL for LLM reasoning

- How and why large-scale reinforcement learning can enhance reasoning capabilities in large language models?
- How do learning and search mechanisms enable language model agents to scale effectively for complex reasoning tasks?



Jiayi Pan

潘家怡

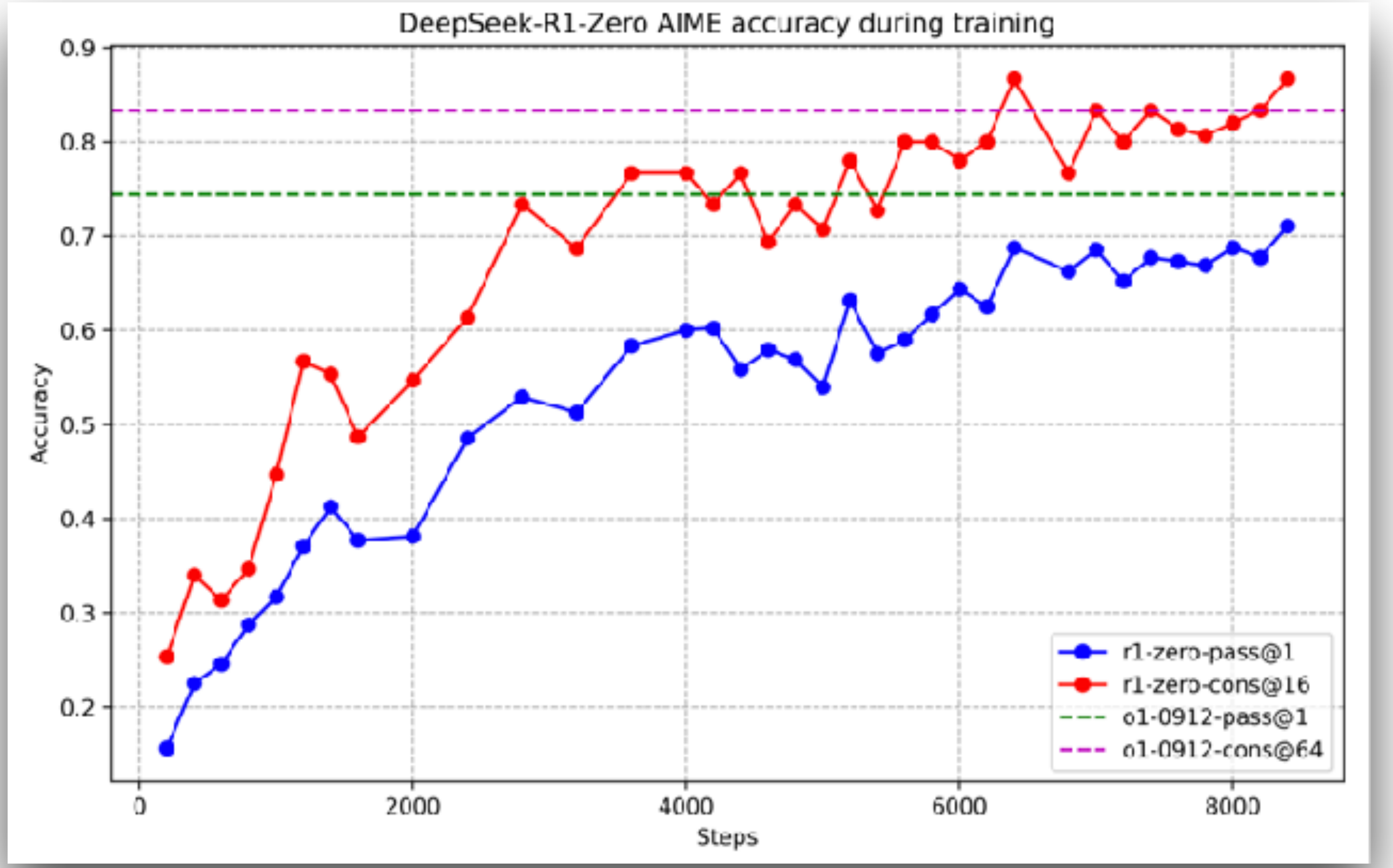
Hi 👋

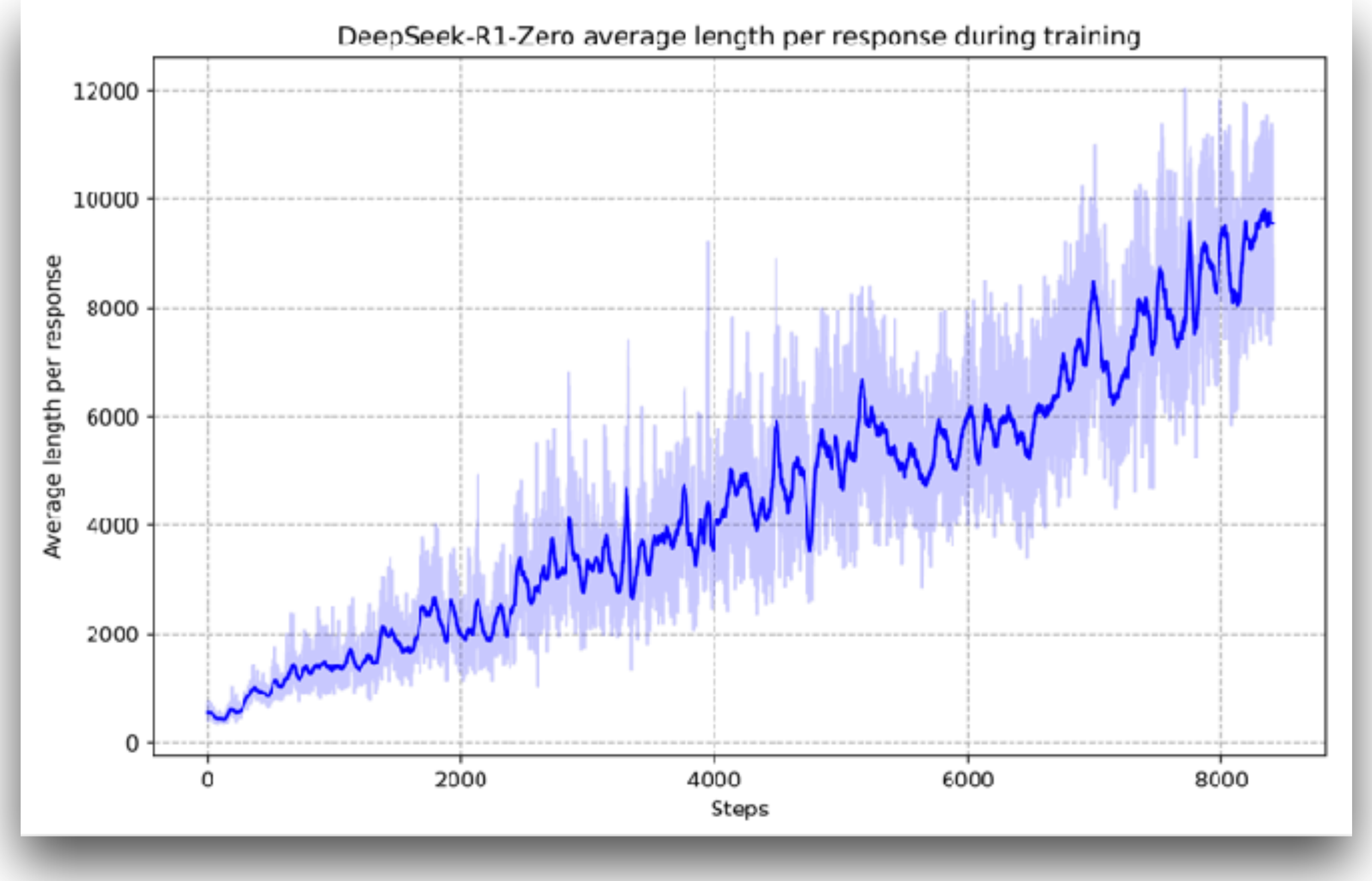
I am a second-year PhD student at Berkeley AI Research. I work with Alane Suhr at Berkeley NLP Group.

I enjoy understanding and making things. I try to learn broadly but bet on a single direction at a time.

Recently, I am most excited about **post-training**, in particular, developing scalable methods to evaluate and improve **language model agents** and **reasoners**.

https://www.jiayipan.com





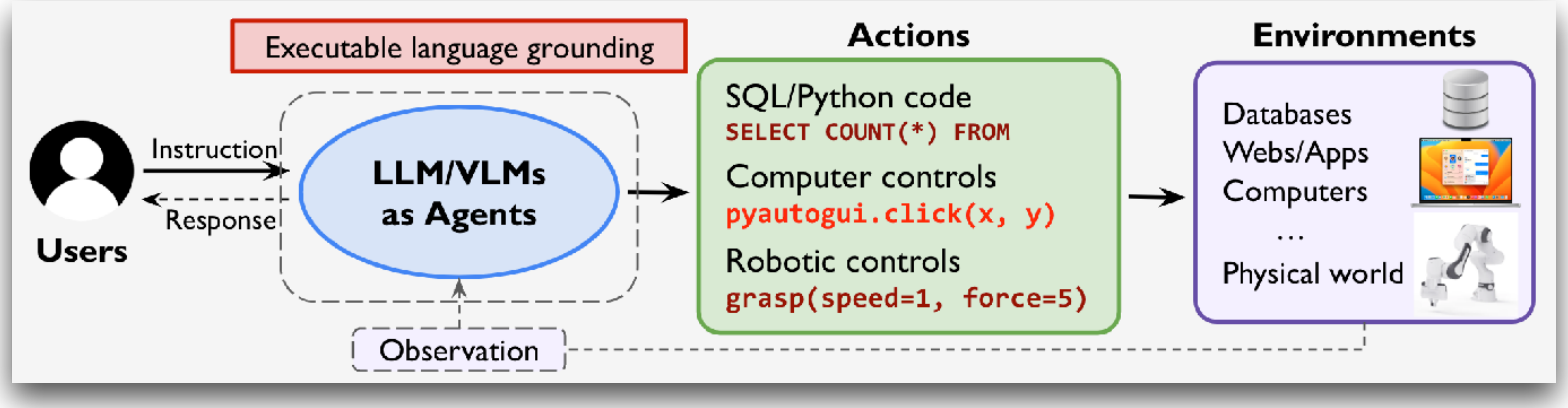
DeepSeek-R1: Incentivizing Reasoning Capability in LLMs via Reinforcement Learning

LLMs/VLMs beyond chatting

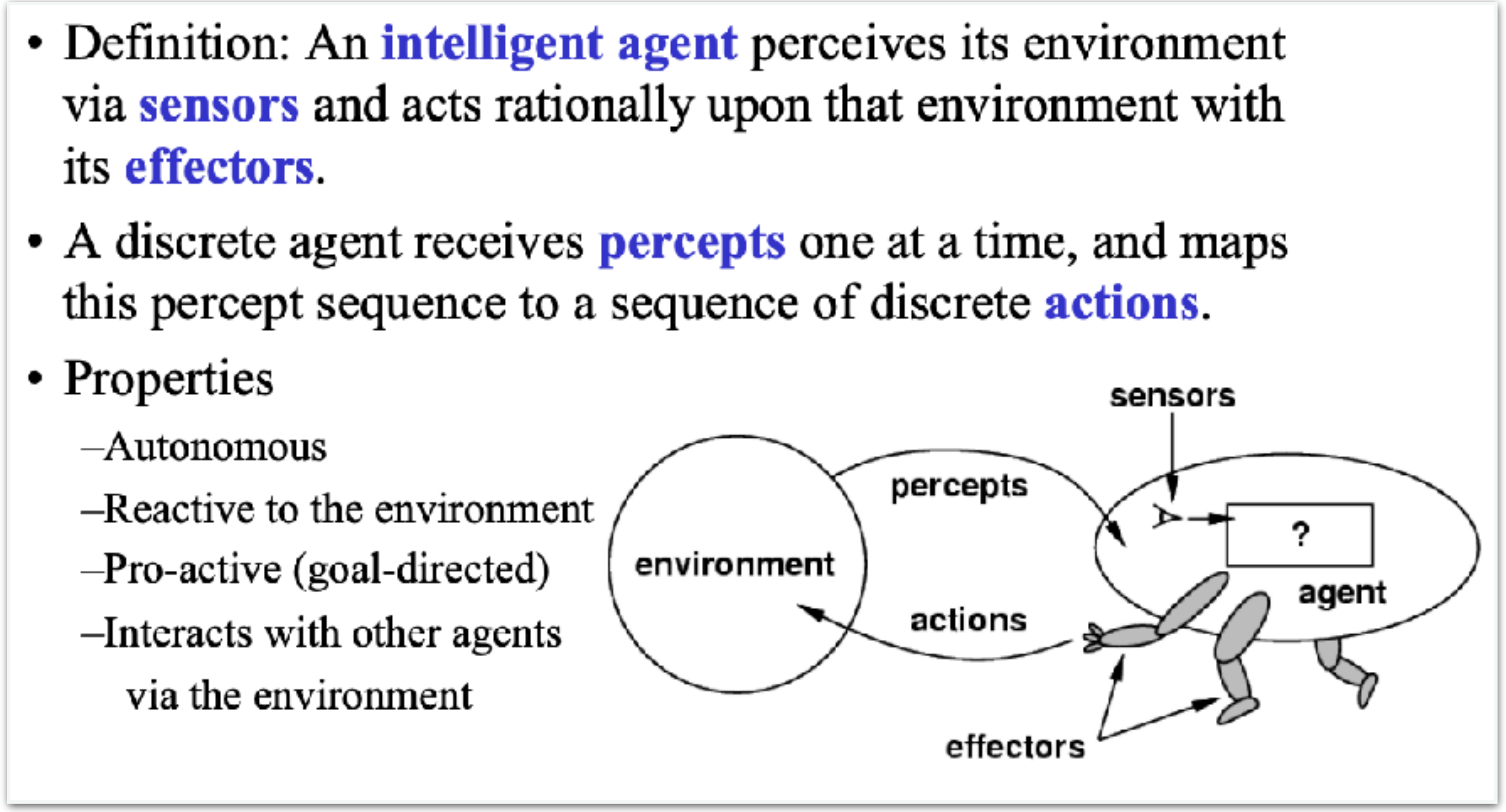
Embodied LLMs/VLMs

LLMs/VLMs beyond chatting

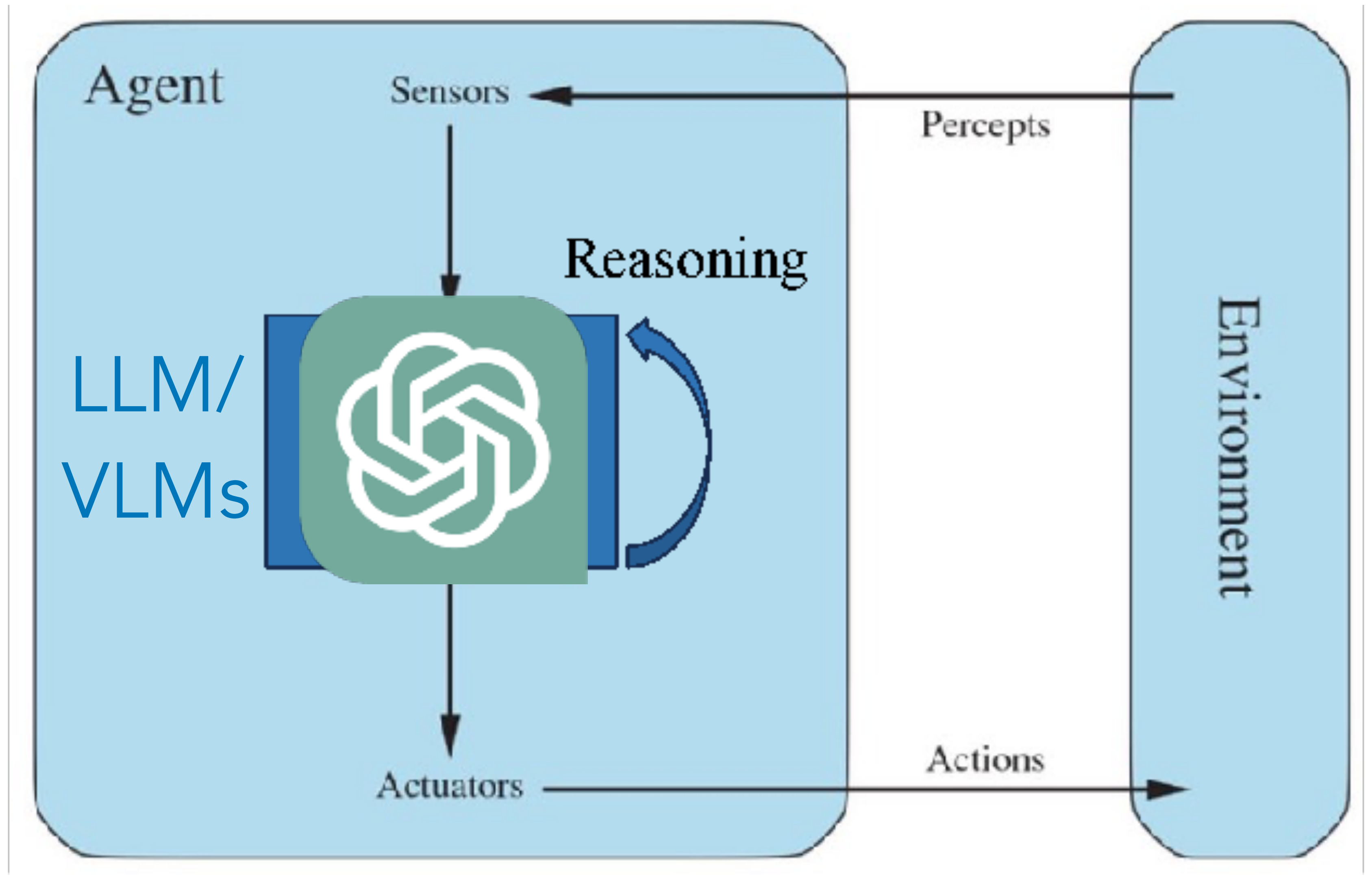
- Not just chatting with you, can we use LLMs/VLMs as brains of intelligent agents that can interact with and learn from humans and real-world environments (database, web browser, systems, physical world)?

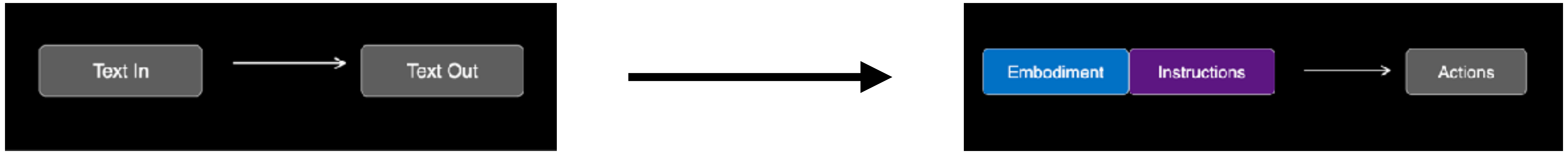


LLM/VLMs as agents



- Definition: An **intelligent agent** perceives its environment via **sensors** and acts rationally upon that environment with its **effectors**.
- A discrete agent receives **percepts** one at a time, and maps this percept sequence to a sequence of discrete **actions**.
- Properties
  - –Autonomous
  - –Reactive to the environment
  - –Pro-active (goal-directed)
  - –Interacts with other agents via the environment

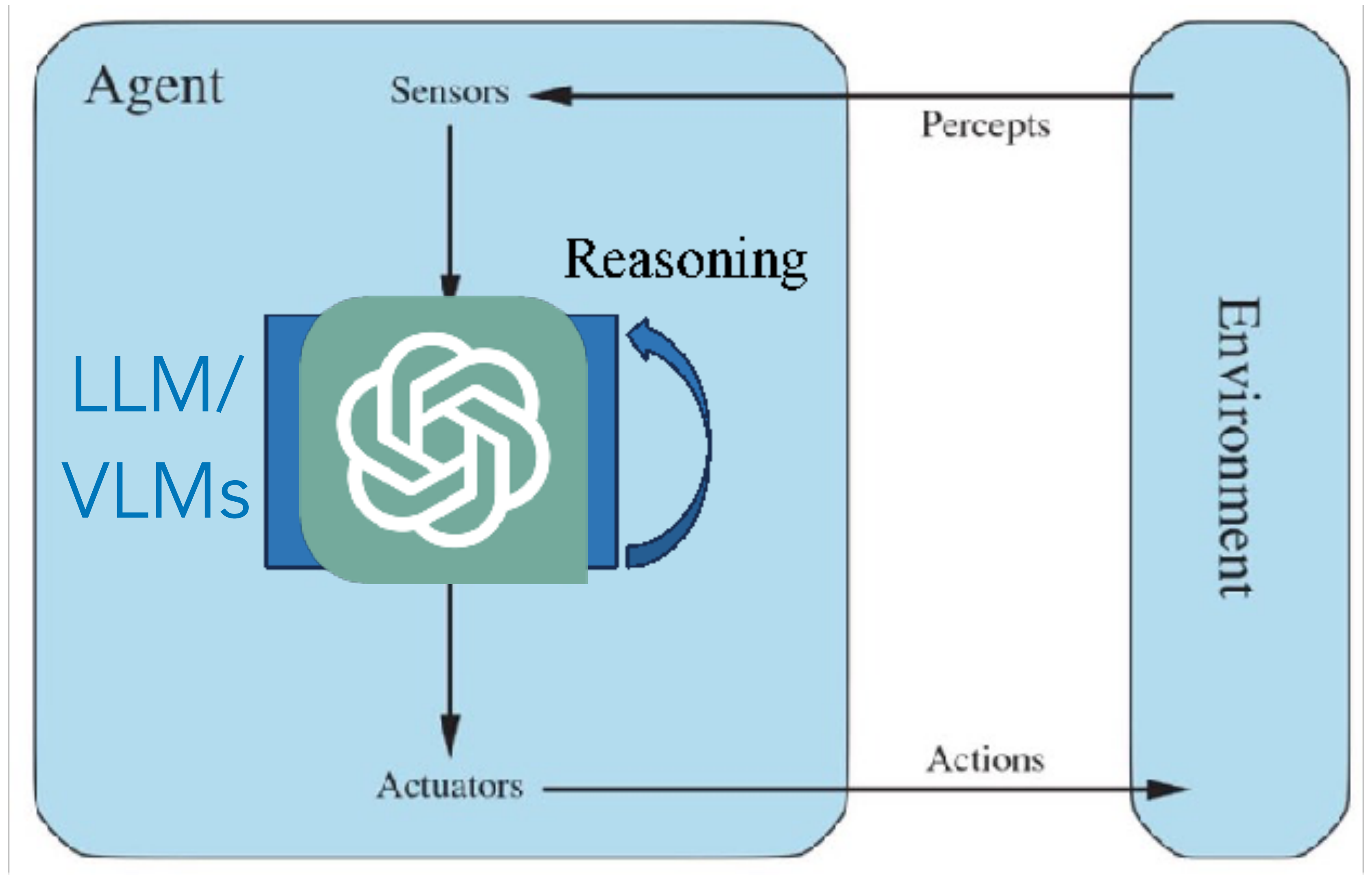




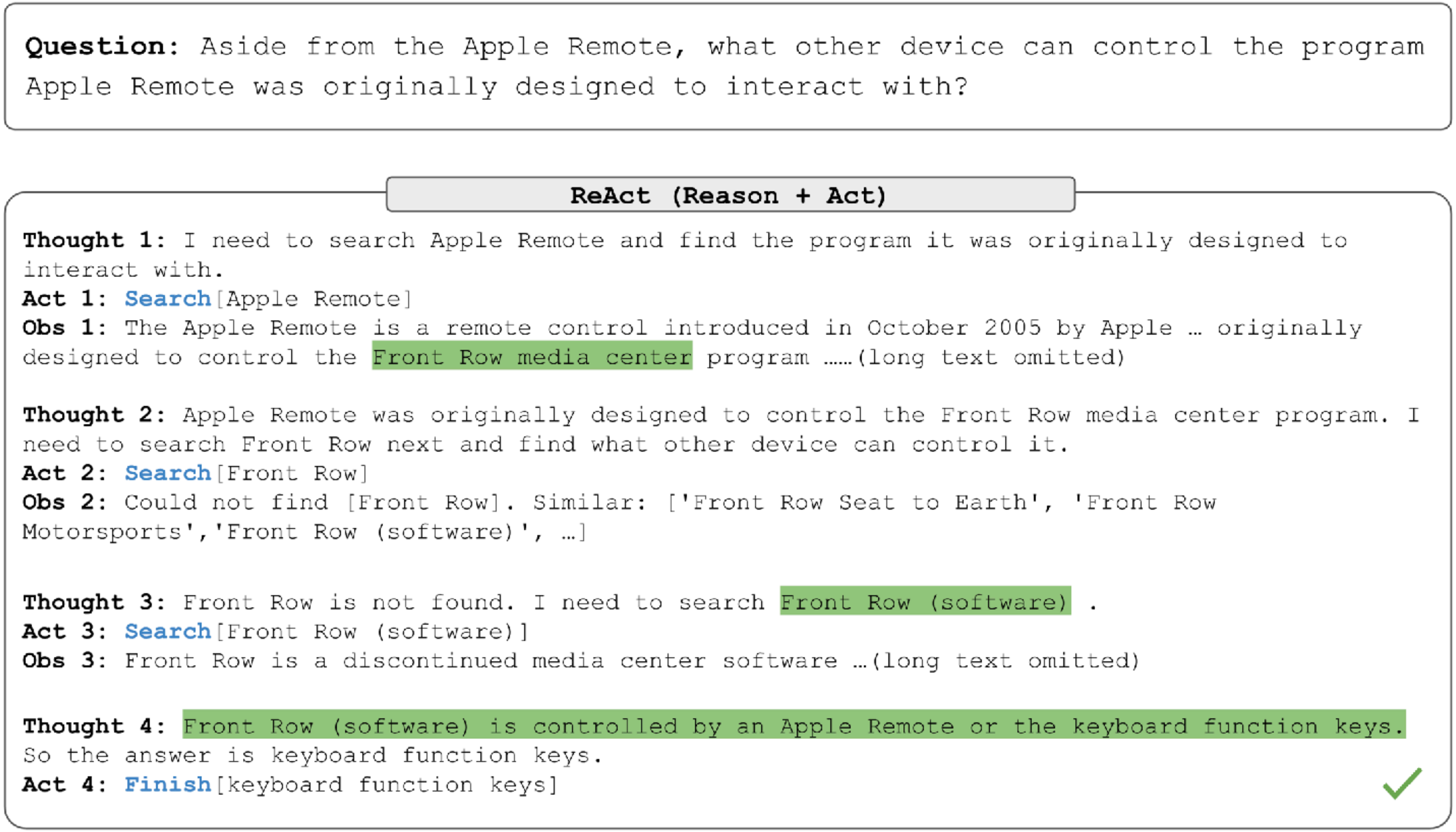
https://openai.com/index/computer-using-agent/

LLM/VLMs as agents

- **Reasoning by generating tokens** is a new type of action (*vs.* actions in external environments)
- **Internal environment**, where reasoning takes place in an inner monologue fashion
- **Self-reflection** is a 'meta' reasoning action (i.e., reasoning over the reasoning process), akin to metacognitive functions
- **Reasoning is for better acting**, by inferring environmental states, retrospection, dynamic replanning, etc.
- **Percept** and **external action spaces** are substantially expanded, thanks to using language for communication and multimodal perception



Reasoning with acting



Question: Aside from the Apple Remote, what other device can control the program Apple Remote was originally designed to interact with?

ReAct (Reason + Act)

Thought 1: I need to search Apple Remote and find the program it was originally designed to interact with.
Act 1: **Search**[Apple Remote]
Obs 1: The Apple Remote is a remote control introduced in October 2005 by Apple … originally designed to control the Front Row media center program ……(long text omitted)

Thought 2: Apple Remote was originally designed to control the Front Row media center program. I need to search Front Row next and find what other device can control it.
Act 2: **Search**[Front Row]
Obs 2: Could not find [Front Row]. Similar: ['Front Row Seat to Earth', 'Front Row Motorsports','Front Row (software)', …]

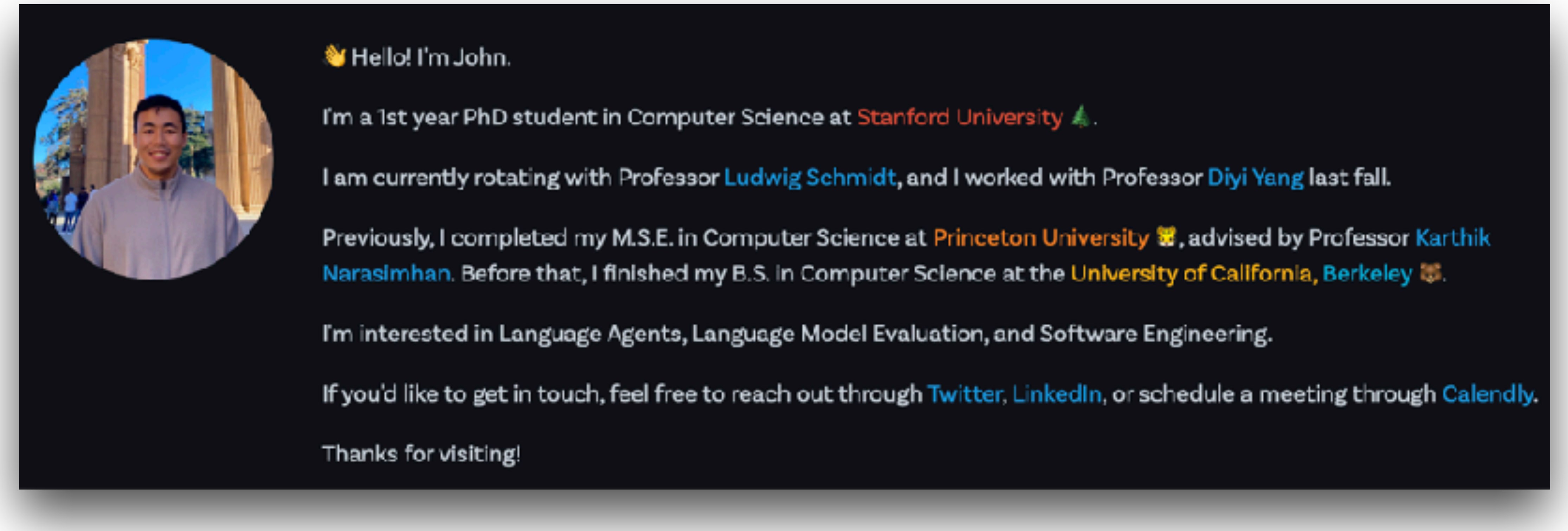
Thought 3: Front Row is not found. I need to search Front Row (software) .
Act 3: **Search**[Front Row (software)]
Obs 3: Front Row is a discontinued media center software …(long text omitted)

Thought 4: Front Row (software) is controlled by an Apple Remote or the keyboard function keys. So the answer is keyboard function keys.
Act 4: **Finish**[keyboard function keys]

✓

LLMs/VLMs as agents

- The LLM/VLM agents need to make decisions for solving complex/abstract problems.
- How LLMs/VLMs as agents? How to use LLMs in an interactive software engineering development environment?



👋 Hello! I'm John.

I'm a 1st year PhD student in Computer Science at Stanford University 🌲.

I am currently rotating with Professor Ludwig Schmidt, and I worked with Professor Diyi Yang last fall.

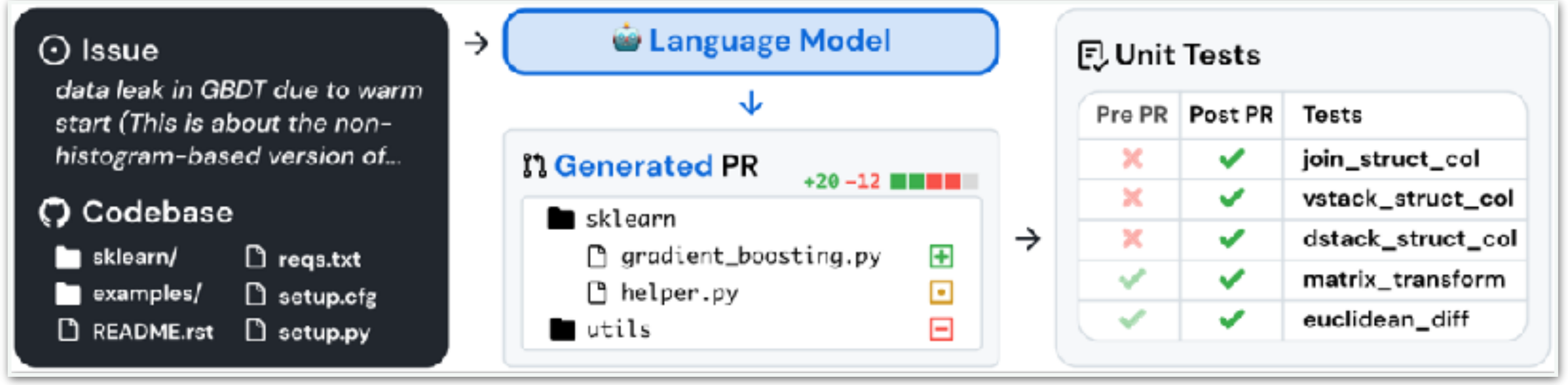
Previously, I completed my M.S.E. in Computer Science at Princeton University 🐯, advised by Professor Karthik Narasimhan. Before that, I finished my B.S. in Computer Science at the University of California, Berkeley 🐻.

I'm interested in Language Agents, Language Model Evaluation, and Software Engineering.

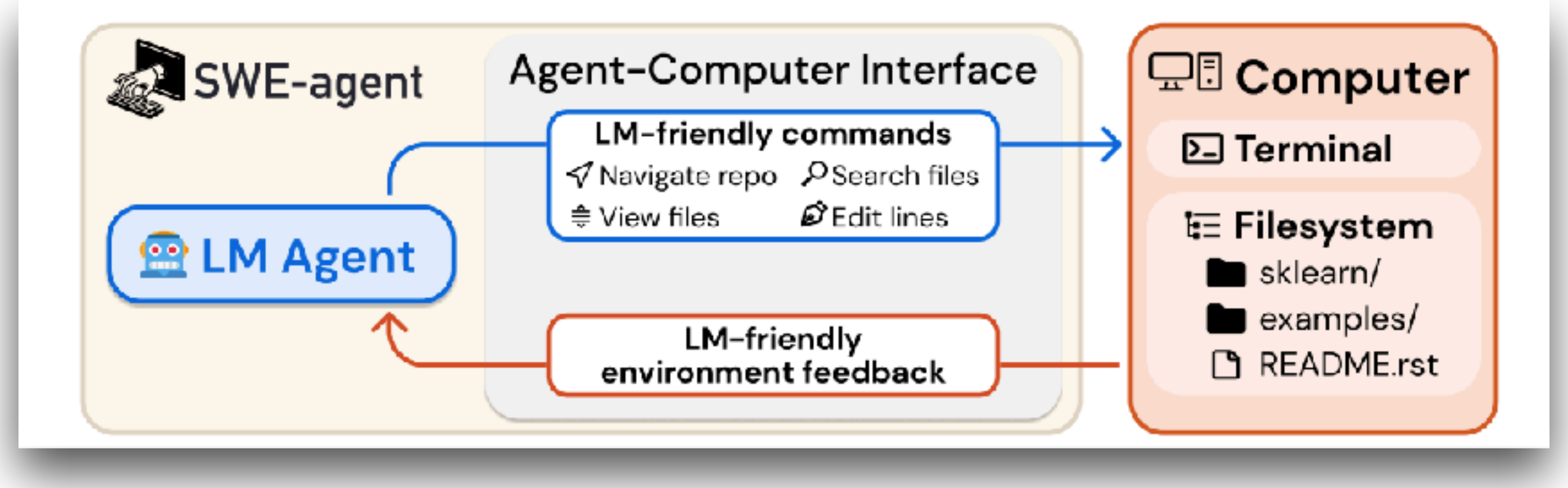
If you'd like to get in touch, feel free to reach out through Twitter, LinkedIn, or schedule a meeting through Calendly.

Thanks for visiting!

https://john-b-yang.github.io



Pre PR	Post PR	Tests
✗	✓	join_struct_col
✗	✓	vstack_struct_col
✗	✓	dstack_struct_col
✓	✓	matrix_transform
✓	✓	euclidean_diff

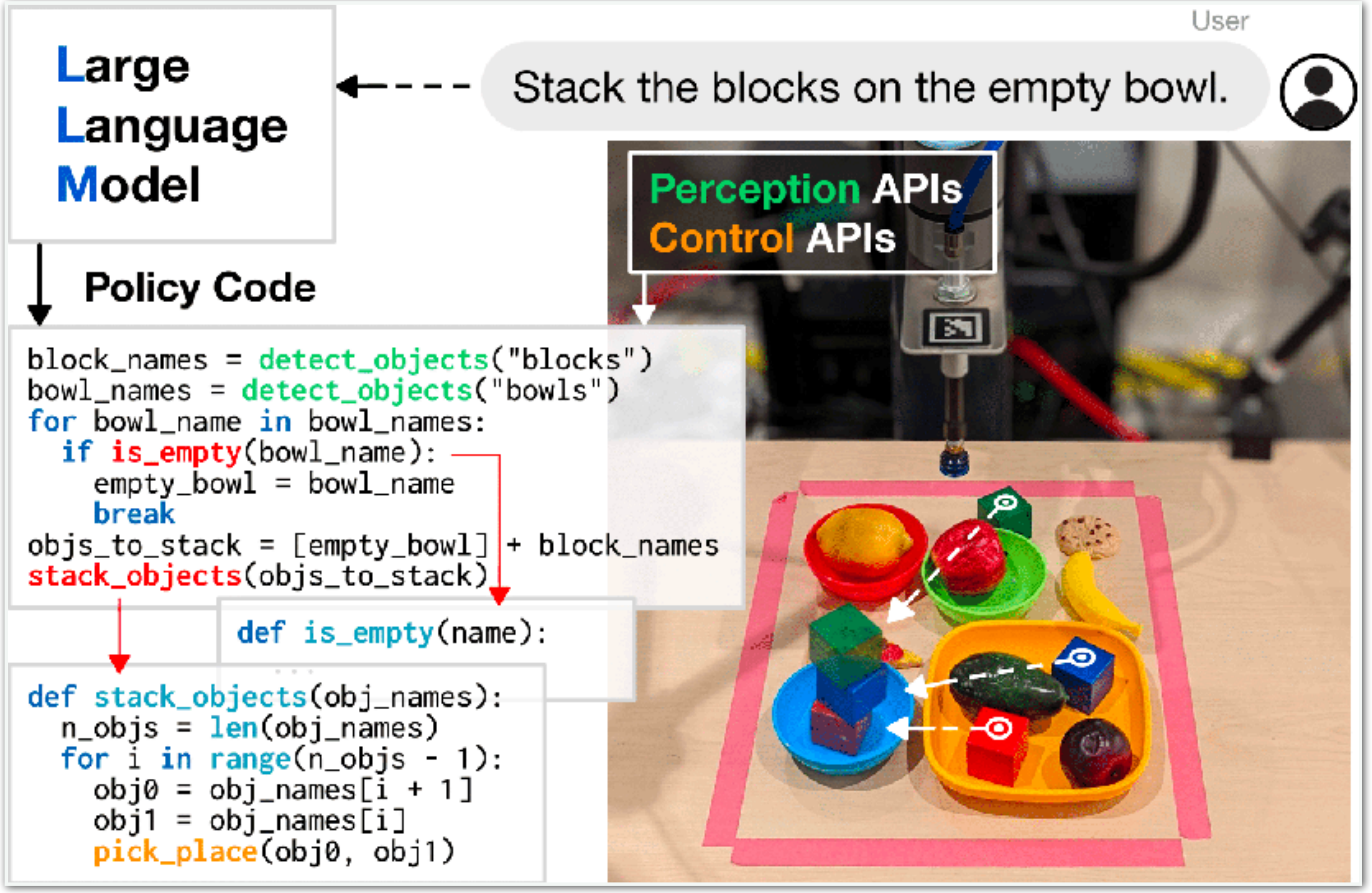


Can Language Models Resolve Real-World GitHub Issues?
SWE-agent: Agent-Computer Interfaces Enable Automated Software Engineering

LLMs/VLMs + robotics/embodied AI

- LLMs/VLMs + robotic agents enables LLMs/VLMs to take actions in real-world environments

- Multimodal LMs



User

Large Language Model

Stack the blocks on the empty bowl.

Perception APIs
Control APIs

Policy Code

```
block_names = detect_objects("blocks")
bowl_names = detect_objects("bowls")
for bowl_name in bowl_names:
  if is_empty(bowl_name):
    empty_bowl = bowl_name
    break
objs_to_stack = [empty_bowl] + block_names
stack_objects(objs_to_stack)
```

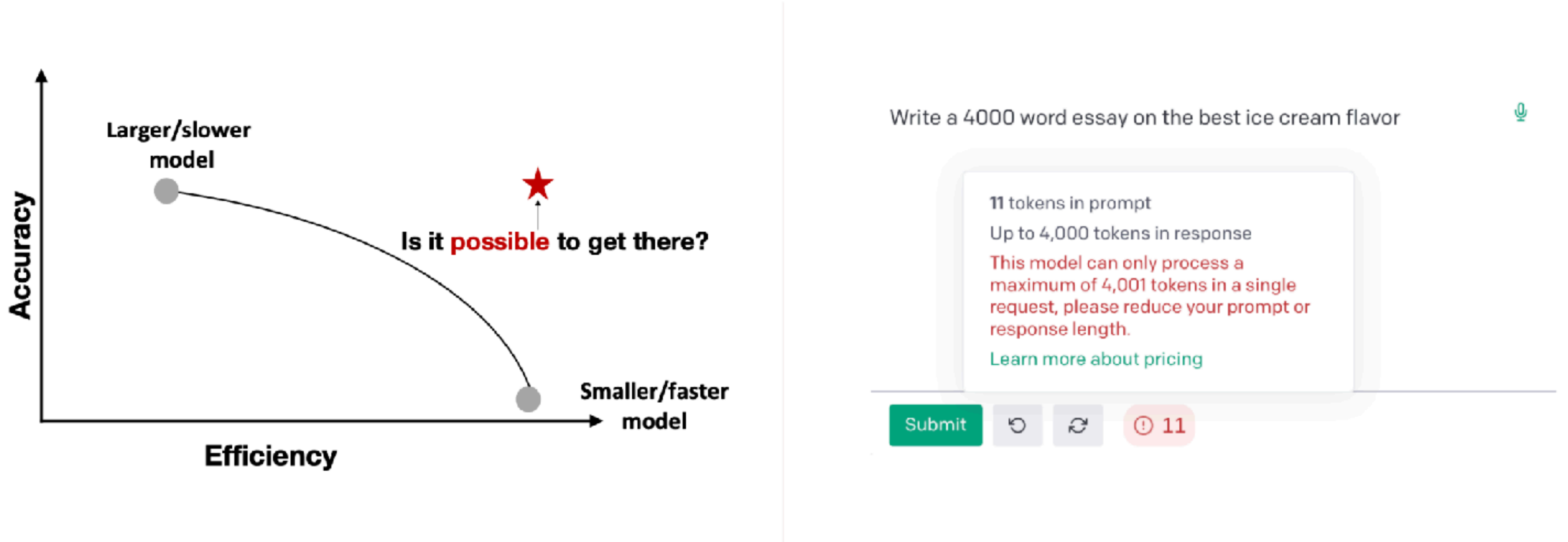
```
def is_empty(name):
  ...
```

```
def stack_objects(obj_names):
  n_objs = len(obj_names)
  for i in range(n_objs - 1):
    obj0 = obj_names[i + 1]
    obj1 = obj_names[i]
    pick_place(obj0, obj1)
```

LLM efficient training and tuning methods

Core challenges with scale: efficiency

- The computational and storage costs of LLM tuning and inference are usually too high, how can we reduct the costs?



Write a 4000 word essay on the best ice cream flavor

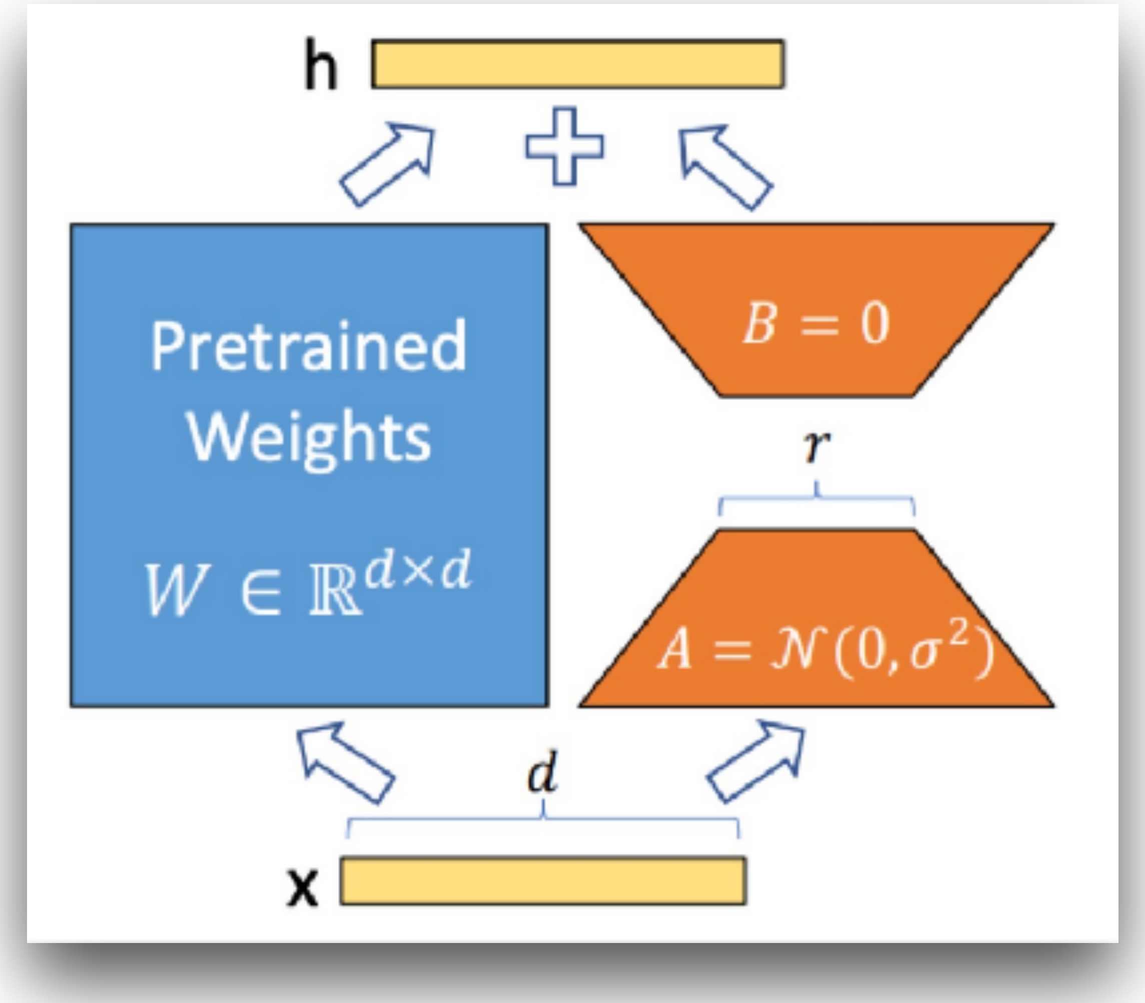
11 tokens in prompt
Up to 4,000 tokens in response
This model can only process a maximum of 4,001 tokens in a single request, please reduce your prompt or response length.
Learn more about pricing

Efficiency eases training, deployment, and facilitates research

Efficiency unlocks new capabilities (e.g., long context)

Efficient LLM methods

- The computational and storage costs of LLM tuning and inference are usually too high, how can we reduct the costs?
- Parameter-efficient LM tuning approaches only fine-tune a small number of (extra) model parameters while freezing most parameters of the pretrained LLMs, thereby greatly decreasing the computational and storage costs.

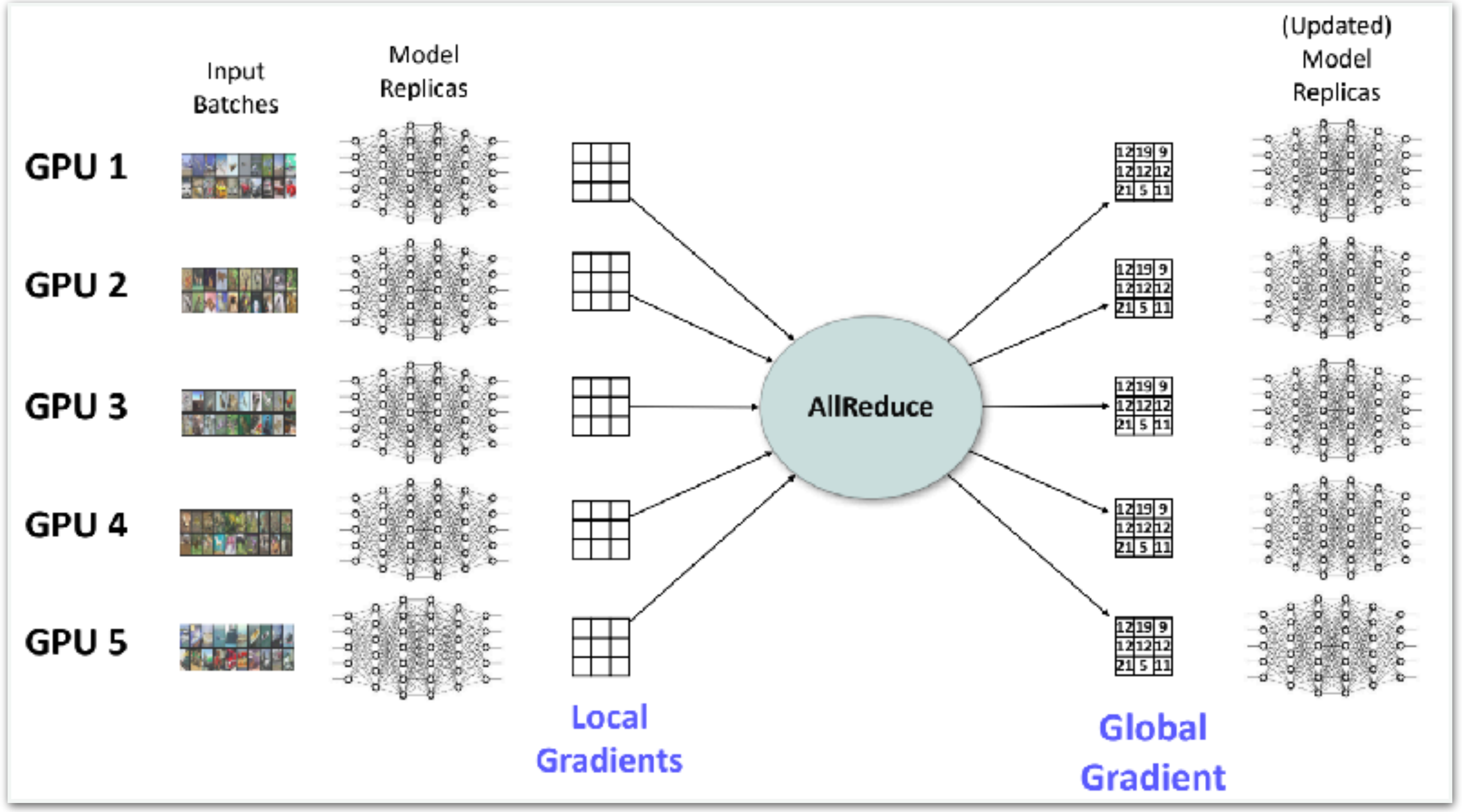


LoRA

LoRA: Low-Rank Adaptation of Large Language Models
FlashAttention: Fast and Memory-Efficient Exact Attention with IO-Awareness

LLM parallel pretraining

- Bigger models means more compute to train them. How to conduct data and model parallel training?
- Split the data and distribute data batches among replicas of the model. Partition the model across GPUs
- DeepSpeed architecture



Other topics

- LM evaluation, data, and benchmarking
- Bias, toxicity, and privacy in LLMs
- …