DATA 8005: Advanced Natural Language Processing

Fall 2023

Announcements

- Make sure that you are added to Slack already (the **primary** mode of communication)
  - Check the Slack channel more often.
    - Task: send your questions and comments in #week4 channel!
  - DM me on Slack instead of emails.
    - Provide feedback on your lectures
    - Answer lecture-related, project questions
    - More importantly, encourage you ask questions, share random thoughts, highlight interesting papers, brag about cool finding there.

Components and grading

- **In-class presentation: 30%**
  - Survey and review papers/blogs on a topic and present it in the class.
- **Class participation: 25%**
  - Read papers before the class and comments on Slack (answer, ask, or add >2 high-quality questions/comments, suggest related papers)
  - In-class group discussions or idea pitches
  - Feedback on presentations from your classmates
- **Final project: 45%**

Announcements

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  - Add “(audit)” after your name on Slack if you are auditing this course

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- Project group registration is due next week (in teams of 2-3).

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- Project group registration is due next week (in teams of 2-3).
- Tentative schedule is up
  - Sign up for preps (in teams of 2, due Monday, 09/25)
  - Can suggest topics

Topics: Large language models (LLMs)

- What are LLMs?
  - Pretraining: from BERT (encoders) to GPT4 (decoders)
- How to use and adapt LLMs?
  - Prompting, in-context learning
  - Instruction tuning
  - Knowledge and reasoning
  - Alignment/RLHF
- How to evaluate and analyze LLMs
  - Data and benchmarking
  - Scaling law
  - Robustness, interpretability, explainability

Large language models (tentative)

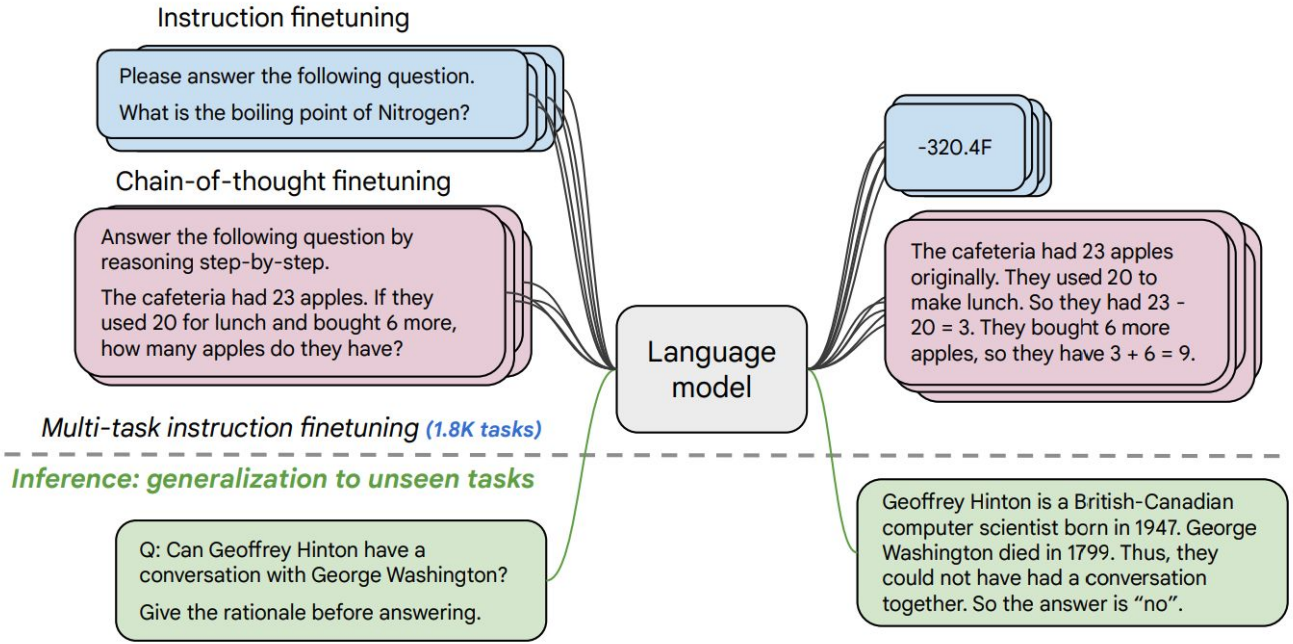
- Other models:
  - Sparse/retrieval- based
  - Code LLMs
  - Multimodal LLMs
- Social impacts
  - Security and privacy
  - Efficiency
  - Ethics

LM agents

- Language and interaction
- Language grounding
- Reasoning and planning
- Tool use
- Multi/human-agent communication
- Personalization, memory, skill learning
- Robotics and embodied interaction
- .....

Instruction tuning

- LM learns to perform many tasks via natural language instructions



LLM agents

Traditional NLP tasks -> LLM agent

Foundational Technologies

- Language Modeling
- Part-of-speech Tagging
- Syntactic Parsing
- Dependency Parsing
- Named Entity recognition
- Coreference resolution
- Word Sense Disambiguation
- Semantic Role Labelling
- ……

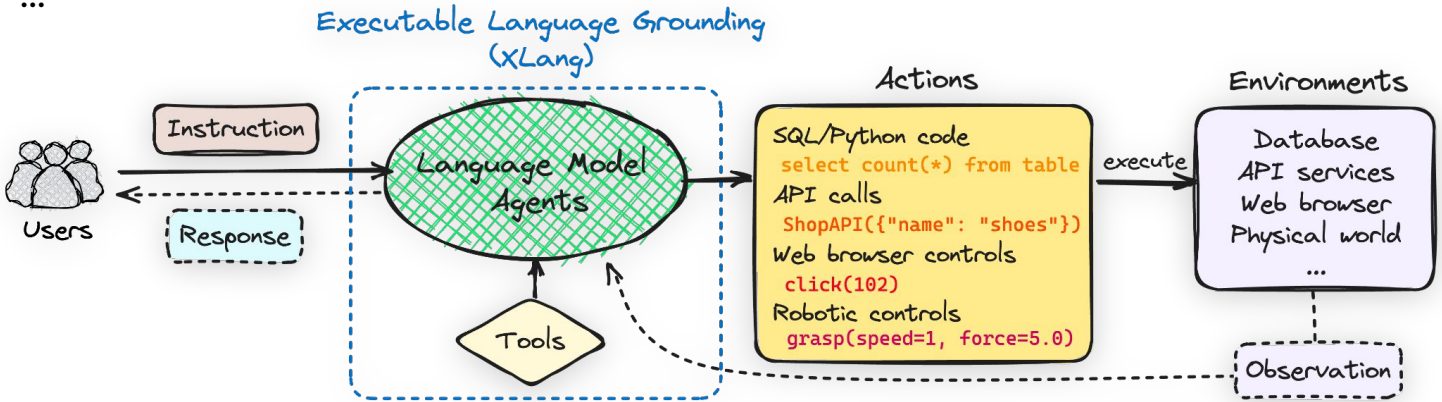
High-Level Tasks and Applications

- Sentiment Analysis
- Information Extraction
- Machine Translation
- Question Answering
- Semantic Parsing
- Summarization
- Dialogue systems
- Language and Vision
- Data-to-Text Generation
- ……

Input X	Output Y	Task
Text	Label	Text Classification (e.g., Sentiment Analysis)
Text	Linguistic Structure	Structured Prediction (e.g., Part-of-Speech Tagging)
Text	Text	Text Generation (e.g., Translation, Summarization)

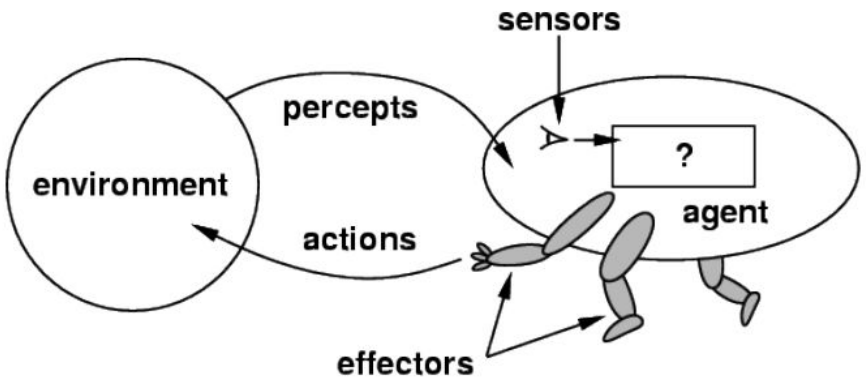
Language model agents

- Interact with and learn from humans and real-world environments *(database, web browser, systems, physical world)*
- Access and know how to use tools *(code interpreter, web/apps, robotic arms, search engines, calculator...)*
- Make decisions for solving complex/abstract problems
  - Reason and plan
  - Ground request and take actions in environments
  - Know to ask questions and abstain
  - Self explore and correct
  - ...



What is an intelligent agent?

- 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://cs.brynmawr.edu/Courses/cs372/spring2012/slides/02_IntelligentAgents.pdf

What are sensors/percepts and effectors/actions?

- Humans
  - Sensors: Eyes (vision), ears (hearing), skin (touch), tongue (gustation), nose (olfaction), neuromuscular system (proprioception)
  - Percepts:
    - At the lowest level – electrical signals from these sensors
    - After preprocessing – objects in the visual field (location, textures, colors, …), auditory streams (pitch, loudness, direction), …
  - Effectors: limbs, digits, eyes, tongue, …
  - Actions: lift a finger, turn left, walk, run, carry an object, …
- The Point: percepts and actions need to be carefully defined, possibly at different levels of abstraction

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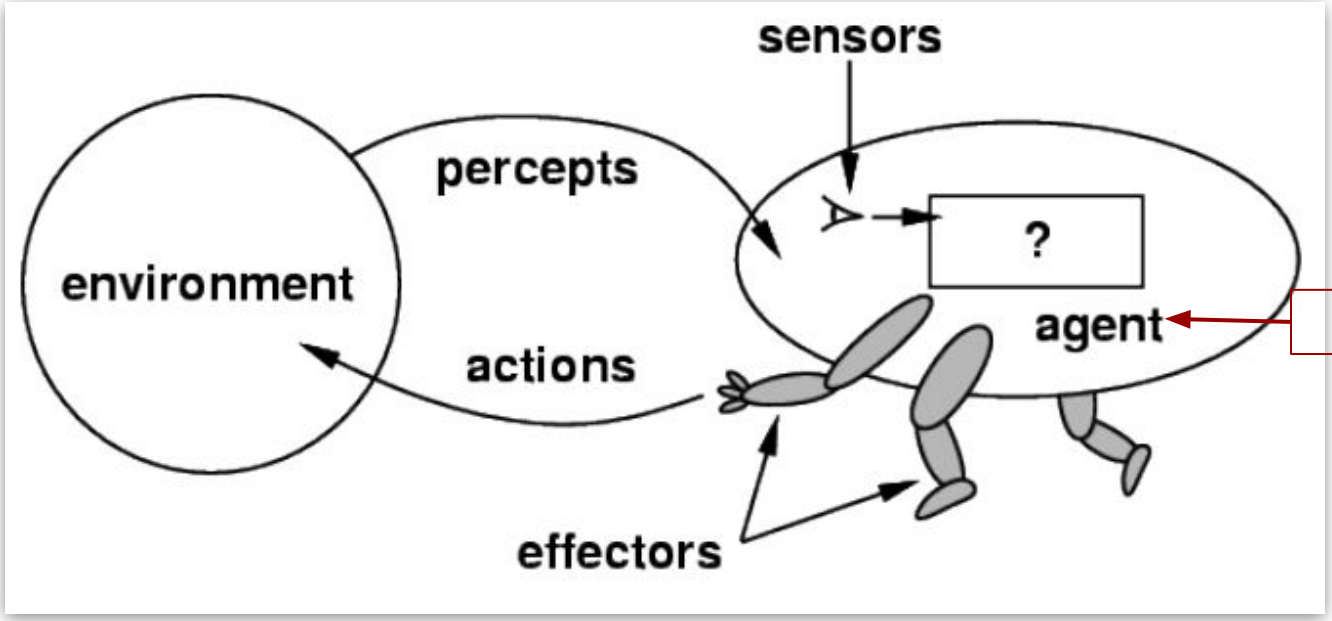
LM agents



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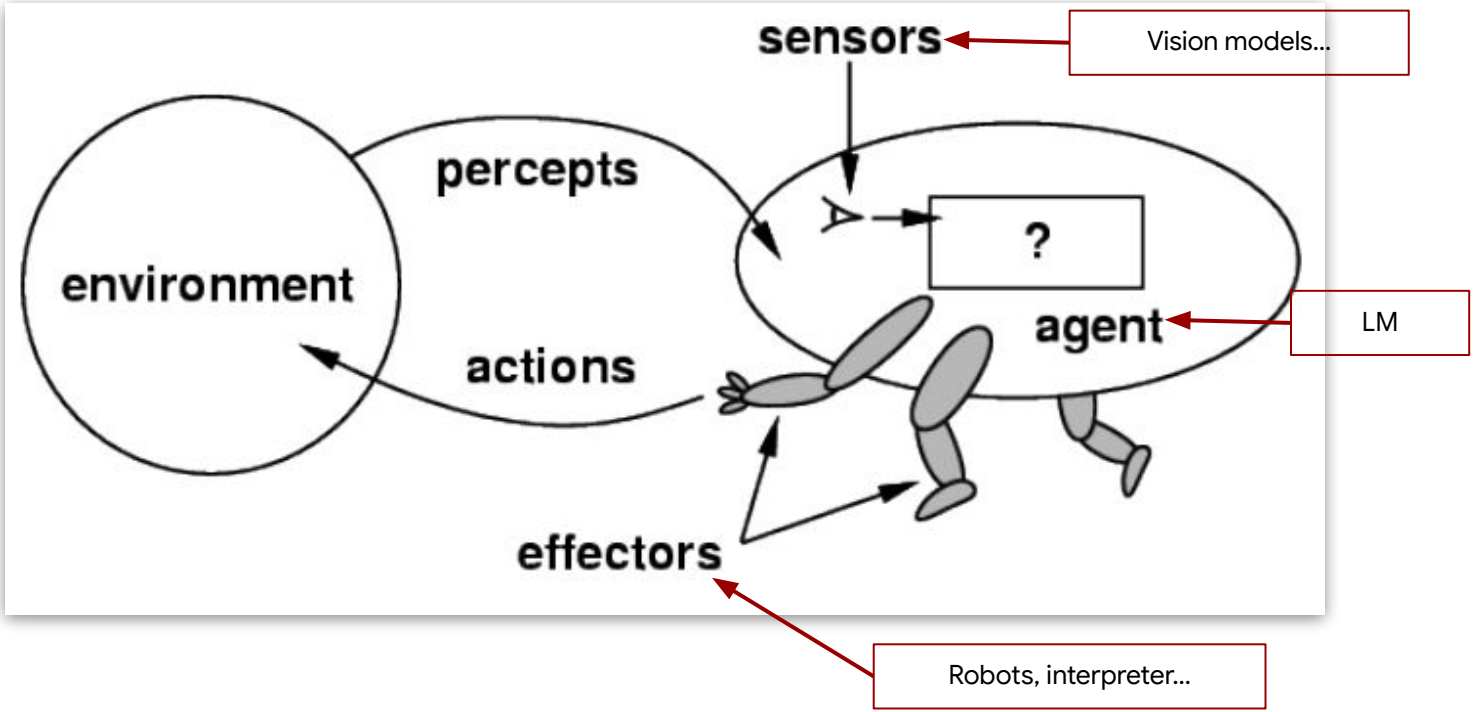
Tool use for LM agents



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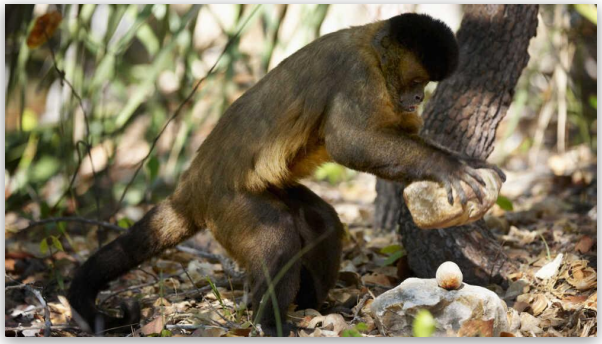
Human + tool use: motivations

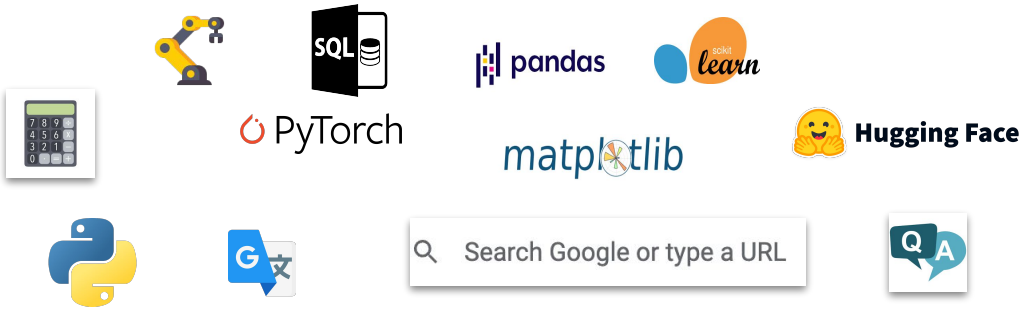
- As humans, we have limited time and memory, feel tired, and have emotions.
- Human + tool use
  - Enhanced scalability
  - Improved consistency
  - Greater interpretability
  - Higher capacity and productivity

https://www.tm-robot.com/en/why-you-should-automate-your-assembly-lines/
https://www.pbs.org/newshour/health/a-new-ruling-could-chip-away-at-the-affordable-care-act-most-in-the-u-s-see-health-care-as-a-basic-right

LLMs + tool use: motivations

- Just like humans, LLMs suffer from the similar limitations. But in the same way,
- LLMs + tool use
  - Enhanced scalability
  - Improved consistency
  - Greater interpretability
  - Higher capacity and productivity

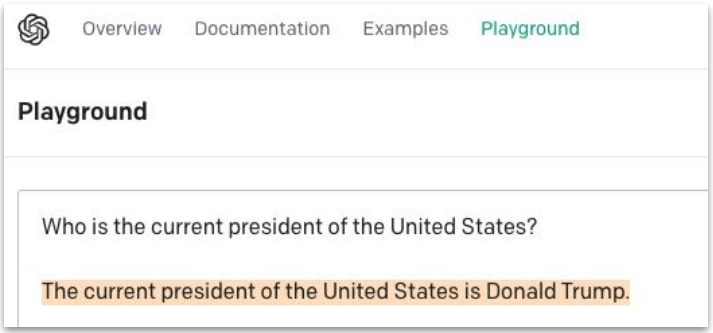




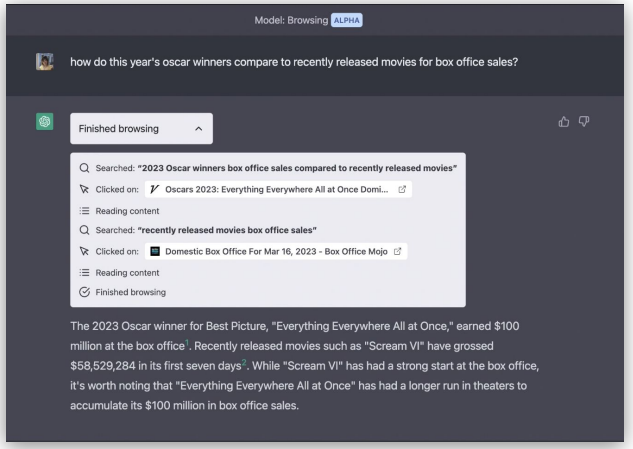
https://www.npr.org/2011/12/23/143833929/myth-busting-the-truth-about-animals-and-tools

LLM + search engine/browser

To gather up-to-date or domain-specific information



GPT-3 without browsing (2 years ago)

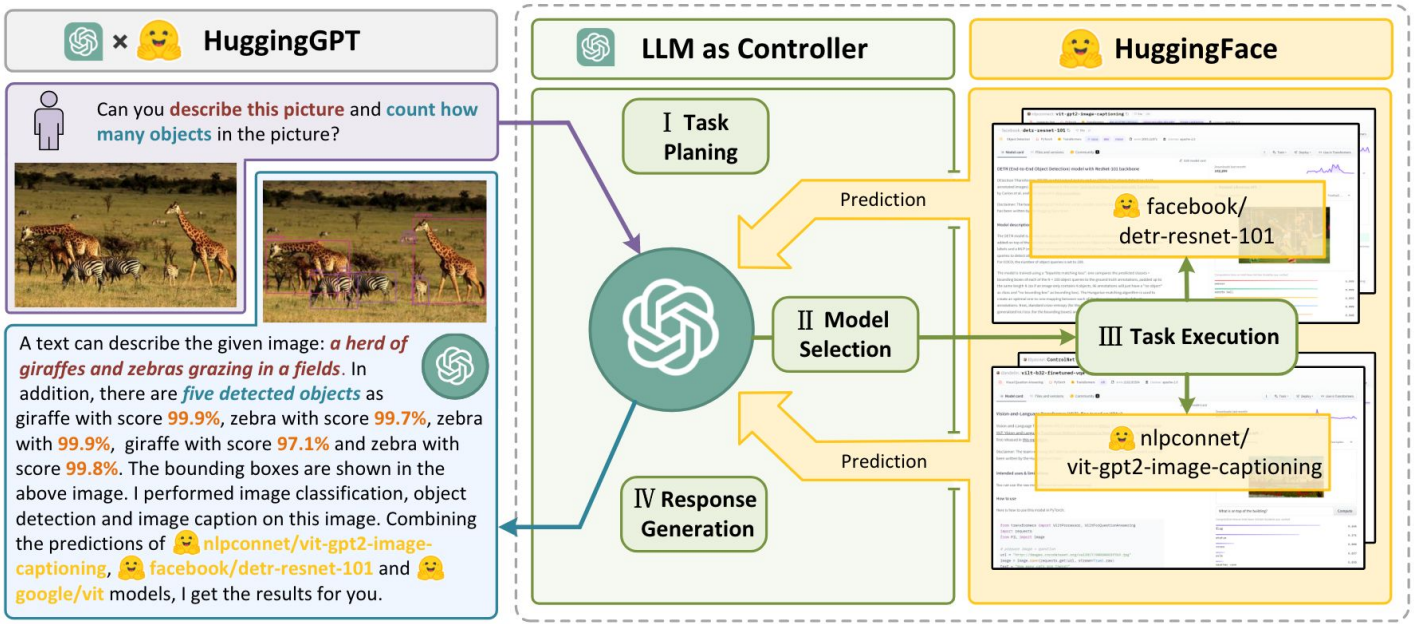


ChatGPT + browsing

WebGPT: Browser-assisted question-answering with human feedback

LLM + expert models

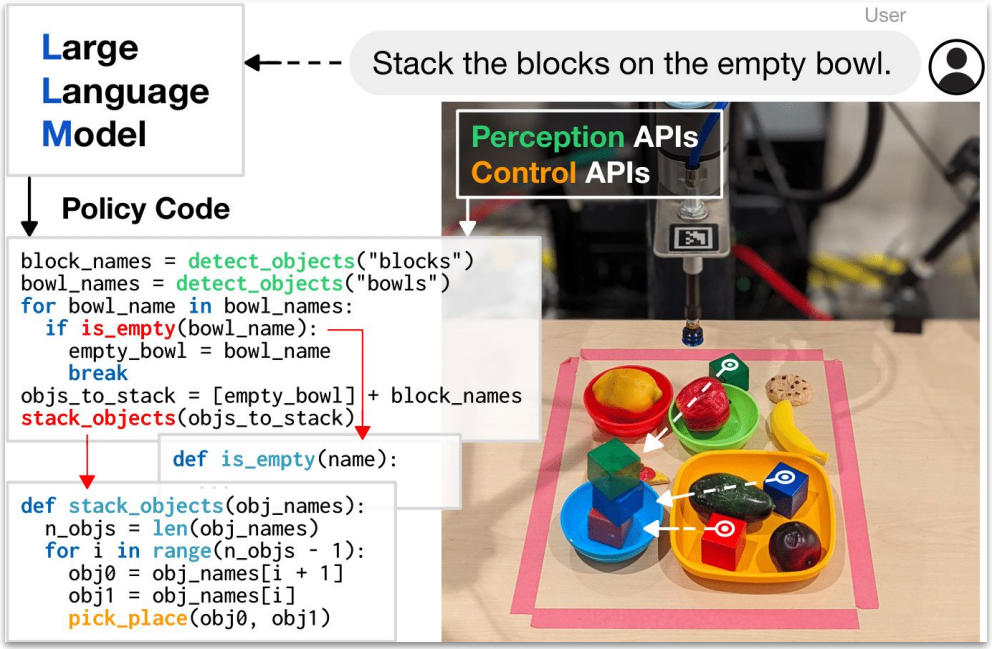
To add specialized capabilities that LLMs may not have or be best at (e.g., LLM + vision)



[HuggingGPT: Solving AI Tasks with ChatGPT and its Friends in HuggingFace]
[Chameleon: Plug-and-Play Compositional Reasoning with Large Language Models]
[TaskMatrix.AI: Completing Tasks by Connecting Foundation Models with Millions of APIs]

LLM + code interpreter, robotic arm …

To enable LLMs to take actions in real-world environments



Code as Policies: Language Model Programs for Embodied Control
Do As I Can, Not As I Say: Grounding Language in Robotic Affordances
ProgPrompt: Generating Situated Robot Task Plans using Large Language Models
Mind's Eye: Grounded Language Model Reasoning through Simulation

Discussion:
What are you most excited about LLMs and want to learn from the class?

This lecture

- For today 🎉🎉🎉
  - Pretraining (Shansan Gong)
  - Prompting, in-context learning (Lei Li)