EMNLP 2024

Language Agents: Foundations, Prospects, and Risks

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Part I: Introduction

Yu Su

The rise, and the divide

Bill Gates

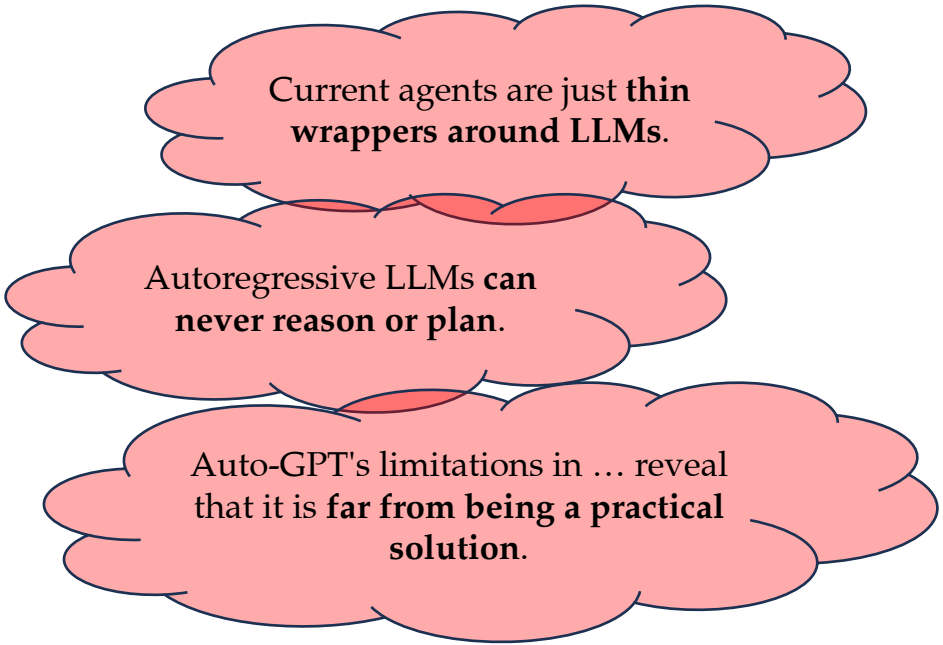
Agents are bringing about the **biggest revolution in computing** since we went from typing commands to tapping on icons.

Andrew Ng

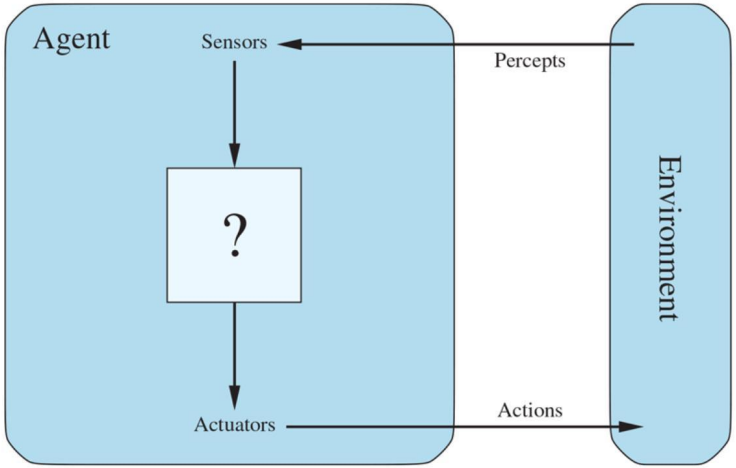
I think AI agentic workflows will drive **massive AI progress** this year.

Sam Altman

2025 is when **agents will work**.



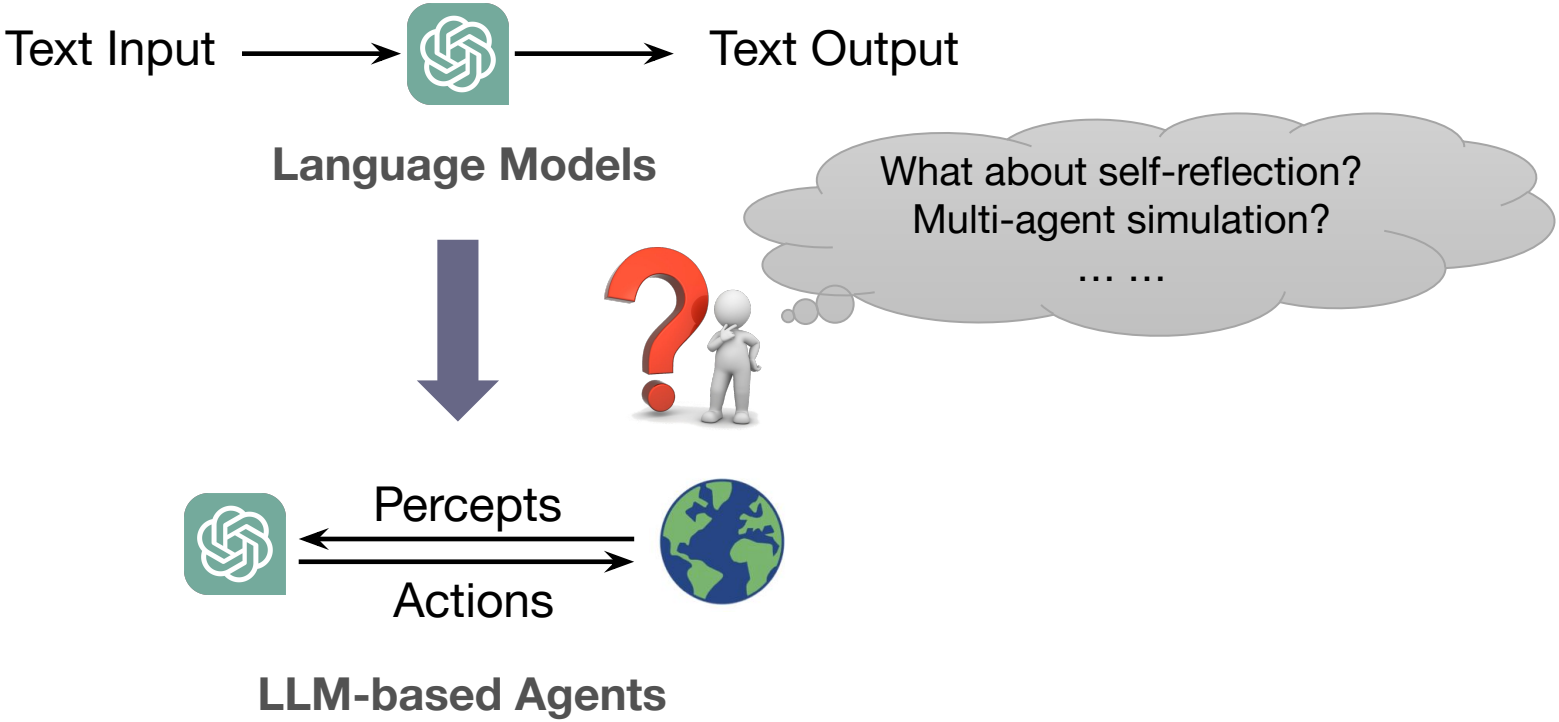
Why agents again?



"An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators."

-- Russell & Norvig, *AI: A Modern Approach* (2020)

‘Modern’ agent = LLM + external environment?



Two competing views

LLM-first view: We make an LLM into an agent!

- Implications: scaffold on top of LLMs, prompting-focused, heavy on engineering

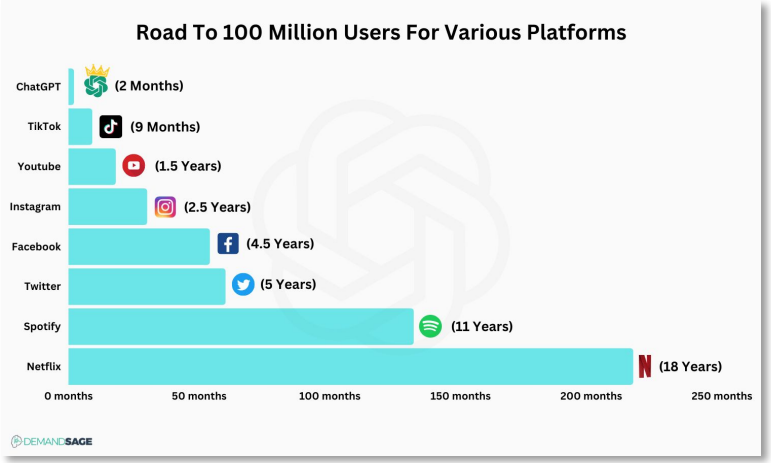
Agent-first view: We integrate LLMs into AI agents so they can use language for reasoning and communication!

- Implications: All the same challenges faced by previous AI agents (e.g., perception, reasoning, world models, planning) still remain, but we need to **re-examine them through the new lens of LLMs** and tackle new ones (e.g., synthetic data, self-reflection, internalized search)

What's fundamentally different now?

Contemporary AI agents, with integrated LLM(s), can *use language as a vehicle for reasoning and communication*

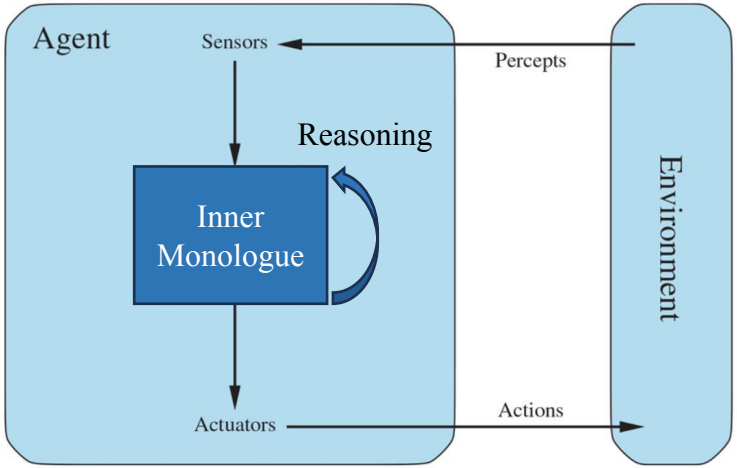
- Instruction following, in-context learning, output customization
- Reasoning (for better acting): state inferences, self-reflection, replanning, etc.



https://www.demandsage.com/chatgpt-statistics/

https://www.reddit.com/r/ChatGPT/comments/16jvl4x/wait_actually_yes/

Reconciling with classic view of agents



Adapted from Russell & Norvig (2020)

- **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

A generalized notion of ‘reasoning’

Unlike humans, LLMs (mostly) only have one mechanism (token generation) for perception, intuitive inferences, and symbolic reasoning; everything is effortful and takes a forward pass

GPT-4o

In this image, we see a young boy sitting on the floor, looking down at a pile of broken dishes. He appears to be sad or remorseful. In front of him, a woman, likely his mother or caregiver, is kneeling and looking at him with a concerned, questioning expression. Her body language, with her hands open and her facial expression, suggests that she's asking him something or expressing surprise or frustration about the broken dishes.

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Perception

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Perception

Intuitive Inference

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Perception

Intuitive Inference

Reasoning

One may alternatively call this ‘thought’ to avoid the over-loaded term of ‘reasoning,’ at the risk of further anthropomorphizing machines

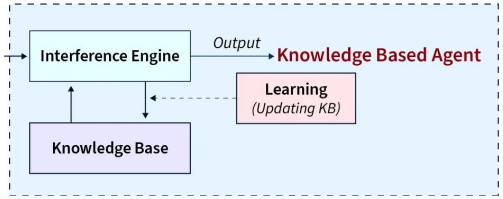
Language agents: a new type of AI agents

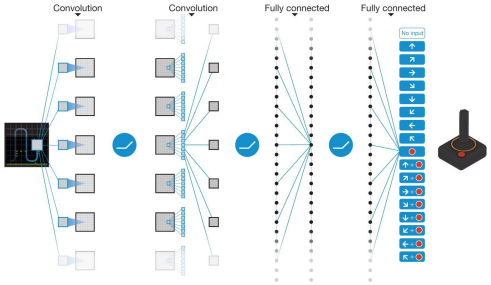
- These contemporary AI agents capable of using language for reasoning and communication are best called "**language agents**." They are qualitatively a different type of AI agents with language being their most distinct trait.

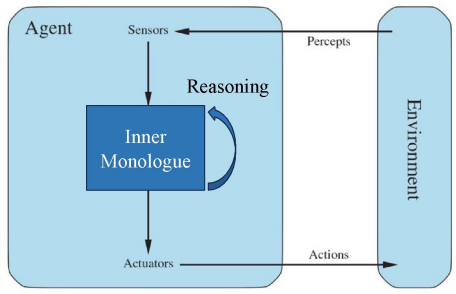
- What about *multimodal agents*?
  - While there's perception of other input modalities, language is still doing the heavy lifting (i.e., reasoning and communication)

- What about simply *LLM agents*?
  - The key is using language for reasoning and communication, but that doesn't have to come from an LLM; that may turn out to be a means to an end
  - Maybe in a few years, we will move beyond LLMs, but the need for universal language understanding and production in agents will remain

Evolution of AI agents





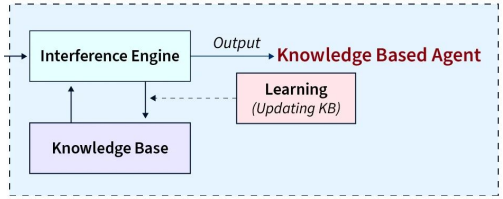


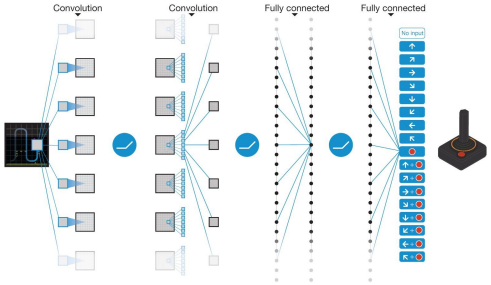
Logical Agent | **Neural Agent** | **Language Agent**

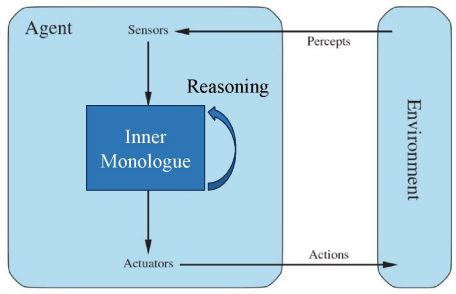
Expressiveness			
Reasoning			
Adaptivity			

Image sources: https://www.scaler.com/topics/artificial-intelligence-tutorial/knowledge-based-agent/,
Mnih et al., "Human-level control through deep reinforcement learning." Nature (2015)

Evolution of AI agents







Logical Agent | **Neural Agent** | **Language Agent**

Expressiveness	Low bounded by the logical language		
Reasoning	Logical inferences sound, explicit, rigid		
Adaptivity	Low bounded by knowledge curation		

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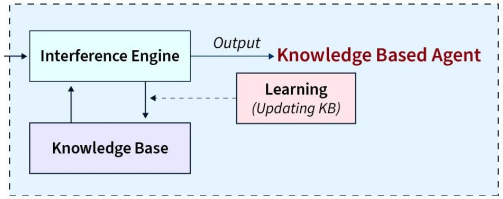
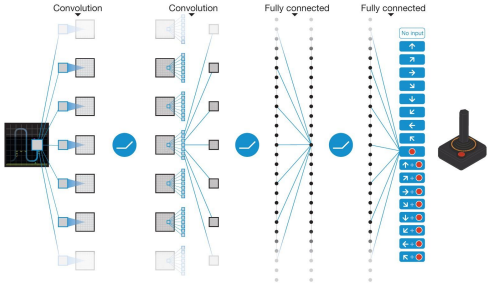
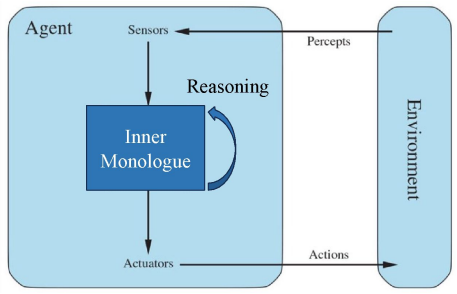
Evolution of AI agents







Logical Agent | **Neural Agent** | **Language Agent**

Expressiveness	Low bounded by the logical language	Medium anything a (small) NN can encode	
Reasoning	Logical inferences sound, explicit, rigid	Parametric inferences stochastic, implicit, rigid	
Adaptivity	Low bounded by knowledge curation	Medium data-driven but sample inefficient	

Image sources: https://www.scaler.com/topics/artificial-intelligence-tutorial/knowledge-based-agent/,
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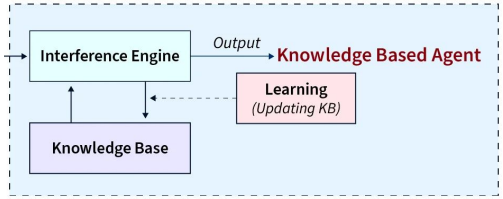
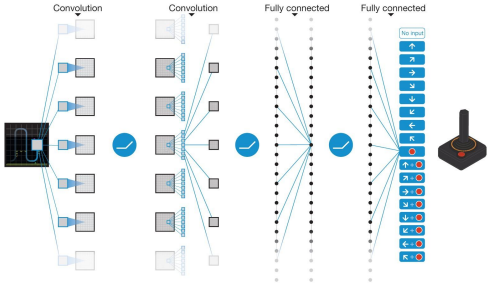
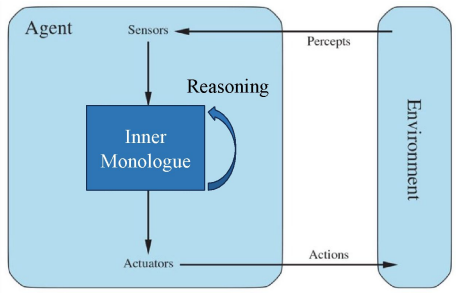
Evolution of AI agents







Logical Agent | **Neural Agent** | **Language Agent**

Expressiveness	Low bounded by the logical language	Medium anything a (small) NN can encode	High almost anything, esp. verbalizable parts of the world
Reasoning	Logical inferences sound, explicit, rigid	Parametric inferences stochastic, implicit, rigid	Language-based inferences fuzzy, semi-explicit, flexible
Adaptivity	Low bounded by knowledge curation	Medium data-driven but sample inefficient	High strong prior from LLMs + language use

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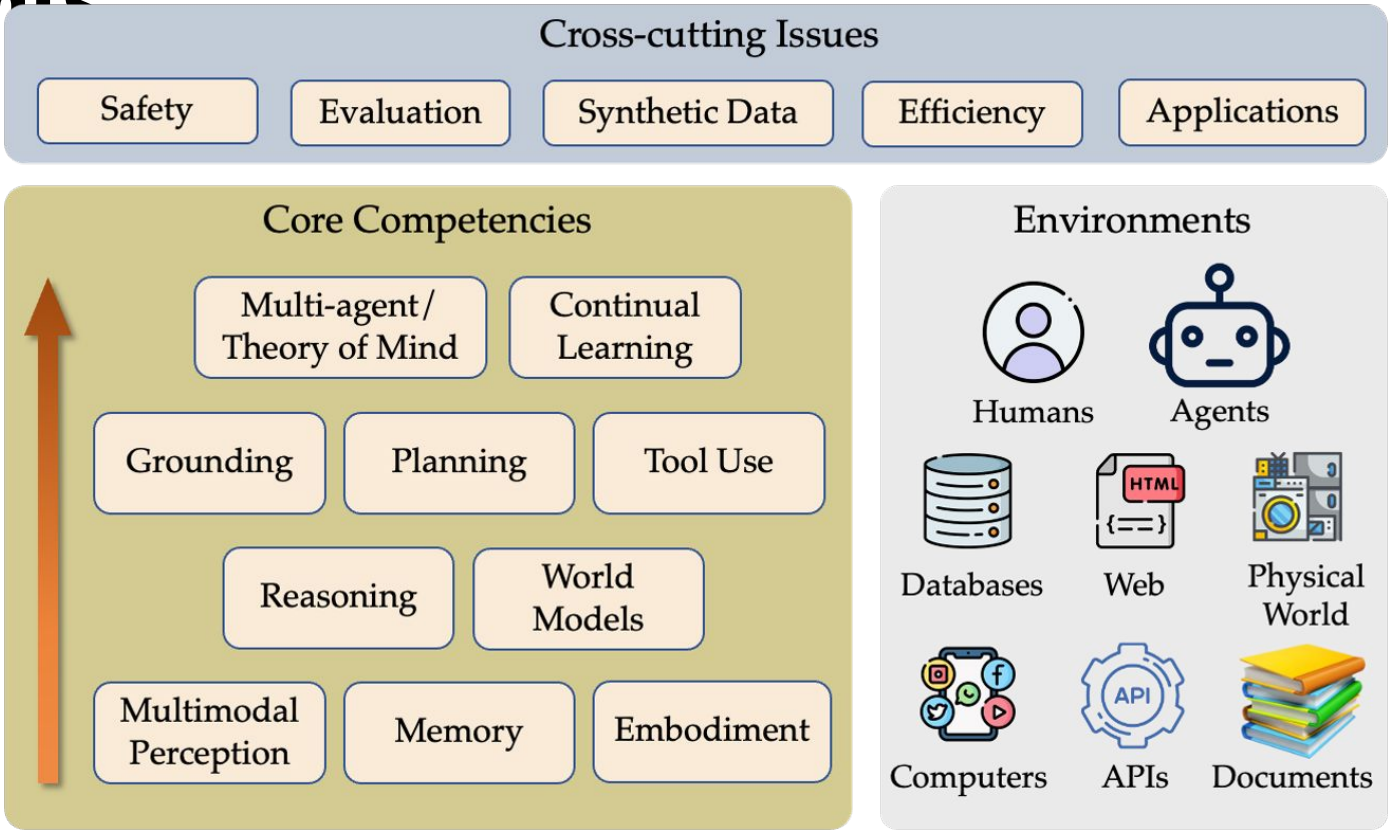
A conceptual framework for language agents



Overview

2:00-2:20 **Part I:** Introduction [20 mins]

2:20-3:20 **Part II:** Foundations: Reasoning, Memory, and Planning [60 mins]

3:20-3:30 **Q&A** [10 mins]

3:30-4:00 **Coffee Break** [30 mins]

4:00-4:45 **Part III:** Applications, Data, and Evaluation [45 mins]

4:45-5:20 **Part IV:** Emerging Topics: Multi-Agent Systems, Safety, and Social Impact [35 mins]

5:20-5:30 **Part V:** Final Remarks and Outlook + Q&A [10 mins]

Disclaimers

This tutorial is

- to offer a **clear definition** and **conceptual framework** for language agents, properly situated in the historical context
- to have a careful discussion on **foundational competencies**, **exciting applications**, and **emerging issues**
- really, our sincere attempt to **get you excited about language agents** as much as we do!

This tutorial is *not*

- a **comprehensive survey** covering as much related work as possible
- a **practitioner's guide** that focuses on code frameworks and best practices

This is a still an emerging topic and we welcome constructive discussions!