CS 294/194-196:
Large Language Model Agents

Teaching Staff

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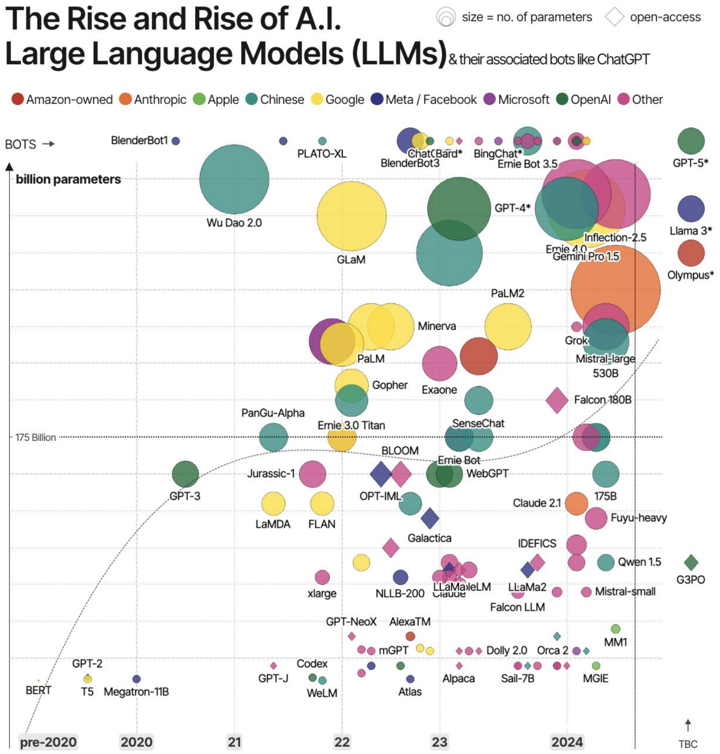
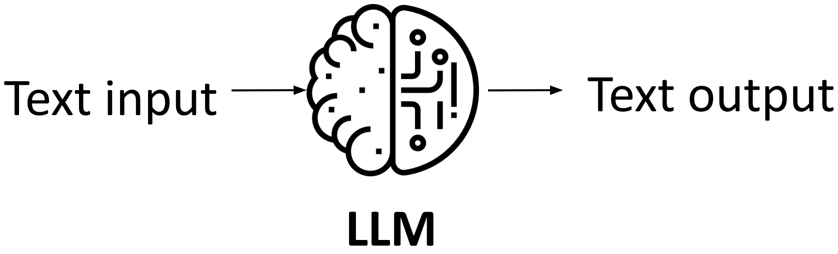
- **(guest) Co-instructor: Dr. Xinyun Chen**
- GSIs: Alex Pan & Sehoon Kim
- Readers: Tara Pande & Ashwin Dara

Accelerated development of large language models (LLMs)



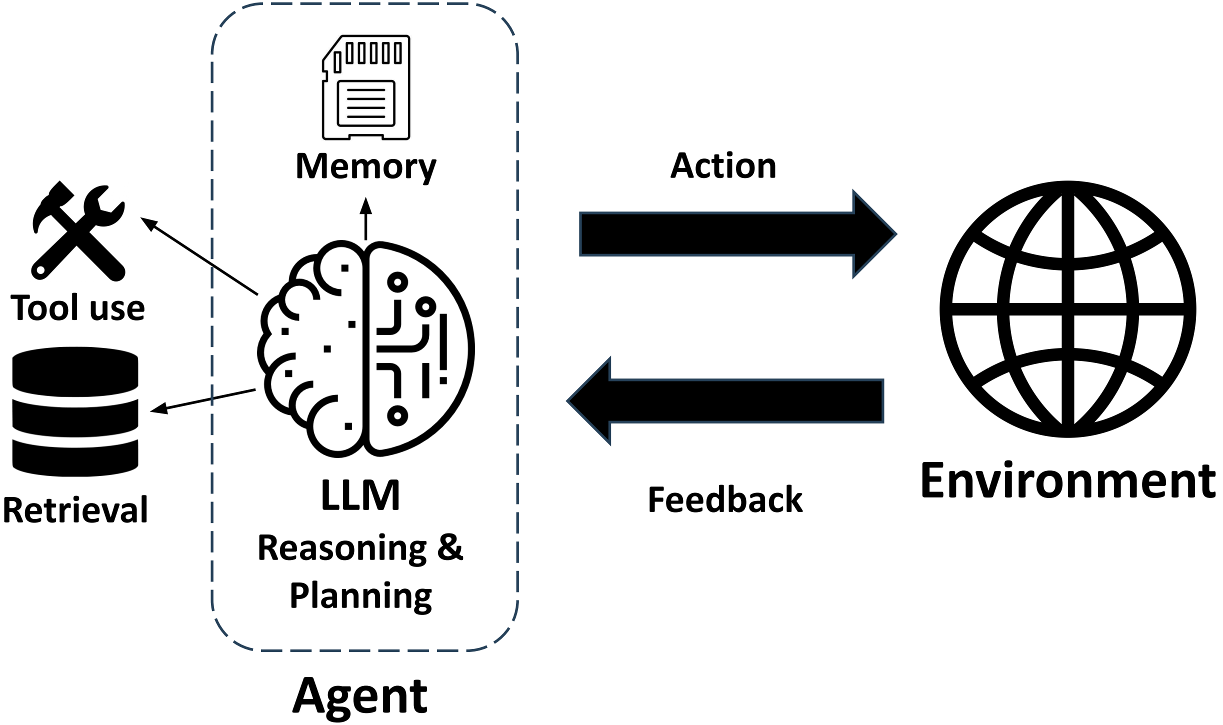
David McCandless, Tom Evans, Paul Barton
Information is Beautiful // UPDATED 20th Mar 24

source: news reports, LifeArchitect.ai
* = parameters undisclosed // see the data

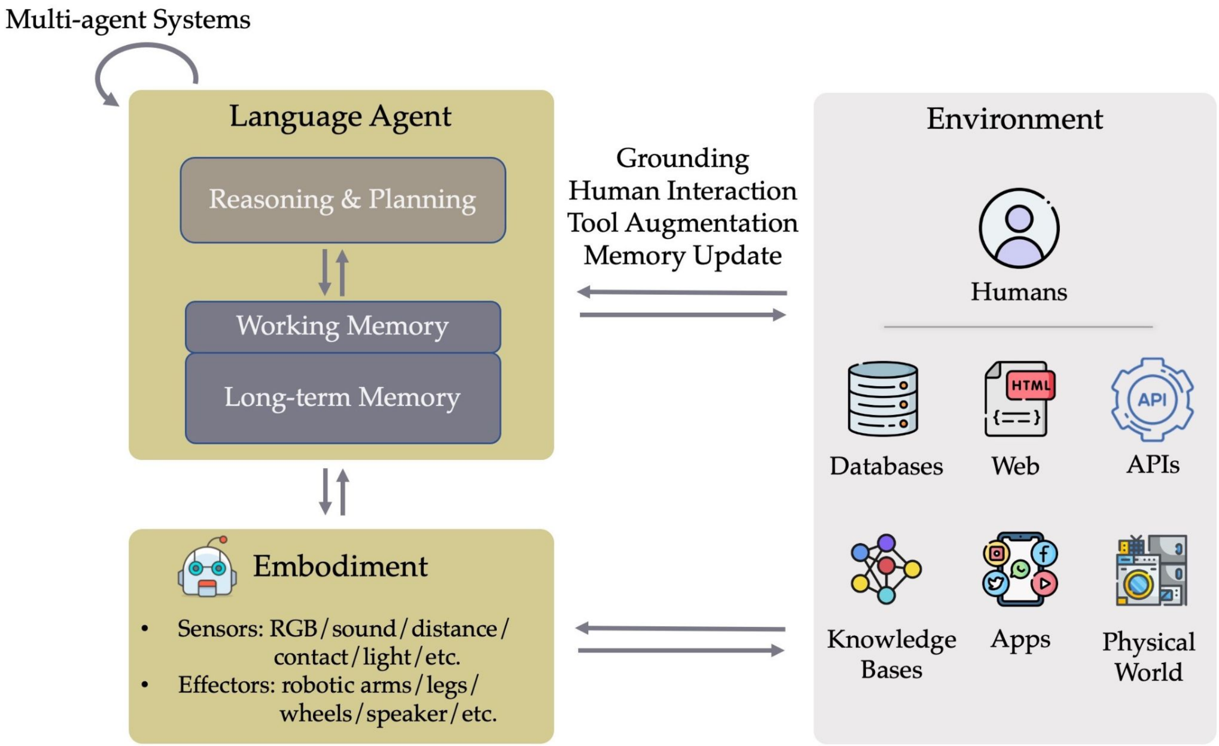


Text input → LLM → Text output

LLM agents: enabling LLMs to interact with the environment



LLM Agents in Diverse Environments



Multi-agent Systems

Language Agent

Reasoning & Planning

Working Memory

Long-term Memory

Grounding
Human Interaction
Tool Augmentation
Memory Update

Environment

Humans

Databases

Web

APIs

Knowledge Bases

Apps

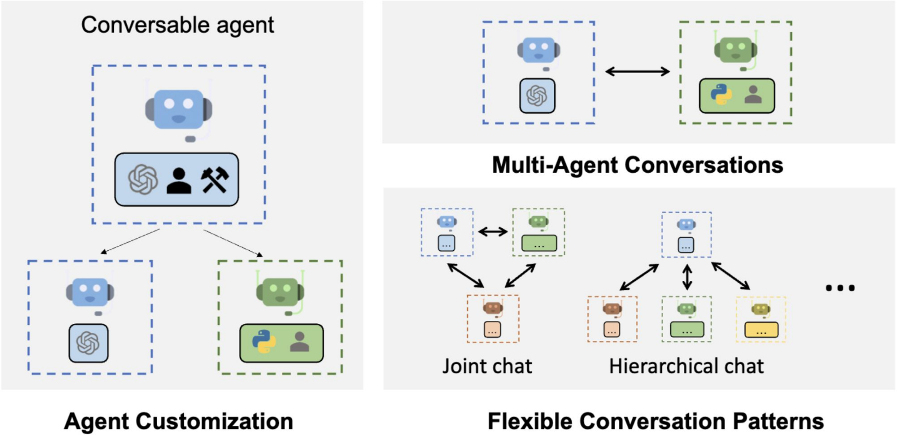
Physical World

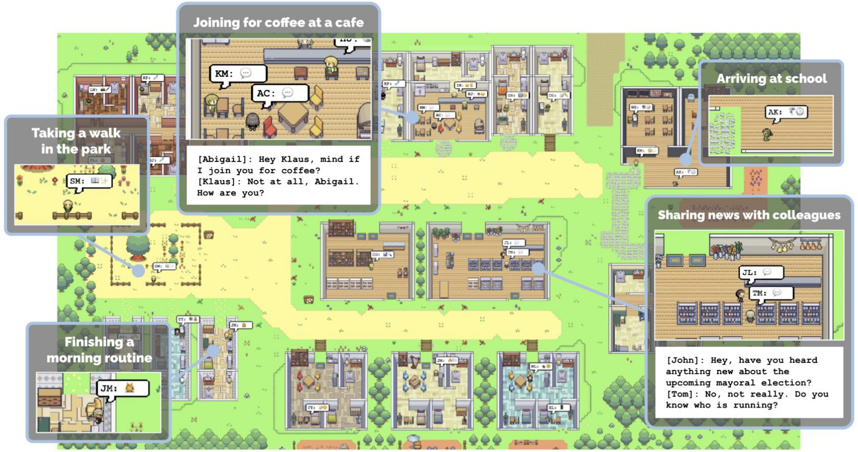
Embodiment

- Sensors: RGB / sound / distance / contact / light / etc.
- Effectors: robotic arms / legs / wheels / speaker / etc.

https://yusu.substack.com/p/language-agents

Multi-agent collaboration: division of labor for complex tasks




Joining for coffee at a cafe
KM:
AC:
Taking a walk in the park
SM:
Arriving at school
AK:
Sharing news with colleagues
JL:
TM:
Finishing a morning routine
JM:

[Abigail]: Hey Klaus, mind if I join you for coffee?
[Klaus]: Not at all, Abigail. How are you?

[John]: Hey, have you heard anything new about the upcoming mayoral election?
[Tom]: No, not really. Do you know who is running?

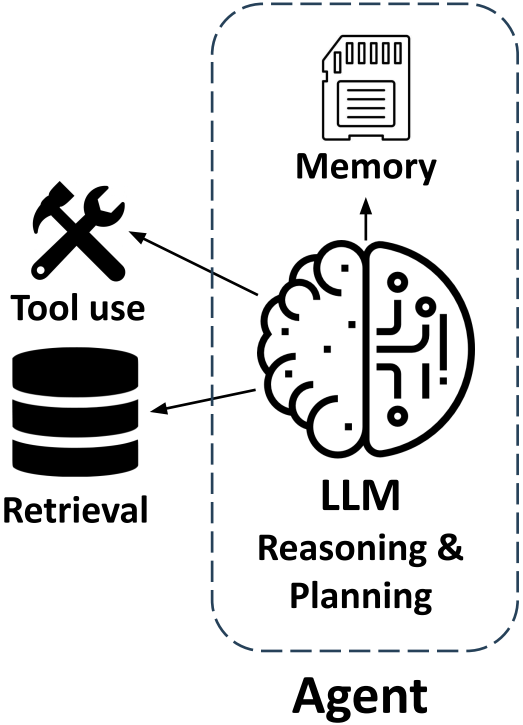
Specialized agents for different subtasks

Autogen, CrewAI, CAMEL, Mixture-of-Agents,...

Emergence of social behaviors with role-play LLMs

Generative agents, Project Sid,...

Why empowering LLMs with the agent framework

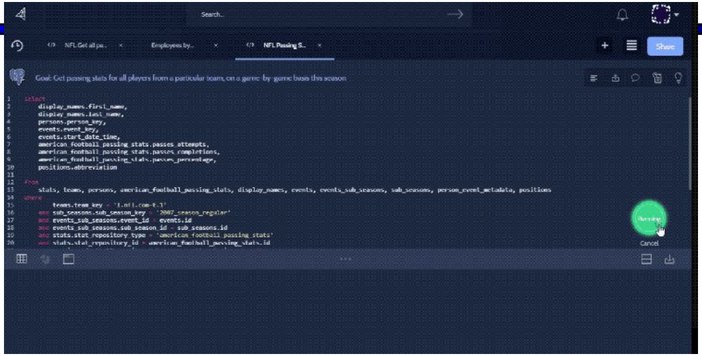


- Solving real-world tasks typically involves a trial-and-error process

- Leveraging external tools and retrieving from external knowledge expand LLM’s capabilities

- Agent workflow facilitates complex tasks
  - Task decomposition
  - Allocation of subtasks to specialized modules
  - Division of labor for project collaboration
  - Multi-agent generation inspires better responses

LLM agents transformed various applications



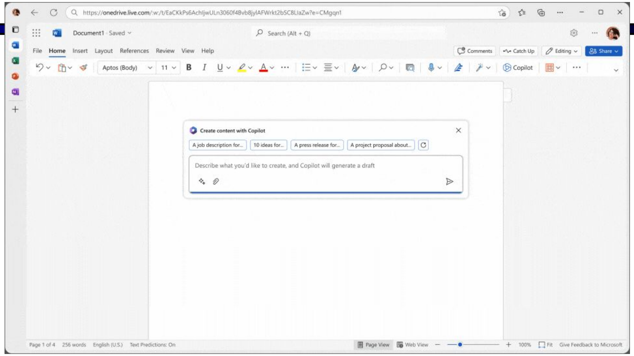
Goal: Get passing stats for all players from a particular team, on a game-by-game basis this season

```
select
    display_names.first_name,
    display_names.last_name,
    persons.person_key,
    events.event_key,
    events.start_date_time,
    american_football_passing_stats.passes_attempts,
    american_football_passing_stats.passes_completions,
    american_football_passing_stats.passes_percentage,
    positions.abbreviation

from
    stats, teams, persons, american_football_passing_stats, display_names, events, events_sub_seasons, sub_seasons, person_event_metadata, positions
where
        teams.team_key = 'l.nfl.com-t.1'
    and sub_seasons.sub_season_key = '2007_season_regular'
    and events_sub_seasons.event_id = events.id
    and events_sub_seasons.sub_season_id = sub_seasons.id
    and stats.stat_repository_type = 'american_football_passing_stats'
    and stats.stat_repository_id = american_football_passing_stats.id
```

Code generation

Cursor, GitHub Copilot, Devin, Replit,…

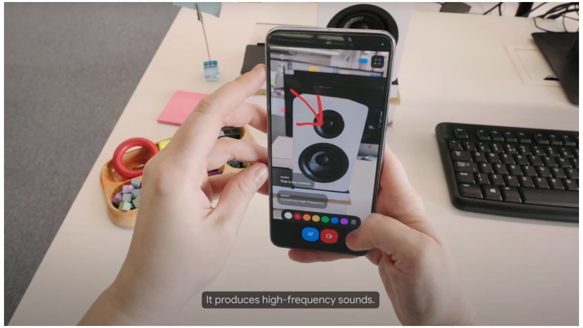


Workflow automation

Microsoft Copilot, Multi-On,…

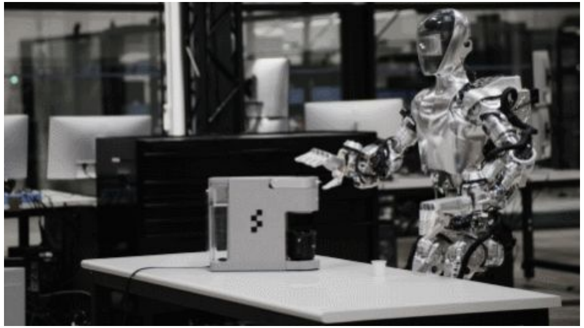
- Education
- Law
- Finance
- Healthcare
- Cybersecurity

…



Personal assistant

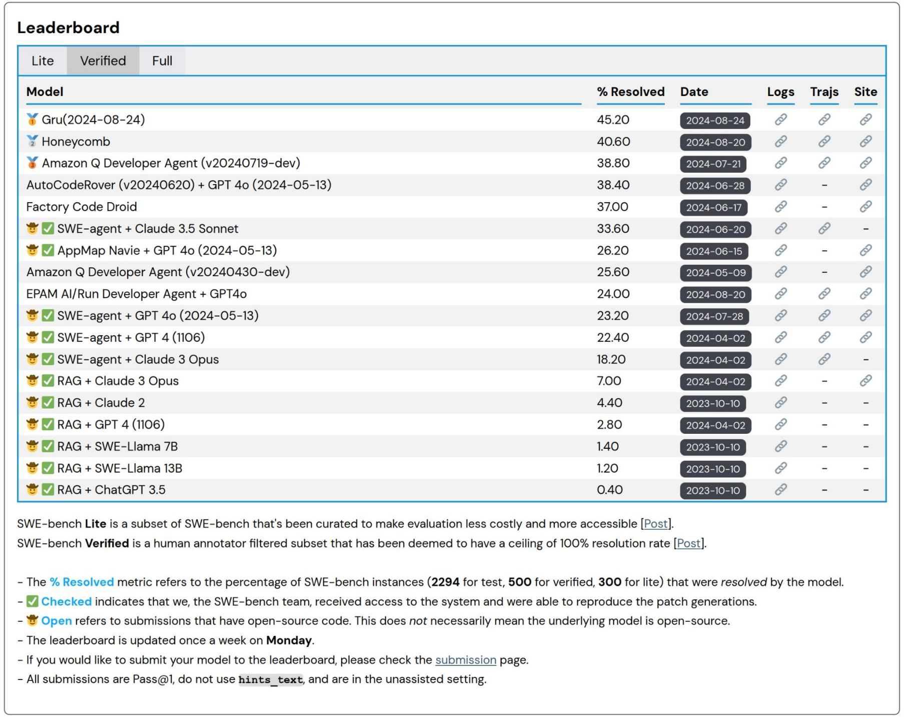
Google Astra, OpenAI GPT-4o,…



Robotics

Figure AI, Tesla Optimus,…

LLM agents are improving



Leaderboard

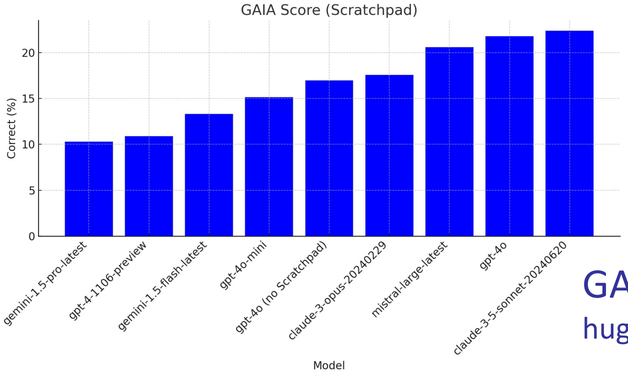
Lite | Verified | Full

Model	% Resolved	Date	Logs	Trajs	Site
🥇 Gru(2024-08-24)	45.20	2024-08-24	🔗	🔗	🔗
🥈 Honeycomb	40.60	2024-08-20	🔗	🔗	🔗
🥉 Amazon Q Developer Agent (v20240719-dev)	38.80	2024-07-21	🔗	🔗	🔗
AutoCodeRover (v20240620) + GPT 4o (2024-05-13)	38.40	2024-06-28	🔗	-	🔗
Factory Code Droid	37.00	2024-06-17	🔗	-	🔗
🤠 ✅ SWE-agent + Claude 3.5 Sonnet	33.60	2024-06-20	🔗	🔗	-
🤠 ✅ AppMap Navie + GPT 4o (2024-05-13)	26.20	2024-06-15	🔗	-	🔗
Amazon Q Developer Agent (v20240430-dev)	25.60	2024-05-09	🔗	-	🔗
EPAM AI/Run Developer Agent + GPT4o	24.00	2024-08-20	🔗	🔗	🔗
🤠 ✅ SWE-agent + GPT 4o (2024-05-13)	23.20	2024-07-28	🔗	🔗	🔗
🤠 ✅ SWE-agent + GPT 4 (1106)	22.40	2024-04-02	🔗	🔗	🔗
🤠 ✅ SWE-agent + Claude 3 Opus	18.20	2024-04-02	🔗	🔗	-
🤠 ✅ RAG + Claude 3 Opus	7.00	2024-04-02	🔗	-	🔗
🤠 ✅ RAG + Claude 2	4.40	2023-10-10	🔗	-	-
🤠 ✅ RAG + GPT 4 (1106)	2.80	2024-04-02	🔗	-	-
🤠 ✅ RAG + SWE-Llama 7B	1.40	2023-10-10	🔗	-	-
🤠 ✅ RAG + SWE-Llama 13B	1.20	2023-10-10	🔗	-	-
🤠 ✅ RAG + ChatGPT 3.5	0.40	2023-10-10	🔗	-	-

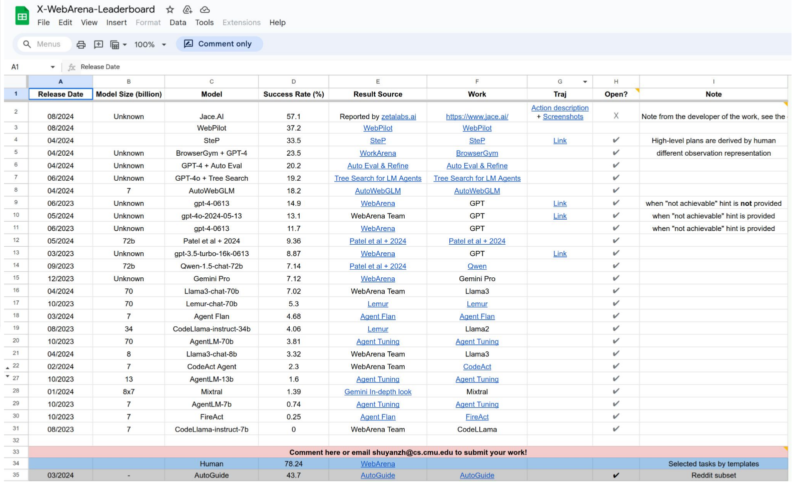
SWE-bench **Lite** is a subset of SWE-bench that's been curated to make evaluation less costly and more accessible [Post].
SWE-bench **Verified** is a human annotator filtered subset that has been deemed to have a ceiling of 100% resolution rate [Post].

- The % Resolved metric refers to the percentage of SWE-bench instances (**2294** for test, **500** for verified, **300** for lite) that were *resolved* by the model.
- ✅ Checked indicates that we, the SWE-bench team, received access to the system and were able to reproduce the patch generations.
- 🤠 Open refers to submissions that have open-source code. This does *not* necessarily mean the underlying model is open-source.
- The leaderboard is updated once a week on **Monday**.
- If you would like to submit your model to the leaderboard, please check the submission page.
- All submissions are Pass@1, do not use `hints_text`, and are in the unassisted setting.

SWE-Bench (Jimenez*, Yang*, et al.)
swebench.com



GAIA (Mialon et al.)
huggingface.co/gaia-benchmark



	Release Date	Model Size (billion)	Model	Success Rate (%)	Result Source	Work	Traj	Open?	Note
2	08/2024	Unknown	Jace.AI	57.1	Reported by zetalabs.ai	https://www.jace.ai/	Action description + Screenshots	X	Note from the developer of the work, see the
3	08/2024		WebPilot	37.2	WebPilot	WebPilot			
4	04/2024		SteP	33.5	SteP	SteP	Link	✔	High-level plans are derived by human
5	04/2024	Unknown	BrowserGym + GPT-4	23.5	WorkArena	BrowserGym		✔	different observation representation
6	04/2024	Unknown	GPT-4 + Auto Eval	20.2	Auto Eval & Refine	Auto Eval & Refine		✔	
7	06/2024	Unknown	GPT-4o + Tree Search	19.2	Tree Search for LM Agents	Tree Search for LM Agents		✔	
8	04/2024	7	AutoWebGLM	18.2	AutoWebGLM	AutoWebGLM		✔	
9	06/2023	Unknown	gpt-4-0613	14.9	WebArena	GPT	Link	✔	when "not achievable" hint is **not** provided
10	05/2024	Unknown	gpt-4o-2024-05-13	13.1	WebArena Team	GPT	Link	✔	when "not achievable" hint is provided
11	06/2023	Unknown	gpt-4-0613	11.7	WebArena	GPT		✔	when "not achievable" hint is provided
12	05/2024	72b	Patel et al + 2024	9.36	Patel et al + 2024	Patel et al + 2024		✔	
13	03/2023	Unknown	gpt-3.5-turbo-16k-0613	8.87	WebArena	GPT	Link	✔	
14	09/2023	72b	Qwen-1.5-chat-72b	7.14	Patel et al + 2024	Qwen		✔	
15	12/2023	Unknown	Gemini Pro	7.12	WebArena	Gemini Pro		✔	
16	04/2024	70	Llama3-chat-70b	7.02	WebArena Team	Llama3		✔	
17	10/2023	70	Lemur-chat-70b	5.3	Lemur	Lemur		✔	
18	03/2024	7	Agent Flan	4.68	Agent Flan	Agent Flan		✔	
19	08/2023	34	CodeLlama-instruct-34b	4.06	Lemur	Llama2		✔	
20	10/2023	70	AgentLM-70b	3.81	Agent Tuning	Agent Tuning		✔	
21	04/2024	8	Llama3-chat-8b	3.32	WebArena Team	Llama3		✔	
22	02/2024	7	CodeAct Agent	2.3	WebArena Team	CodeAct		✔	
27	10/2023	13	AgentLM-13b	1.6	Agent Tuning	Agent Tuning		✔	
28	01/2024	8x7	Mixtral	1.39	Gemini In-depth look	Mixtral		✔	
29	10/2023	7	AgentLM-7b	0.74	Agent Tuning	Agent Tuning		✔	
30	10/2023	7	FireAct	0.25	Agent Flan	FireAct		✔	
31	08/2023	7	CodeLlama-instruct-7b	0	WebArena Team	CodeLLama		✔	
32									
33	**Comment here or email shuyanzh@cs.cmu.edu to submit your work!**								
34			Human	78.24	WebArena				Selected tasks by templates
35	03/2024	-	AutoGuide	43.7	AutoGuide	AutoGuide		✔	Reddit subset

WebArena
(Zhou et al.)
webarena.dev

Challenges for LLM agent deployment in the wild

- Reasoning and planning
  - LLM agents tend to make mistakes when performing complex tasks end-to-end
- Embodiment and learning from environment feedback
  - LLM agents are not yet efficient at recovering from mistakes for long-horizon tasks
  - Continuous learning, self-improvement
  - Multimodal understanding, grounding and world models
- Multi-agent learning, theory of mind
- Safety and privacy
  - LLMs are susceptible to adversarial attacks, can emit harmful messages and leak private data
- Human-agent interaction, ethics
  - How to effectively control the LLM agent behavior, and design the interaction mode between humans and LLM agents

Topics covered in this course

- Model core capabilities
  - Reasoning
  - Planning
  - Multimodal understanding
- LLM agent frameworks
  - Workflow design
  - Tool use
  - Retrieval-augmented generation
  - Multi-agent systems
- Applications
  - Software development
  - Workflow automation
  - Multimodal applications
  - Enterprise applications
- Safety and ethics

Large Language Model Agents MOOC

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