



SCHOOL OF
COMPUTING &
DATA SCIENCE
The University of Hong Kong

Towards Versatile Computer Agents: Cross-Domain Frontiers, Security Guardrails, and the Open-Source Landscape

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Today



ScienceBoard: Evaluating Multimodal Autonomous Agents in Realistic Scientific Workflows



From Digital Agents to AI Co-Scientists



OS-Sentinel : Towards Safety-Enhanced Mobile GUI Agents via Hybrid Validation in Realistic Workflows



Infra, Benchmark and Method for advancing GUI agents' safety

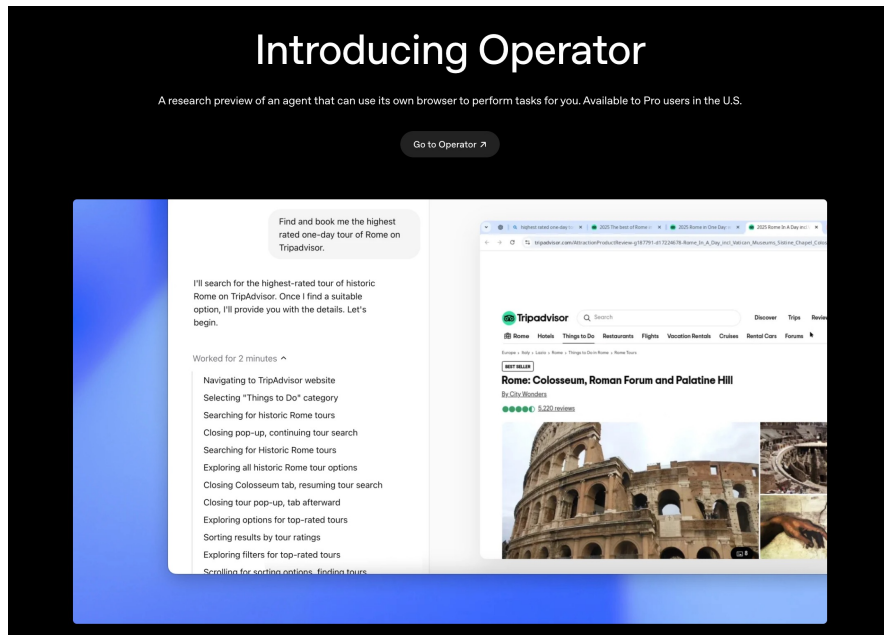


OpenMobile: Building Open Mobile Agents with Task and Trajectory Synthesis

Towards open-sourced, competitive mobile agent

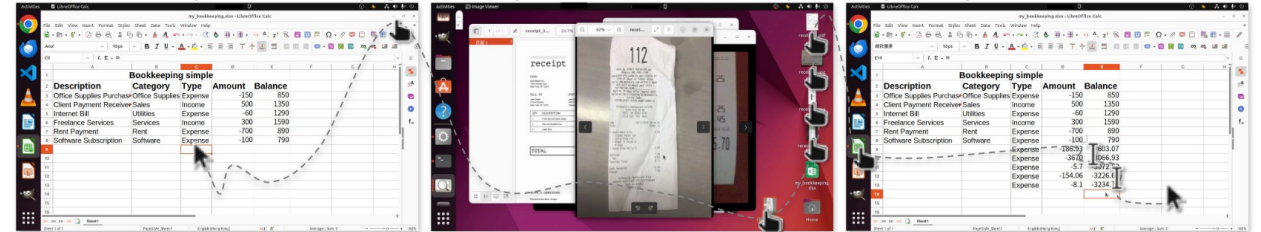
Computer-Using Agents

Automating daily computer tasks

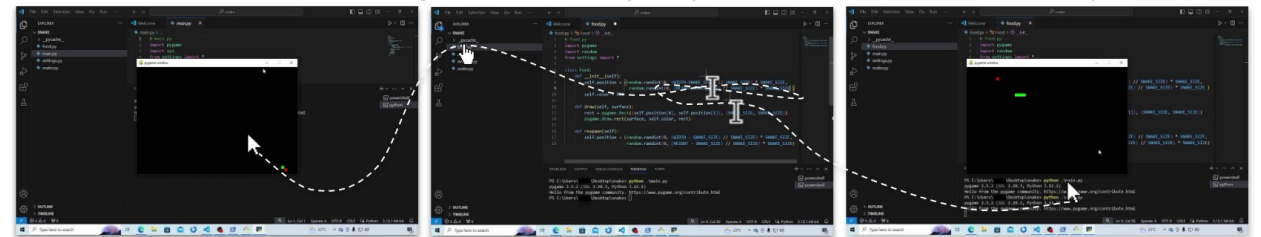


OpenAI Operator

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?



Daily Computer Use

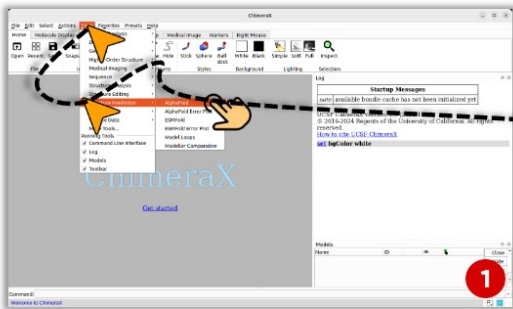
[1] Introducing Operator: A research preview of an agent that can use its own browser to perform tasks for you., Jan 23, 2025

[2] OSWorld: Benchmarking Multimodal Agents for Open-Ended Tasks in Real Computer Environments

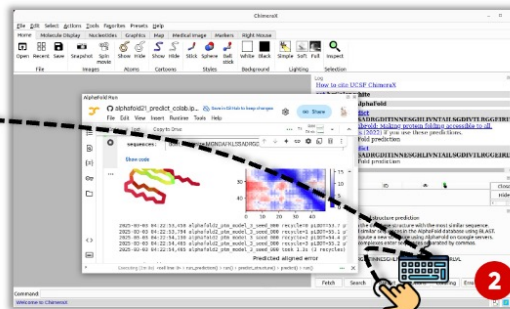
Computer-using Agents

Is it possible for CUAs to automate scientific workflows, be your co-scientist?

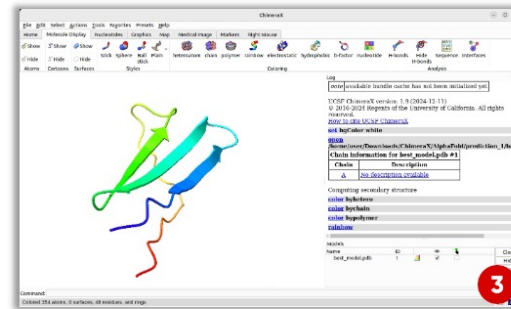
Instruction: Predict the protein structure for the amino acid sequence of 'MGND...' via AlphaFold in ChimeraX.



Step1: Toggle the widget of AlphaFold.

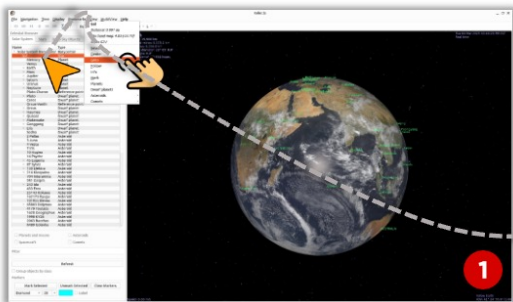


Step2: Input the given sequence and call out AlphaFold for structure prediction.

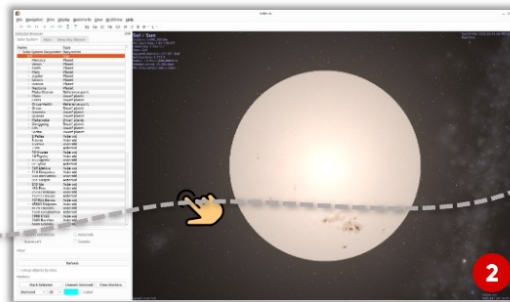


Step3: Wait until the prediction finished.

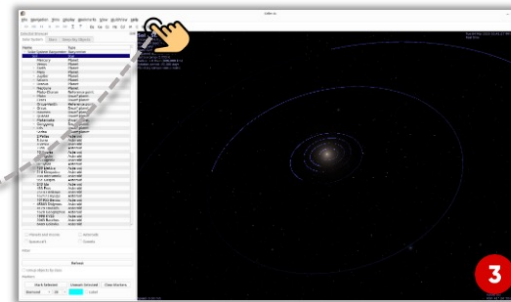
Instruction: Show planets' orbits of Solar System in Celestia.



Step1: Select the Sol and click 'Goto' in context menu.



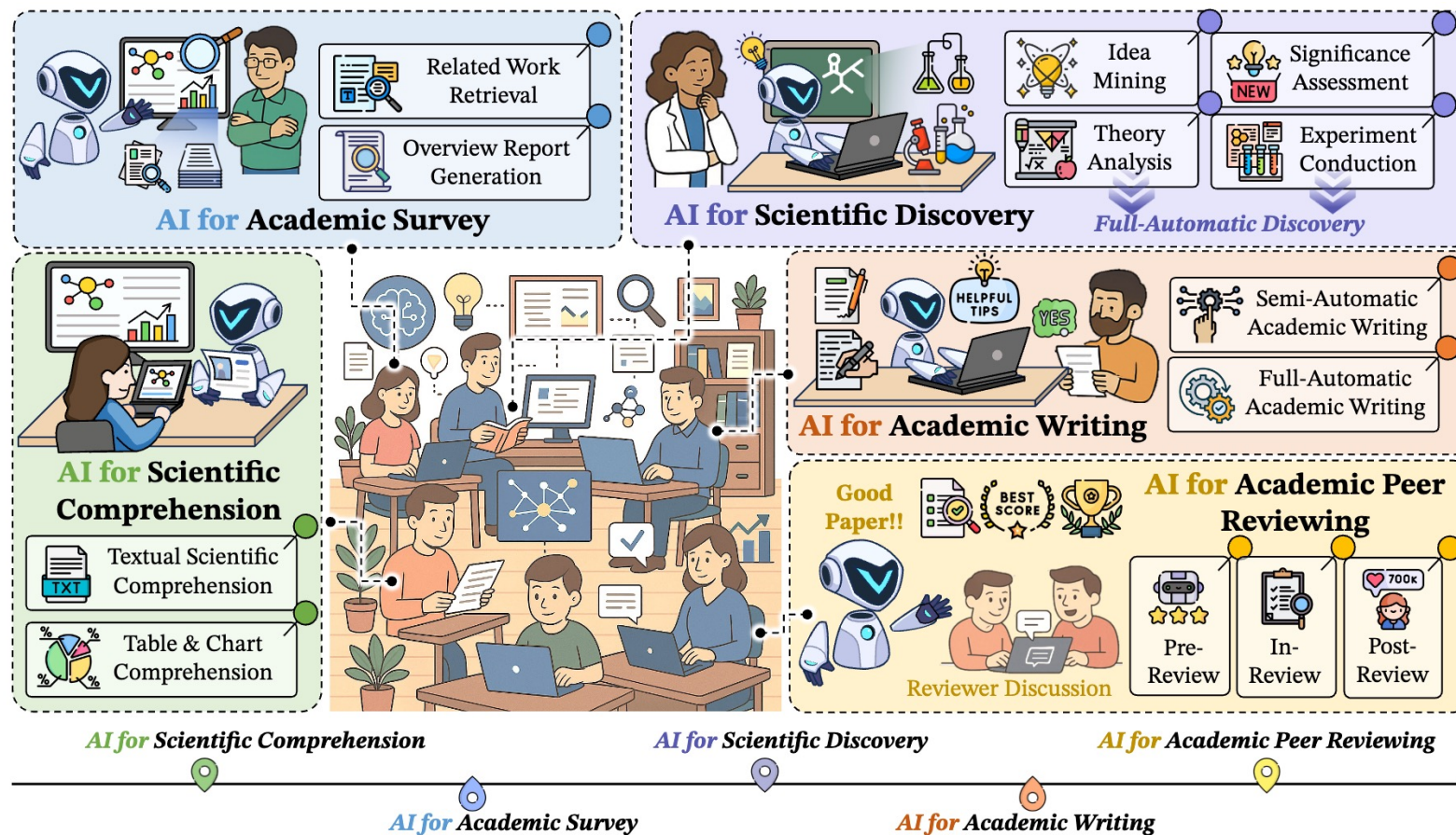
Step2: Slide the mouse wheel to move the camera away from Sol.



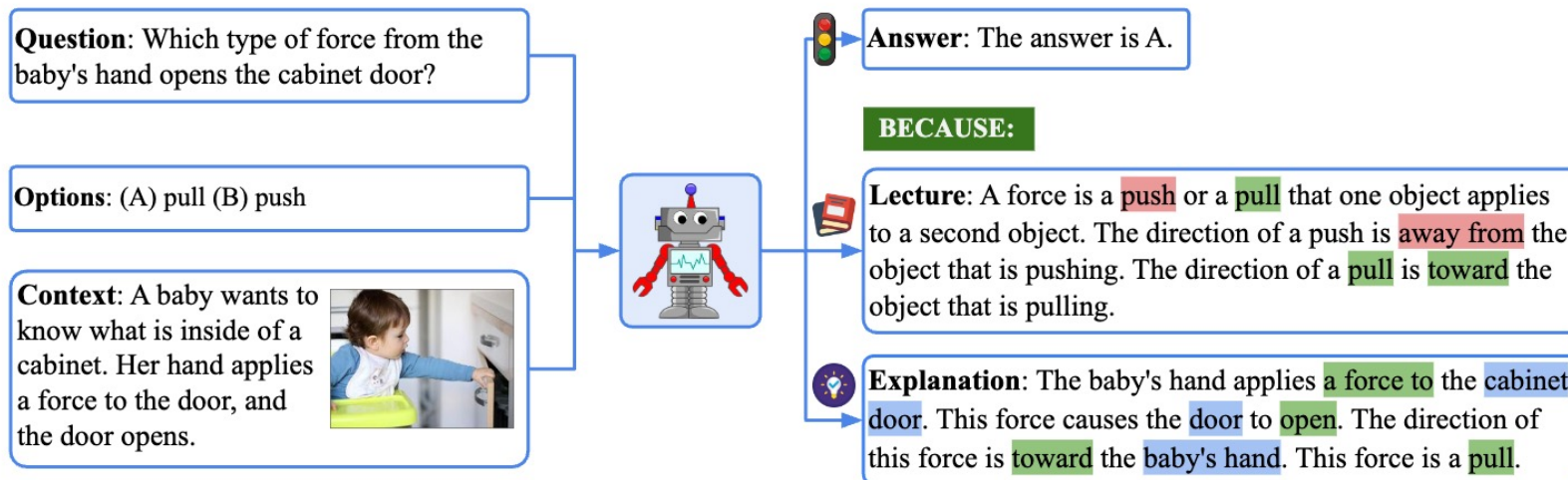
Step3: Click to show orbits of planets.

Backgrounds

AI4Research is a highly popular concept.



Backgrounds: Pastoral Age



ScienceQA (NIPS 2022)

- Multimodal Reasoning (Chain-of-Thought)
- Natural science, language science, and social science
- 12k Grade school-level MCQ

Backgrounds: Contemporary Era

SciCode (NIPS 2024)

- 16 subfields (e.g., math, physics, chem).
- 80 main problems, decomposed into 338 subproblems involving recall, reasoning, and code synthesis.
- Each question verified by 2 senior researchers to ensure scientific accuracy and relevance.

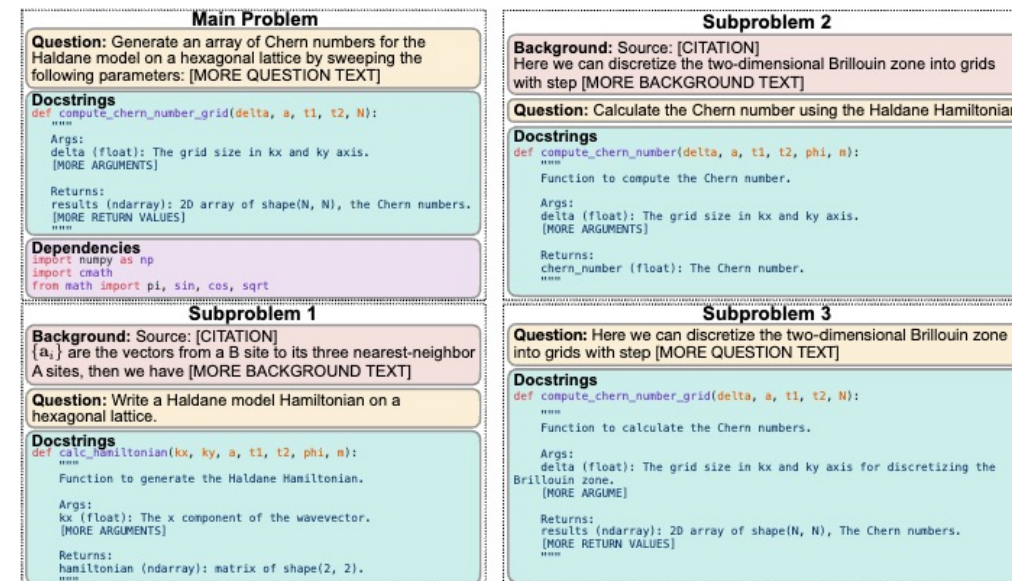


Figure 1: A SciCode main problem is decomposed into multiple smaller and easier subproblems. Docstrings specify the requirements and input-output formats. When necessary, scientific background knowledge is provided, written by our scientist annotators. The full problem is shown in subsection A.3

Backgrounds: Contemporary Era

A lot of “AI Research” systems have been built...

2024-9-4

The AI Scientist: Towards Fully Automated Open-Ended Scientific Discovery

Chris Lu^{1,2,*}, Cong Lu^{3,4,*}, Robert Tjarko Lange^{1,*}, Jakob Foerster^{2,†}, Jeff Clune^{3,4,5,†} and David Ha^{1,*}
*Equal Contribution, ¹Sakana AI, ²FLAIR, University of Oxford, ³University of British Columbia, ⁴Vector Institute, ⁵Canada CIFAR AI Chair, [†]Equal Advising

SciMON : Scientific Inspiration Machines Optimized for Novelty

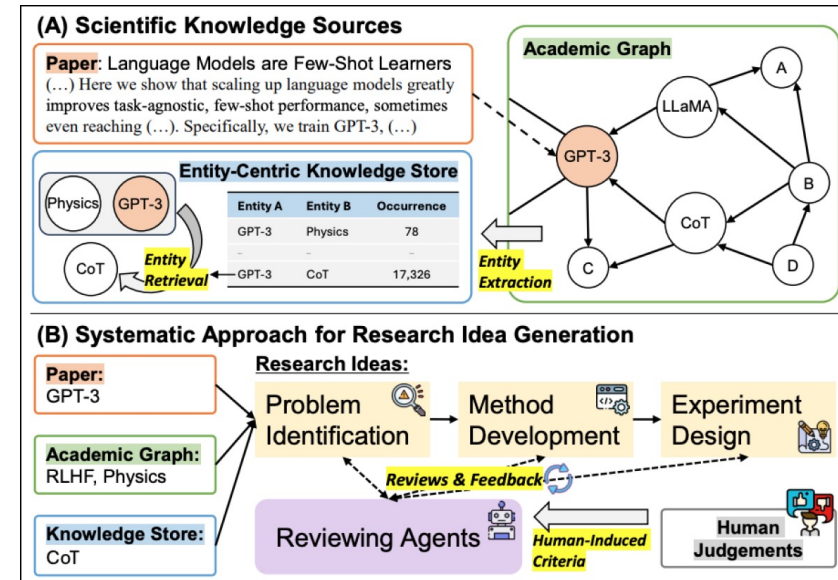
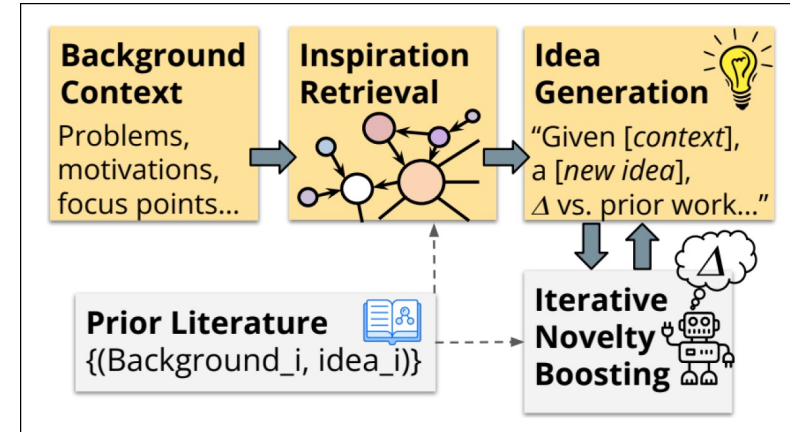
Qingyun Wang¹, Doug Downey², Heng Ji¹, Tom Hope^{2,3}
¹University of Illinois at Urbana-Champaign ²Allen Institute for Artificial Intelligence (AI2) ³The Hebrew University of Jerusalem
 {tomh,doug}@allenai.org, {qingyun4,hengji}@illinois.edu

ResearchAgent: Iterative Research Idea Generation over Scientific Literature with Large Language Models

Jinheon Baek¹ Sujay Kumar Jauhar² Silviu Cucerzan² Sung Ju Hwang^{1,3}
 KAIST¹ Microsoft Research² DeepAuto.ai³
 {jinheon.baek, sjhwang82}@kaist.ac.kr {sjauhar, silviu}@microsoft.com

Automated Peer Reviewing in Paper SEA: Standardization, Evaluation, and Analysis

Jianxiang Yu[◇], Zichen Ding[◇], Jiaqi Tan[◇], Kangyang Luo[◇], Zhenmin Weng[◇],
 Chenghua Gong[◇], Long Zeng[◇], Renjing Cui[◇], Chengcheng Han[◇],
 Qiushi Sun[◇], Zhiyong Wu[◇], Yunshi Lan[◇], Xiang Li^{◇†}
[◇]East China Normal University, Shanghai, China
[◇]Shanghai AI Laboratory, Shanghai, China
 sea.ecnu@gmail.com
<https://ecnu-sea.github.io/>



Thinking

Currently, AI acted as an “**Analyzer**,” helping with idea thinking, data analysis, writing, and visualization.

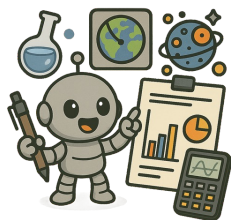
Can AI evolve into an “**Executor**” that helps (1) formulate a plan, (2) directly operates scientific software via GUI or CLI, and (3) even generates some reports?

The answer is **YES**—with the emergence of **computer-using agents**.

Let’s move beyond QA and Coding to actively performing some research tasks!



From Digital Agents to AI Co-Scientists





ScienceBoard: Evaluating **Multimodal** Autonomous Agents in **Realistic** Scientific Workflows

Qiushi Sun, Zhoumianze Liu, Chang Ma, Zichen Ding, Fangzhi Xu, Zhangyue Yin, Haiteng Zhao, Zhenyu Wu, Kanzhi Cheng, Zhaoyang Liu, Jianing Wang, Qintong Li, Xiangru Tang, Tianbao Xie, Xiachong Feng, Xiang Li, Ben Kao, Wenhai Wang, Biqing Qi, Lingpeng Kong, Zhiyong Wu



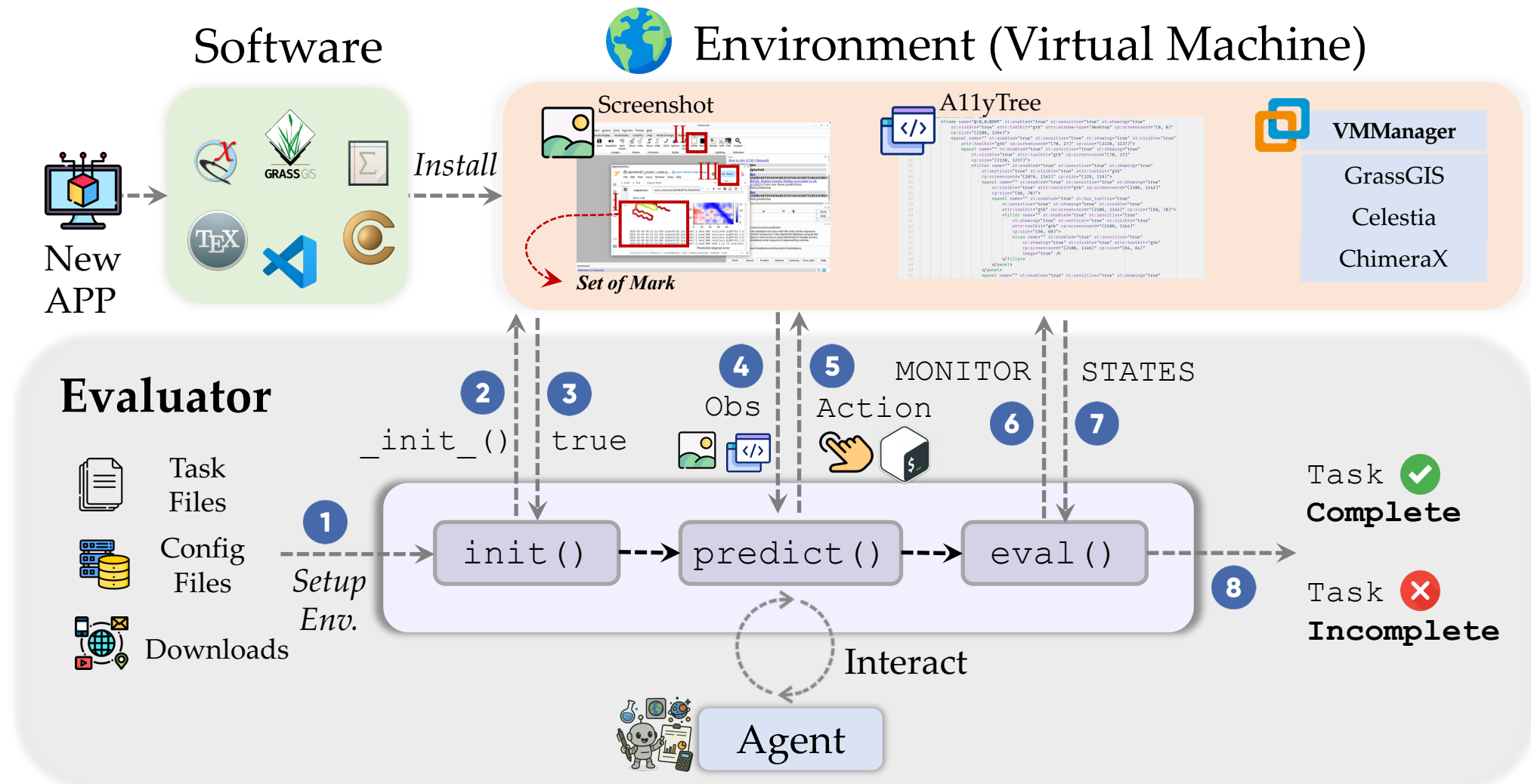
ScienceBoard Infra

So to achieve our goal, we need an environment that allows agents to actively interact.

1. Supports native **multimodal** interaction 
2. Fully **compatible** with coding and conversational research assistance 
3. Enables rigorous **validation** 

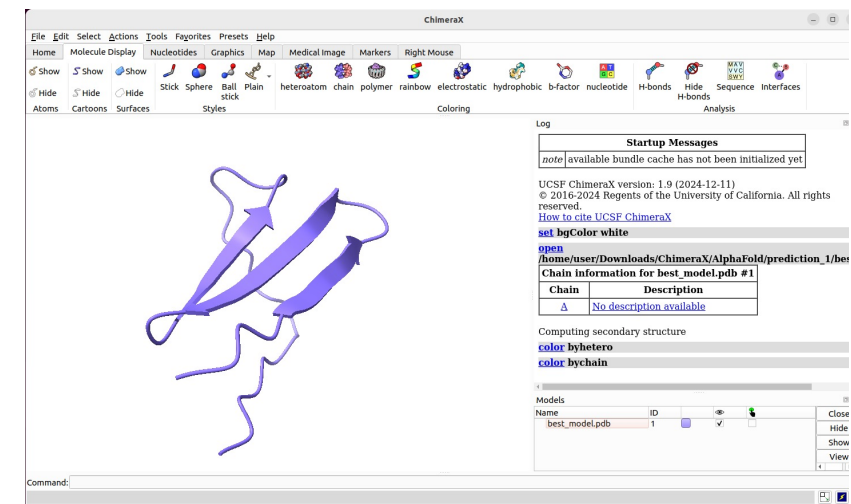
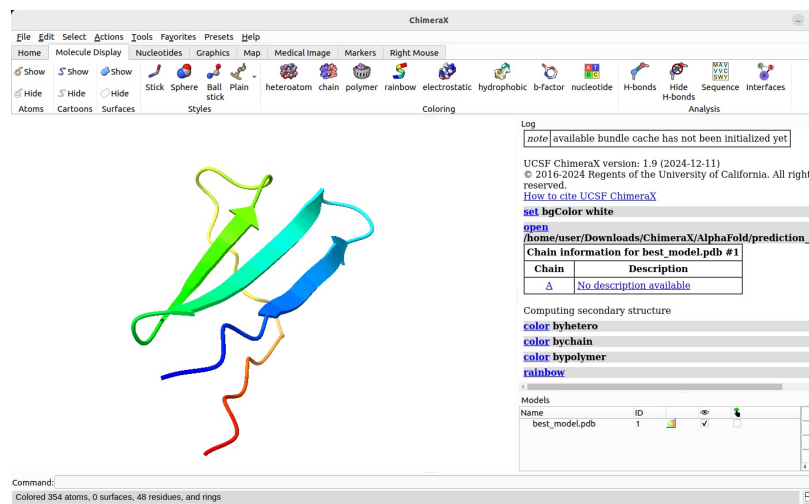
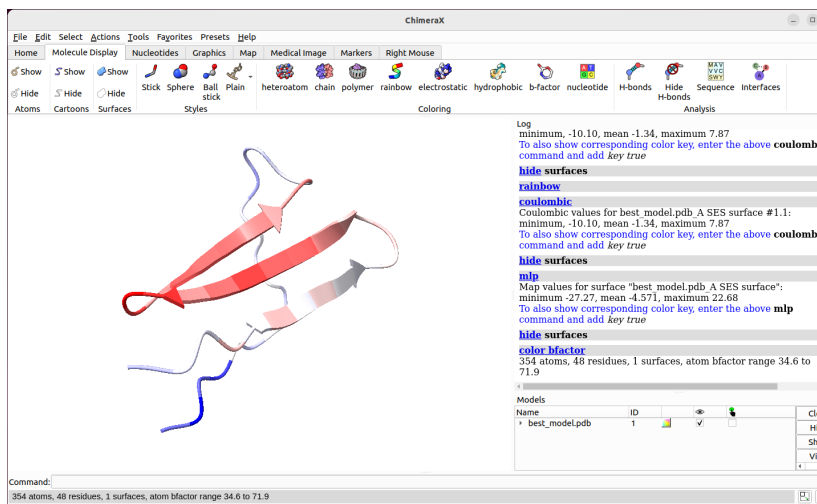
A playground — a virtual machine pre-installed with well-adapted scientific software.

ScienceBoard Infra



The Dilemma of Evaluation

Evaluation is harder than we expect, let's take visualization as an example



It is impossible to “match”

How to Evaluate?

We rely on **internal states**.

By modifying the software, we access intermediate runtime states and enable precise state-based evaluation, e.g., UCSF ChimeraX 

Quick Links

[UCSF ChimeraX Home](#)
[Advantages](#)
[Documentation](#)
[User Guide](#)
[Tutorials and Videos](#)
[Presentations](#)
[Download](#)
[Toolshed](#)
[Statistics](#)
[Citing ChimeraX](#)
[Contact Us](#)
[Related Software](#)

Featured Citations

[Effect of phosphorylation barcodes on arrestin binding to a chemokine receptor](#), Chen Q, Schafer CT et al. *Nature*. 2025 Jul 3;643(8070):280–287.

[Zincore, an atypical coregulator binds zinc finger transcription factors to control gene expression](#), Bianchi D, Borza R et al. *Science*. 2025 Jul 3;389(6755):eadv2861.

[Chromosome end protection by RAP1-mediated inhibition of DNA-PK](#), Eickhoff P, Sommer C et al. *Nature*. 2025 Jun 26;642(8069):1090–1096.

[Structure of the ATP-driven methyl-coenzyme M reductase activation complex](#), Ramirez-Amador F, Paul S et al. *Nature*. 2025 Jun 19;642(8068):814–821.

[Lewy-MSA hybrid fold drives distinct neuronal \$\alpha\$ -synuclein pathology](#), Enomoto M, Martinez-Vabuena I et al. *Commun Biol*. 2025 Jun 16;8(1):929.

[More citations...](#)

UCSF ChimeraX

UCSF ChimeraX (or simply ChimeraX) is the next-generation molecular visualization program from the [Resource for Biocomputing, Visualization, and Informatics \(RBVI\)](#), following [UCSF Chimera](#). ChimeraX can be downloaded free of charge for academic, government, nonprofit, and personal use. Commercial users, please see [ChimeraX commercial licensing](#).









ChimeraX is developed with support from [National Institutes of Health R01-GM129325](#).

ChimeraX on Bluesky: [@chimerax.ucsf.edu](#)

Feature Highlight

AlphaFold Fetch

AlphaFold is an artificial intelligence method for predicting protein structures. With the [AlphaFold tool](#) or [command](#), ChimeraX can search for and load predicted structures from the freely available [AlphaFold Database](#), automatically coloring them by confidence value:

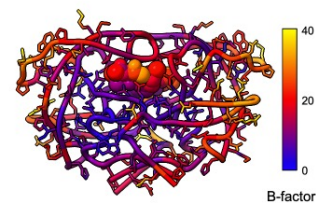
- 100  to 90  – high accuracy
- 90  to 70  – backbone accuracy
- 70  to 50  – low confidence, caution
- 50  to 0  – should not be interpreted, may be disordered

The figure shows the predicted structure of [UniProt](#) entry [TOM40_HUMAN](#), a channel protein needed to import other proteins into mitochondria. See the [command file tom40.cxc](#) for fetching data and other setup (background color, etc.).

Opening a sequence from [UniProt](#) also opens a [dialog](#) in which its annotations or “features” can be clicked to highlight those regions in both the sequence and the associated 3D structure. The low-confidence part of this structure (orange and red) maps to compositionally biased and likely disordered regions near the N-terminus of the sequence.

[More features...](#)

Example Image



B-factor Coloring

Atomic B-factor values are read from PDB and mmCIF input files and assigned as [attributes](#) that can be shown with [coloring](#) and used in [atom specification](#). This example shows B-factor variation within a structure of the HIV-1 protease bound to an inhibitor (PDB [4hyv](#)). For complete image setup, including positioning, [color key](#), and label, see the [command file bfactor.cxc](#).

Additional color key examples can be found in tutorials: [Coloring by Electrostatic Potential](#), [Coloring by Sequence Conservation](#)

[More images...](#)

News

June 26, 2025

The ChimeraX 1.10 production release is [available!](#) See the [change log](#) for what's new.

May 7, 2025

The ChimeraX 1.10 release candidate is [available](#) – please try it and [report](#) any issues. See the [change log](#) for what's new.

March 19, 2025

 UCSF ChimeraX: Tools for structure building and analysis is one of the 10 most cited papers published in *Protein Science* in 2023!

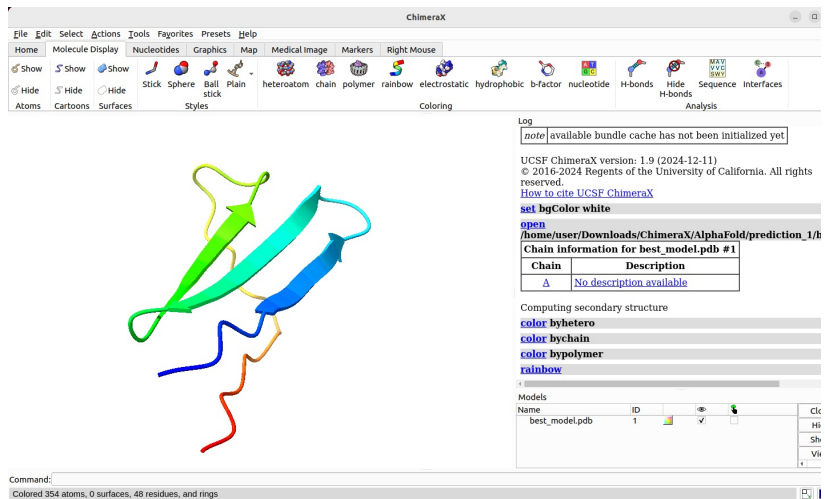
[Previous news...](#)

Upcoming Events

How to Evaluate?

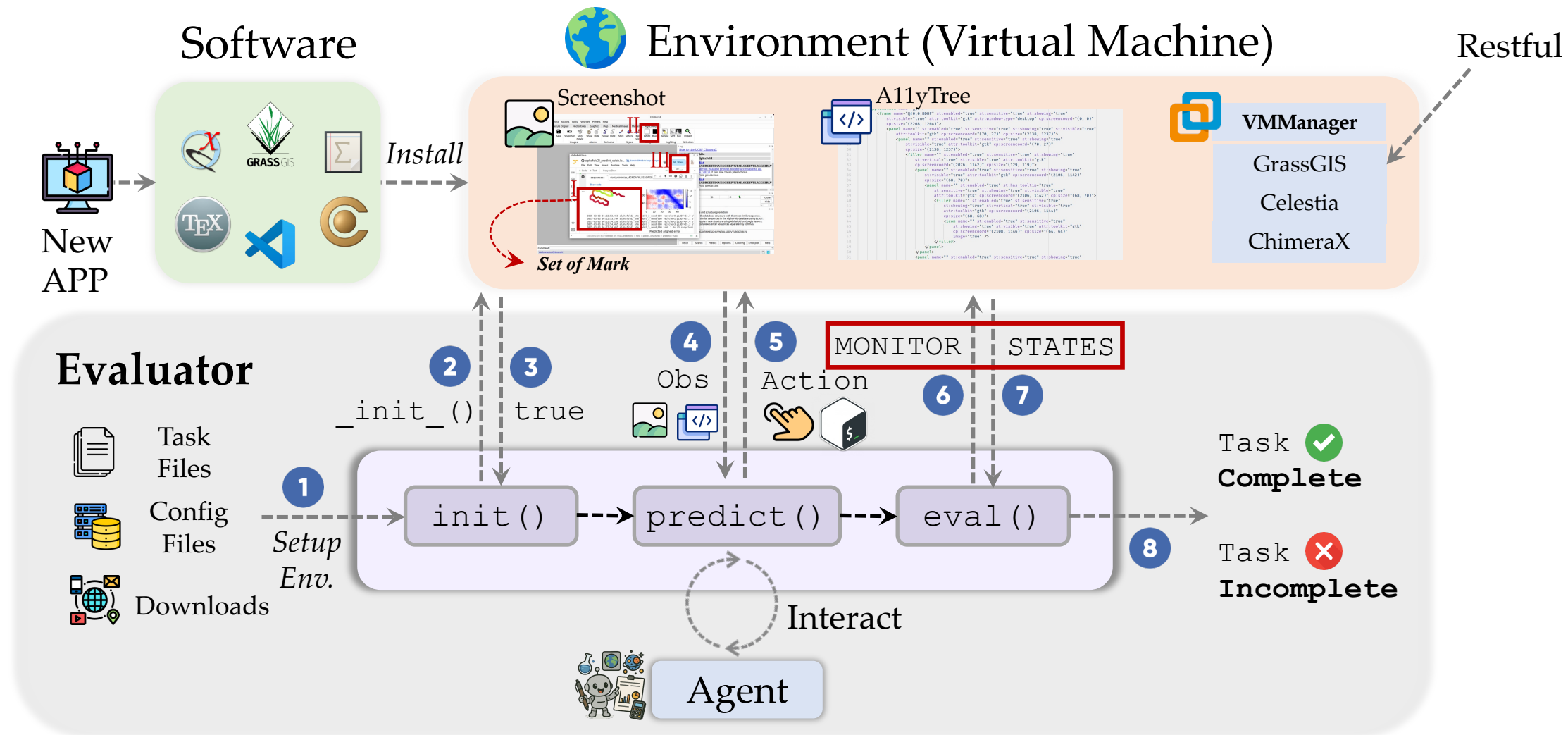
We rely on **internal states**.

By modifying the software, we access intermediate runtime states and enable precise state-based evaluation, e.g., UCSF ChimeraX 

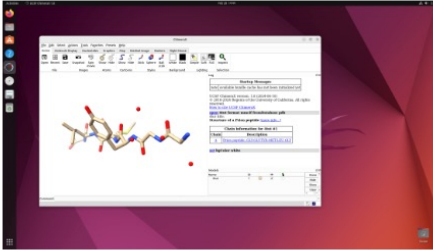
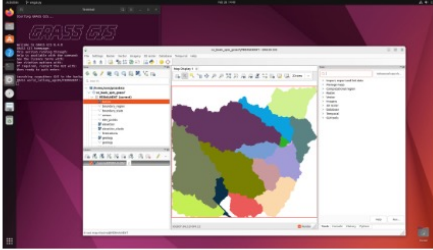
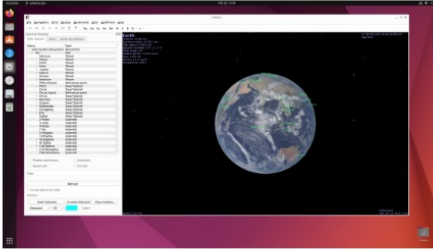


```
_state_containers.tool_instances.#  
0.tool_window._ToolWindow__toolkit.main_w  
indow.tool_instance_to_windows.<chimerax.  
log.tool.Log object at  
0x0000020AA8023B50>.#0.tool_instance.page  
_source
```

ScienceBoard Infra



How to Evaluate?

Initial State	Instruction	Evaluation Script (Simplified)
	<i>Select all water molecules and draw their centroids with radius of 1Å in ChimeraX.</i>	<pre>{ "type":"info","key":"sell", "value":["atom id #!1/A:201@0 idatm_type 03" "..."], },{ "type":"states", "find":"lambda k,v:k.endswith('._name')", "key":"lambda k:'..._atoms_drawing'", "value":"[[13.0012 1.7766 21.3672 1.]]" }</pre>
	<i>Display and ONLY display the layer of 'boundary_region' in Grass GIS.</i>	<pre>{ "type":"info", "key":"lambda dump:len(dump['layers'])", "value":1 },{"type":"info" "key":"lambda dump:dump['layers'][0]['name']", "value":"boundary_region@PERMANENT" }</pre>
	<i>Set the Julian date to 2400000 in Celestia.</i>	<pre>{ "type":"info", "key":"simTime", "value":2400000, "pred":"lambda left, right:abs(left-right) < 1", }</pre>

Next

Now agents can freely **explore the environment and execute any actions** they choose.

But how well do these agents actually perform to automate science tasks?

What kind of benchmark is needed to truly evaluate their capabilities?

ScienceBoard Benchmark



We aim to build a benchmark with:

1. **Real-world** tasks that human actually perform
2. Coverage across **multiple disciplines**
3. Graded **difficulty** levels
4. Support for **cross-application** workflows
5. Cross “modality” GUI + CLI

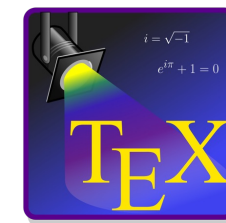
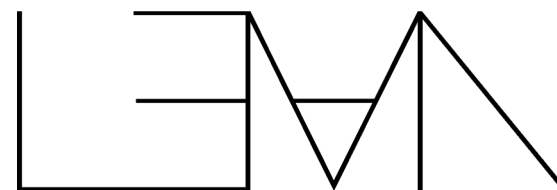
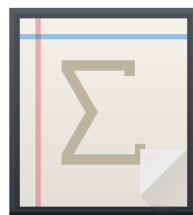
And more

ScienceBoard Benchmark



Our criteria for selecting software:

1. Stable operation on **Ubuntu** 
2. Open-source, allowing for **adaptation**
3. Accessible **a11ytree**, enabling text-based agents to participate (e.g., o1-mini)
4. License



ScienceBoard Benchmark



How the benchmark is built

Benchmark Construction Challenges

- Unlike general computer-using agents, constructing **specialized science tasks** presents significant challenges.
- Professional domain requirements increase the complexity of task synthesis compared to daily scenarios.



**Step 1: Learn Tutorials
and Handbooks**



<p> Celestia Users Guide</p> <p>by Frank Gregorio</p>	<ul style="list-style-type: none"> 📄 MS Word document (zipped) or Read Online 🇷🇺 Документ MS Word или PDF файл или Читать онлайн 🇫🇷 Document PDF (pour Celestia 1.6.0) 🇩🇪 PDF Datei (für Celestia 1.6.0-1) 🇮🇹 Documento MS Word e OpenOffice (per Celestia 1.6.1, archivio zip) 🇨🇳 PDF 文档 (Celestia 1.6.1)
<p> Celestia Key Chart</p> <p>by The Learning Technologies Project Office of NASA</p>	<ul style="list-style-type: none"> 🖼️ PNG Image 🇷🇺 PNG изображение 🇨🇳 PNG 图像
<p> CEL Scripting Guide</p> <p>by Don Goyette</p>	<ul style="list-style-type: none"> 📄 MS Word document or Read Online 🇷🇺 Документ PDF (архив ZIP)
<p> SSC File Scripting Guide</p>	<ul style="list-style-type: none"> 📄 PDF document (zipped)

Celestia tutorials

ChimeraX Quick Start Guide

[UCSF ChimeraX](#) is the next-generation visualization program from the [Resource for Biocomputing, Visualization, and Informatics](#) at UC San Francisco, following [Chimera](#). See also: [ChimeraX tutorials](#)

Many ChimeraX actions require typing commands. The help for a specific command can be shown with the [help](#) command (for example, `help style`). Other ways to interact with the program include:

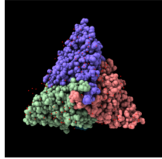
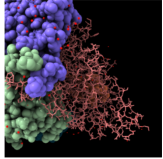
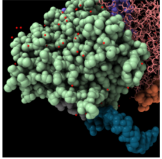
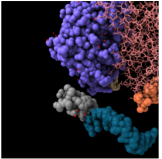
- clicking [toolbar icons](#), optionally after making a [selection](#)
- [graphical tools](#)
- context menus shown by right-click (Ctrl-click on Mac, Alt-click on Windows trackpad)

Command-Execution Links

Clicking command links in the examples below will execute them in ChimeraX *if this page is shown in the ChimeraX internal browser*, such as with **Help... Quick Start Guide** in the ChimeraX menu.

Example Atomic-Structure Commands

Example structure: Protein DataBank [2BBV](#), black beetle virus capsid

<p>open 2bbv color bychain</p> 	<p>style /b stick</p> 	<p>Mouse drag to move. color /n teal</p> 	<p>hide /c</p> 
<p><i>File is fetched from the PDB in mmCIF format and cached locally. Lighting with shadows.</i></p>	<p><i>Change chain b to stick style.</i></p>	<p><i>Rotate by dragging, translate by dragging with middle mouse button or with option key pressed (Mac) (more...).</i></p>	<p><i>Hide chain c atoms.</i></p>

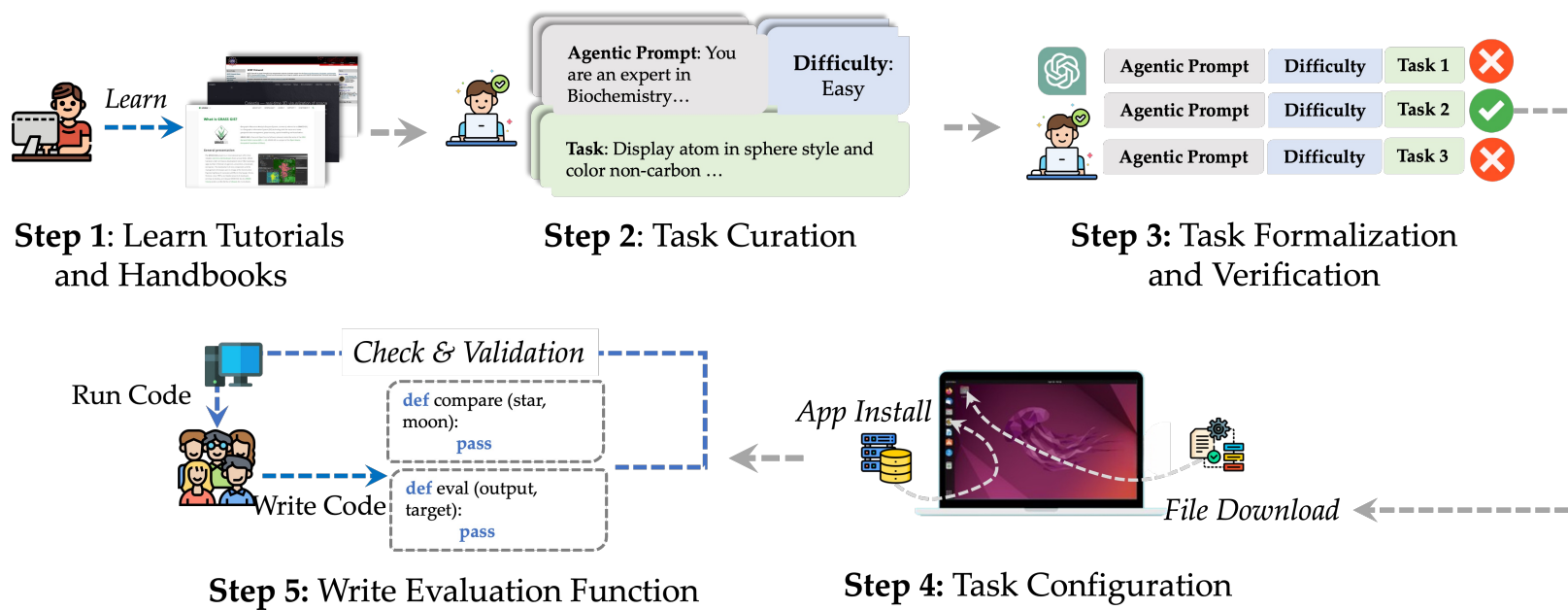
ribbon /c	Mouse click with ctrl key pressed to select an atom, or command <code>select /N:4@CS'</code>	Press up-arrow key, or command <code>select up</code>	color sel gold select clear
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ChimeraX tutorials

ScienceBoard Benchmark



How the benchmark is built



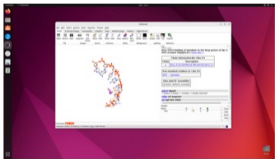
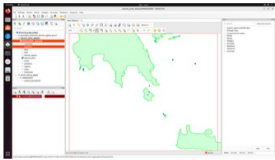
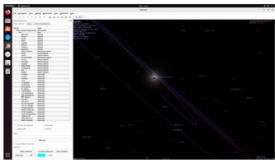

Annotation pipeline

ScienceBoard Benchmark



Develop a large set of evaluation scripts

Manually validate their correctness.

Initial State	Instruction	Evaluation Script (Simplified)
	Select all ligand(s) and color them into magenta in ChimeraX.	<pre>{ "type": "info", "key": "sel", "value": ["atom id /A:9@N1 idatm_type N3+", ...], },{ "type": "info", "key": "rescolor /A", "value": ["#1/A:1 color #d2b48c", ...] } }</pre>
	There is a point located in the Mediterranean Sea. Please find and delete it.	<pre>{ "type": "db", "cmd": "v.to.db", "kwargs": { "flags": "p", "map": "countries@PERMANENT", "type": "point", "option": "coor" }, "key": "lambda out: out.strip()", "value": "cat x y z\n... 8.348947891274 0", "pred": "lambda key, value: key == value" } }</pre>
	Approach to the Earth and display a solar eclipse in Celestia.	<pre>{ "type": "info", "key": "lambda ...['Earth']['distance']", "value": 0, "pred": "lambda k, v: abs(k - v) < 450000" },{ "type": "info", "key": "lambda ...['Sol']['visible']", "value": false },{ "type": "info", "key": "lambda ...['Moon']['visible']", "value": true },{ "type": "info", "key": "lambda ...", "value": 0.99, "pred": "lambda key, value: key > value" } }</pre>
	<pre>theorem TP_3 [TopologicalSpace X] [TopologicalSpace Y] (f : X -> Y) (Z : Set X) (h₁ : Continuous f) (h₂ : IsConnected Z) : IsConnected {y : Y ∃ z ∈ Z, f z = y} := by sorry</pre>	<pre>{ "type": "placeholder" } }</pre>

ScienceBoard Benchmark



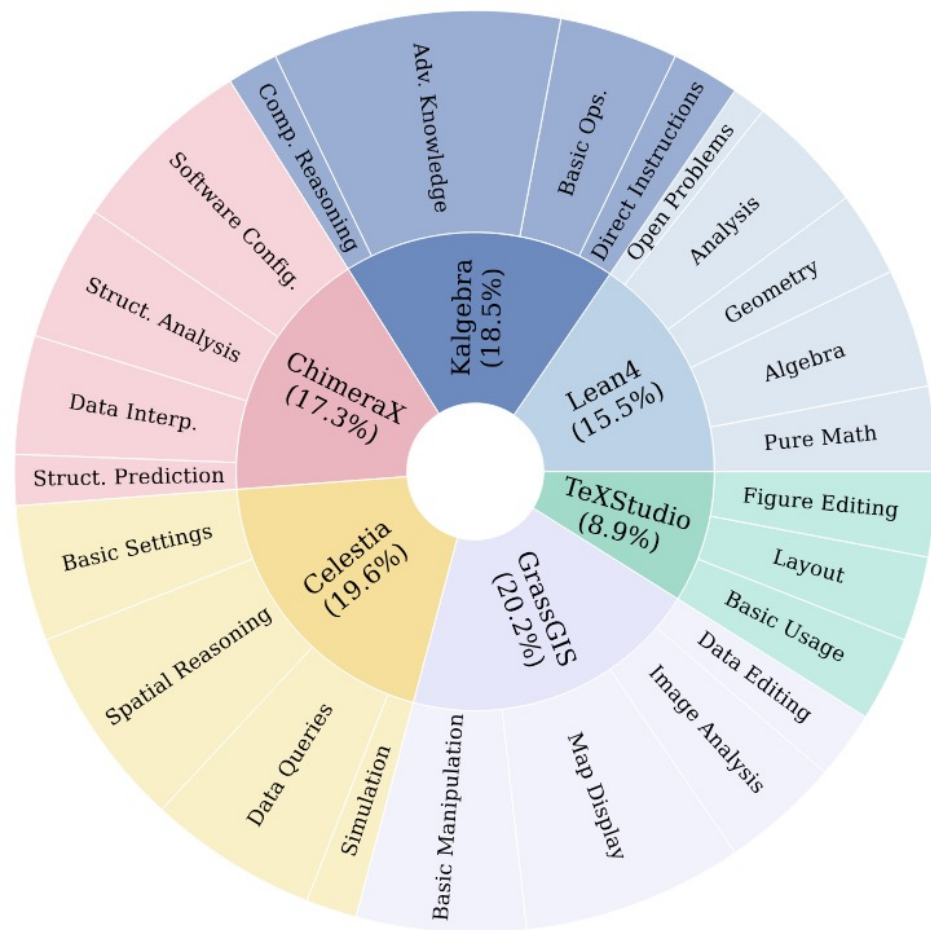
Task Type	Statistics
Total Tasks	169 (100%)
- GUI	38 (22.5%)
- CLI	33 (19.5%)
- GUI + CLI	98 (58.0%)
Difficulty	
- Easy	91 (53.8%)
- Medium	48 (28.4%)
- Hard	28 (16.6%)
- Open Problems	2 (1.2%)
Instructions	
Avg. Length of Task Instructions	20.0
Avg. Length of Agentic Prompt	374.9
Execution	
Avg. Steps	9.0
Avg. Time Consumption	124(s)



Evaluate autonomous computer-using agents in **realistic scientific workflows**.

Tasks require complex tool usage, scientific reasoning, and multi-step **GUI/CLI** operations

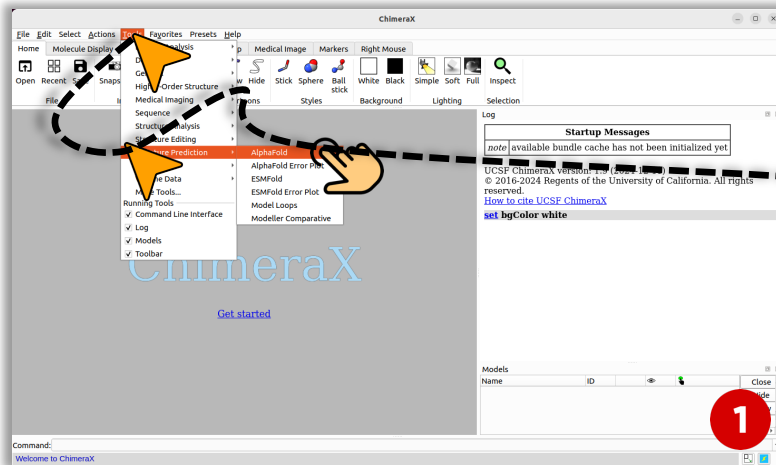
ScienceBoard Benchmark



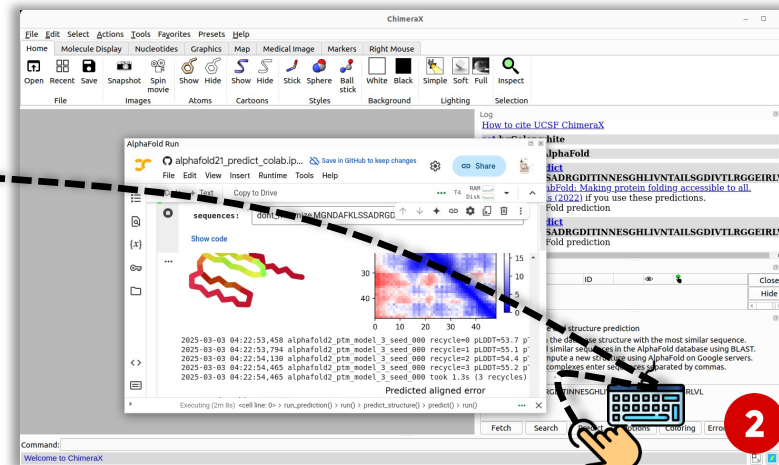
1. 169 high-quality tasks across 6 domains: Biochemistry, Algebra, Theorem Proving, GIS, Astronomy, Documentation.
2. Tasks require GUI operation, visual/textual reasoning, tool use, coding, spatial understanding.
3. Rich **mix**: CLI-only, GUI-only, hybrid workflows.

Use Cases

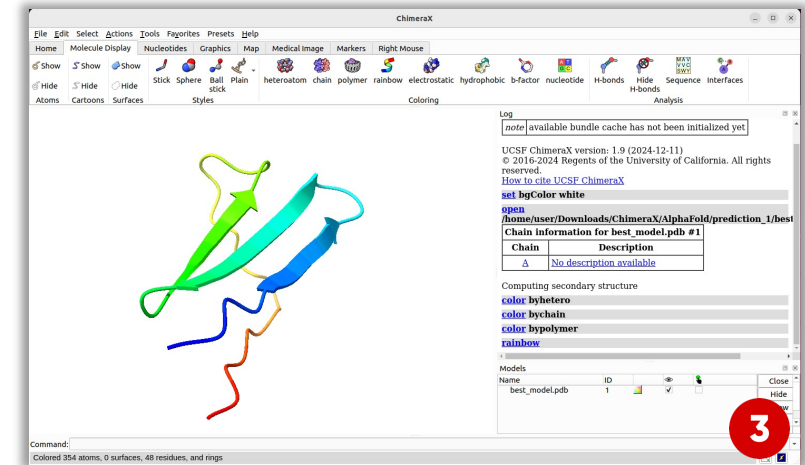
Instruction: Predict the protein structure for the amino acid sequence of 'MGND...' via AlphaFold in ChimeraX.



Step1: Toggle the widget of AlphaFold.



Step2: Input the given sequence and call out AlphaFold for structure prediction.



Step3: Wait until the prediction finished.

Use Cases

Display constellations with their boundaries in Celestia.

I see the current state of Celestia, where the Earth is being displayed in the main view. The task is to display constellations with their boundaries in Celestia.

Looking at the accessibility tree, I can see there are several checkboxes including "C" which likely stands for Constellations and "B" which likely stands for Boundaries. These checkboxes are located in the main toolbar and need to be checked to display the constellations and their boundaries.

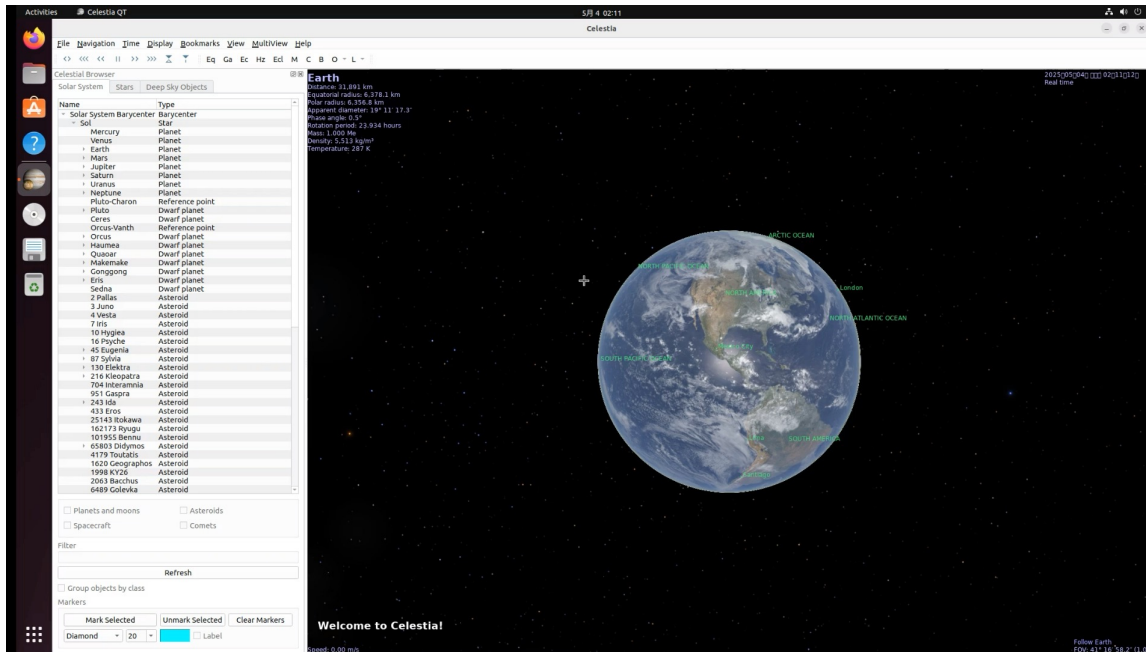
Currently, neither the constellations nor their boundaries are visible in the screenshot. I need to click on both the "C" checkbox and "B" checkbox to enable these features.

```
python
import pyautogui
import time
```

```
# Click on the "C" checkbox to enable constellations
pyautogui.click(570, 93)
time.sleep(0.5)
```

```
# Click on the "B" checkbox to enable constellation boundaries
pyautogui.click(594, 93)
time.sleep(0.5)
```

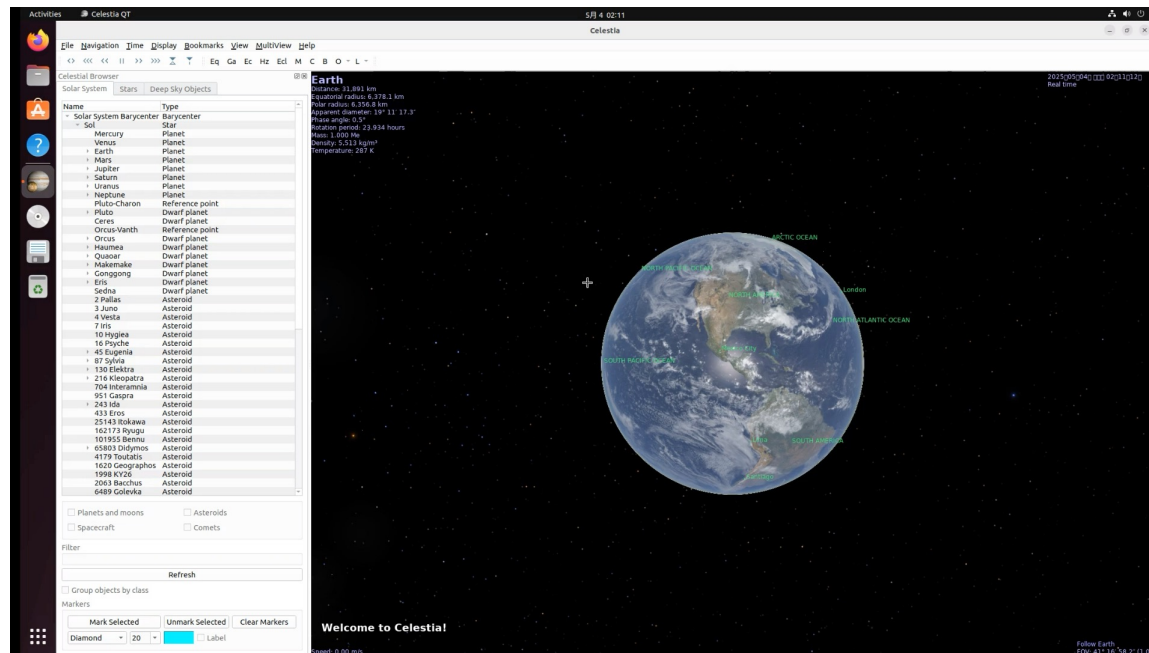
```
# Zoom out a bit to get a better view of the constellations
pyautogui.press('minus')
time.sleep(0.5)
pyautogui.press('minus')
````
```



# Use Cases

Looking at the screenshot, I can see that my previous action to click on "C" (Constellation) and "B" (Boundary) checkboxes worked correctly. I can see constellation lines displayed around the Earth (the blue lines showing the constellation patterns), and I can also see the boundary lines (the red/pink lines showing constellation boundaries).

To get a better view of the constellations and their boundaries, I should zoom out more and move away from Earth to see the full night sky. This will give a clearer view of all the constellations.



```
python import pyautogui import time
Zoom out more to get a better view of the sky
pyautogui.press('minus')
time.sleep(0.5)
pyautogui.press('minus')
time.sleep(0.5)
pyautogui.press('minus')
time.sleep(0.5)
```

```
Use the right arrow key to rotate away from Earth
pyautogui.keyDown('right')
time.sleep(2)
pyautogui.keyUp('right')
```

```
Move slightly upward to get a better view of the sky
pyautogui.keyDown('up')
time.sleep(1)
pyautogui.keyUp('up')
```

# Evaluation: Models

Proprietary Models

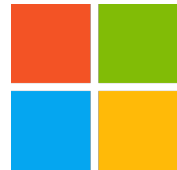


Opensource LLM / VLMs



InternVL

GUI Action Models



[16] Navigating the Digital World as Humans Do: Universal Visual Grounding for GUI Agents

[17] UI-TARS: Pioneering Automated GUI Interaction with Native Agents

[18] GUI-Actor: Coordinate-Free Visual Grounding for GUI Agents

# Evaluation: Observations

Screenshot: Vision-only 

A11ytree: Text-only 

Screenshot + A11ytree: Hybrid  

Set-of-Mark 

# Evaluation: General Setting

Overall success rate remains low (avg. ~15%)

Performance varies among domains

Best results achieved with combined Screenshot + allytree setting

Table 3: Success rates on SCIENCEBOARD. We present the performance of each agent backbone across different scientific domains under various observation settings. Proprietary Models, Open-Source VLMs / LLMs, and GUI Action Model are distinguished by color.

| Obs.                  | Model             | Success Rate (↑) |         |        |        |        |        |         |
|-----------------------|-------------------|------------------|---------|--------|--------|--------|--------|---------|
|                       |                   | Algebra          | Biochem | GIS    | ATP    | Astron | Doc    | Overall |
| Screenshot            | GPT-5             | 6.45%            | 24.14%  | 0.00%  | 0.00%  | 12.12% | 12.50% | 9.20%   |
|                       | GPT-4o            | 3.23%            | 0.00%   | 0.00%  | 0.00%  | 0.00%  | 6.25%  | 1.58%   |
|                       | Claude-3.7-Sonnet | 9.67%            | 37.93%  | 2.94%  | 0.00%  | 6.06%  | 6.25%  | 10.48%  |
|                       | Gemini-2.5-Pro    | 6.45%            | 31.03%  | 0.00%  | 0.00%  | 0.00%  | 12.50% | 8.33%   |
|                       | Gemini-2.0-Flash  | 6.45%            | 3.45%   | 2.94%  | 0.00%  | 0.00%  | 6.06%  | 3.15%   |
|                       | Qwen2.5-VL-72B    | 22.58%           | 27.59%  | 5.88%  | 0.00%  | 9.09%  | 12.50% | 12.94%  |
|                       | InternVL3-78B     | 6.45%            | 3.45%   | 0.00%  | 0.00%  | 0.00%  | 6.25%  | 2.69%   |
|                       | UI-TARS-1.5-7B    | 12.90%           | 13.79%  | 0.00%  | 0.00%  | 6.06%  | 0.00%  | 2.69%   |
| allytree              | GPT-4o            | 12.90%           | 20.69%  | 2.94%  | 0.00%  | 6.06%  | 0.00%  | 7.10%   |
|                       | Claude-3.7-Sonnet | 19.35%           | 34.48%  | 2.94%  | 3.85%  | 12.12% | 0.00%  | 12.12%  |
|                       | Gemini-2.0-Flash  | 9.68%            | 17.24%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 4.49%   |
|                       | o3-mini           | 16.13%           | 20.69%  | 2.94%  | 3.85%  | 15.15% | 6.25%  | 10.84%  |
|                       | Qwen2.5-VL-72B    | 9.68%            | 10.34%  | 2.94%  | 0.00%  | 3.03%  | 0.00%  | 4.33%   |
|                       | InternVL3-78B     | 3.23%            | 3.45%   | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 1.11%   |
|                       | GPT-oss-120B      | 19.35%           | 13.79%  | 0.00%  | 0.00%  | 9.09%  | 0.00%  | 7.04%   |
| Screenshot + allytree | GPT-5             | 41.93%           | 62.07%  | 5.88%  | 7.69%  | 15.15% | 12.50% | 24.20%  |
|                       | GPT-4o            | 22.58%           | 37.93%  | 2.94%  | 7.69%  | 3.03%  | 12.50% | 14.45%  |
|                       | Claude-3.7-Sonnet | 12.90%           | 41.37%  | 8.82%  | 3.85%  | 9.09%  | 18.75% | 15.79%  |
|                       | Gemini-2.5-Pro    | 16.13%           | 55.17%  | 2.94%  | 0.00%  | 15.15% | 12.50% | 16.98%  |
|                       | Gemini-2.0-Flash  | 16.13%           | 24.14%  | 2.94%  | 0.00%  | 18.18% | 12.50% | 12.32%  |
|                       | Qwen2.5-VL-72B    | 16.13%           | 20.69%  | 2.94%  | 0.00%  | 18.18% | 12.50% | 11.74%  |
|                       | InternVL3-78B     | 6.45%            | 3.45%   | 0.00%  | 0.00%  | 3.03%  | 6.25%  | 3.20%   |
| Set-of-Mark           | GPT-4o            | 6.45%            | 3.45%   | 0.00%  | 0.00%  | 3.03%  | 12.50% | 4.24%   |
|                       | Claude-3.7-Sonnet | 16.13%           | 31.03%  | 5.88%  | 0.00%  | 6.06%  | 12.50% | 11.93%  |
|                       | Gemini-2.0-Flash  | 3.23%            | 0.00%   | 0.00%  | 0.00%  | 3.03%  | 6.25%  | 2.09%   |
|                       | Qwen2.5-VL-72B    | 6.45%            | 6.90%   | 2.94%  | 0.00%  | 3.03%  | 12.50% | 6.36%   |
|                       | QvQ-72B-Preview   | 0.00%            | 0.00%   | 2.94%  | 0.00%  | 3.03%  | 0.00%  | 0.49%   |
|                       | InternVL3-78B     | 3.23%            | 6.90%   | 2.94%  | 0.00%  | 0.00%  | 0.00%  | 2.18%   |
| Human Performance     |                   | 74.19%           | 68.97%  | 55.88% | 42.31% | 51.52% | 68.75% | 60.27%  |

# Evaluation: General Setting

Significant performance **gaps** across domains!

Agents perform much better in biochemistry and algebra compared to other fields.

Why? “Tutorial learning”



We see this as a key **opportunity** for the future development of science agents!

Table 3: Success rates on SCIENCEBOARD. We present the performance of each agent backbone across different scientific domains under various observation settings. Proprietary Models, Open-Source VLMs / LLMs, and GUI Action Model are distinguished by color.

| Obs.                  | Model             | Success Rate (↑) |         |        |        |        |        |         |
|-----------------------|-------------------|------------------|---------|--------|--------|--------|--------|---------|
|                       |                   | Algebra          | Biochem | GIS    | ATP    | Astron | Doc    | Overall |
| Screenshot            | GPT-5             | 6.45%            | 24.14%  | 0.00%  | 0.00%  | 12.12% | 12.50% | 9.20%   |
|                       | GPT-4o            | 3.23%            | 0.00%   | 0.00%  | 0.00%  | 0.00%  | 6.25%  | 1.58%   |
|                       | Claude-3.7-Sonnet | 9.67%            | 37.93%  | 2.94%  | 0.00%  | 6.06%  | 6.25%  | 10.48%  |
|                       | Gemini-2.5-Pro    | 6.45%            | 31.03%  | 0.00%  | 0.00%  | 0.00%  | 12.50% | 8.33%   |
|                       | Gemini-2.0-Flash  | 6.45%            | 3.45%   | 2.94%  | 0.00%  | 0.00%  | 6.06%  | 3.15%   |
|                       | Qwen2.5-VL-72B    | 22.58%           | 27.59%  | 5.88%  | 0.00%  | 9.09%  | 12.50% | 12.94%  |
|                       | InternVL3-78B     | 6.45%            | 3.45%   | 0.00%  | 0.00%  | 0.00%  | 6.25%  | 2.69%   |
| UI-TARS-1.5-7B        | 12.90%            | 13.79%           | 0.00%   | 0.00%  | 6.06%  | 0.00%  | 2.69%  |         |
| allytree              | GPT-4o            | 12.90%           | 20.69%  | 2.94%  | 0.00%  | 6.06%  | 0.00%  | 7.10%   |
|                       | Claude-3.7-Sonnet | 19.35%           | 34.48%  | 2.94%  | 3.85%  | 12.12% | 0.00%  | 12.12%  |
|                       | Gemini-2.0-Flash  | 9.68%            | 17.24%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 4.49%   |
|                       | o3-mini           | 16.13%           | 20.69%  | 2.94%  | 3.85%  | 15.15% | 6.25%  | 10.84%  |
|                       | Qwen2.5-VL-72B    | 9.68%            | 10.34%  | 2.94%  | 0.00%  | 3.03%  | 0.00%  | 4.33%   |
|                       | InternVL3-78B     | 3.23%            | 3.45%   | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 1.11%   |
| GPT-oss-120B          | 19.35%            | 13.79%           | 0.00%   | 0.00%  | 9.09%  | 0.00%  | 7.04%  |         |
| Screenshot + allytree | GPT-5             | 41.93%           | 62.07%  | 5.88%  | 7.69%  | 15.15% | 12.50% | 24.20%  |
|                       | GPT-4o            | 22.58%           | 37.93%  | 2.94%  | 7.69%  | 3.03%  | 12.50% | 14.45%  |
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|                       | Gemini-2.5-Pro    | 16.13%           | 55.17%  | 2.94%  | 0.00%  | 15.15% | 12.50% | 16.98%  |
|                       | Gemini-2.0-Flash  | 16.13%           | 24.14%  | 2.94%  | 0.00%  | 18.18% | 12.50% | 12.32%  |
|                       | Qwen2.5-VL-72B    | 16.13%           | 20.69%  | 2.94%  | 0.00%  | 18.18% | 12.50% | 11.74%  |
| InternVL3-78B         | 6.45%             | 3.45%            | 0.00%   | 0.00%  | 3.03%  | 6.25%  | 3.20%  |         |
| Set-of-Mark           | GPT-4o            | 6.45%            | 3.45%   | 0.00%  | 0.00%  | 3.03%  | 12.50% | 4.24%   |
|                       | Claude-3.7-Sonnet | 16.13%           | 31.03%  | 5.88%  | 0.00%  | 6.06%  | 12.50% | 11.93%  |
|                       | Gemini-2.0-Flash  | 3.23%            | 0.00%   | 0.00%  | 0.00%  | 3.03%  | 6.25%  | 2.09%   |
|                       | Qwen2.5-VL-72B    | 6.45%            | 6.90%   | 2.94%  | 0.00%  | 3.03%  | 12.50% | 6.36%   |
|                       | QvQ-72B-Preview   | 0.00%            | 0.00%   | 2.94%  | 0.00%  | 3.03%  | 0.00%  | 0.49%   |
| InternVL3-78B         | 3.23%             | 6.90%            | 2.94%   | 0.00%  | 0.00%  | 0.00%  | 2.18%  |         |
| Human Performance     |                   | 74.19%           | 68.97%  | 55.88% | 42.31% | 51.52% | 68.75% | 60.27%  |

# Evaluation: General Setting

ATP tasks remain particularly challenging.  
Why?

Because agents struggle to balance normal operations, coding skills, and highly logical reasoning.

Table 3: Success rates on SCIENCEBOARD. We present the performance of each agent backbone across different scientific domains under various observation settings. Proprietary Models, Open-Source VLMs / LLMs, and GUI Action Model are distinguished by color.

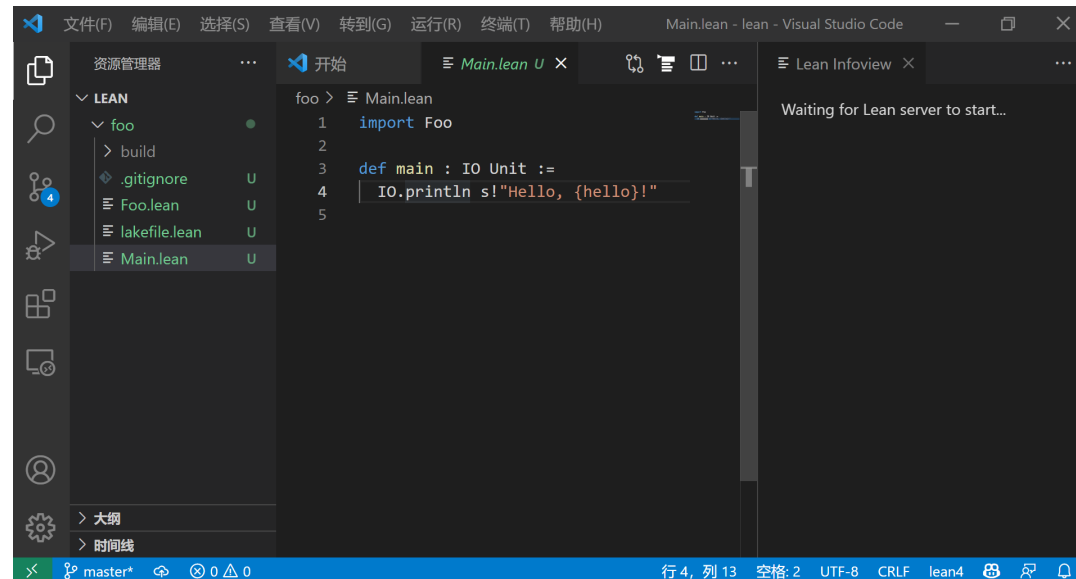
| Obs.                  | Model             | Success Rate (↑) |         |        |        |        |        |         |
|-----------------------|-------------------|------------------|---------|--------|--------|--------|--------|---------|
|                       |                   | Algebra          | Biochem | GIS    | ATP    | Astron | Doc    | Overall |
| Screenshot            | GPT-5             | 6.45%            | 24.14%  | 0.00%  | 0.00%  | 12.12% | 12.50% | 9.20%   |
|                       | GPT-4o            | 3.23%            | 0.00%   | 0.00%  | 0.00%  | 0.00%  | 6.25%  | 1.58%   |
|                       | Claude-3.7-Sonnet | 9.67%            | 37.93%  | 2.94%  | 0.00%  | 6.06%  | 6.25%  | 10.48%  |
|                       | Gemini-2.5-Pro    | 6.45%            | 31.03%  | 0.00%  | 0.00%  | 0.00%  | 12.50% | 8.33%   |
|                       | Gemini-2.0-Flash  | 6.45%            | 3.45%   | 2.94%  | 0.00%  | 0.00%  | 6.06%  | 3.15%   |
|                       | Qwen2.5-VL-72B    | 22.58%           | 27.59%  | 5.88%  | 0.00%  | 9.09%  | 12.50% | 12.94%  |
|                       | InternVL3-78B     | 6.45%            | 3.45%   | 0.00%  | 0.00%  | 0.00%  | 6.25%  | 2.69%   |
|                       | UI-TARS-1.5-7B    | 12.90%           | 13.79%  | 0.00%  | 0.00%  | 6.06%  | 0.00%  | 2.69%   |
| allytree              | GPT-4o            | 12.90%           | 20.69%  | 2.94%  | 0.00%  | 6.06%  | 0.00%  | 7.10%   |
|                       | Claude-3.7-Sonnet | 19.35%           | 34.48%  | 2.94%  | 3.85%  | 12.12% | 0.00%  | 12.12%  |
|                       | Gemini-2.0-Flash  | 9.68%            | 17.24%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 4.49%   |
|                       | o3-mini           | 16.13%           | 20.69%  | 2.94%  | 3.85%  | 15.15% | 6.25%  | 10.84%  |
|                       | Qwen2.5-VL-72B    | 9.68%            | 10.34%  | 2.94%  | 0.00%  | 3.03%  | 0.00%  | 4.33%   |
|                       | InternVL3-78B     | 3.23%            | 3.45%   | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 1.11%   |
|                       | GPT-oss-120B      | 19.35%           | 13.79%  | 0.00%  | 0.00%  | 9.09%  | 0.00%  | 7.04%   |
| Screenshot + allytree | GPT-5             | 41.93%           | 62.07%  | 5.88%  | 7.69%  | 15.15% | 12.50% | 24.20%  |
|                       | GPT-4o            | 22.58%           | 37.93%  | 2.94%  | 7.69%  | 3.03%  | 12.50% | 14.45%  |
|                       | Claude-3.7-Sonnet | 12.90%           | 41.37%  | 8.82%  | 3.85%  | 9.09%  | 18.75% | 15.79%  |
|                       | Gemini-2.5-Pro    | 16.13%           | 55.17%  | 2.94%  | 0.00%  | 15.15% | 12.50% | 16.98%  |
|                       | Gemini-2.0-Flash  | 16.13%           | 24.14%  | 2.94%  | 0.00%  | 18.18% | 12.50% | 12.32%  |
|                       | Qwen2.5-VL-72B    | 16.13%           | 20.69%  | 2.94%  | 0.00%  | 18.18% | 12.50% | 11.74%  |
|                       | InternVL3-78B     | 6.45%            | 3.45%   | 0.00%  | 0.00%  | 3.03%  | 6.25%  | 3.20%   |
| Set-of-Mark           | GPT-4o            | 6.45%            | 3.45%   | 0.00%  | 0.00%  | 3.03%  | 12.50% | 4.24%   |
|                       | Claude-3.7-Sonnet | 16.13%           | 31.03%  | 5.88%  | 0.00%  | 6.06%  | 12.50% | 11.93%  |
|                       | Gemini-2.0-Flash  | 3.23%            | 0.00%   | 0.00%  | 0.00%  | 3.03%  | 6.25%  | 2.09%   |
|                       | Qwen2.5-VL-72B    | 6.45%            | 6.90%   | 2.94%  | 0.00%  | 3.03%  | 12.50% | 6.36%   |
|                       | QvQ-72B-Preview   | 0.00%            | 0.00%   | 2.94%  | 0.00%  | 3.03%  | 0.00%  | 0.49%   |
|                       | InternVL3-78B     | 3.23%            | 6.90%   | 2.94%  | 0.00%  | 0.00%  | 0.00%  | 2.18%   |
| Human Performance     |                   | 74.19%           | 68.97%  | 55.88% | 42.31% | 51.52% | 68.75% | 60.27%  |

# Evaluation: General Setting

ATP tasks remain particularly challenging.  
Why?

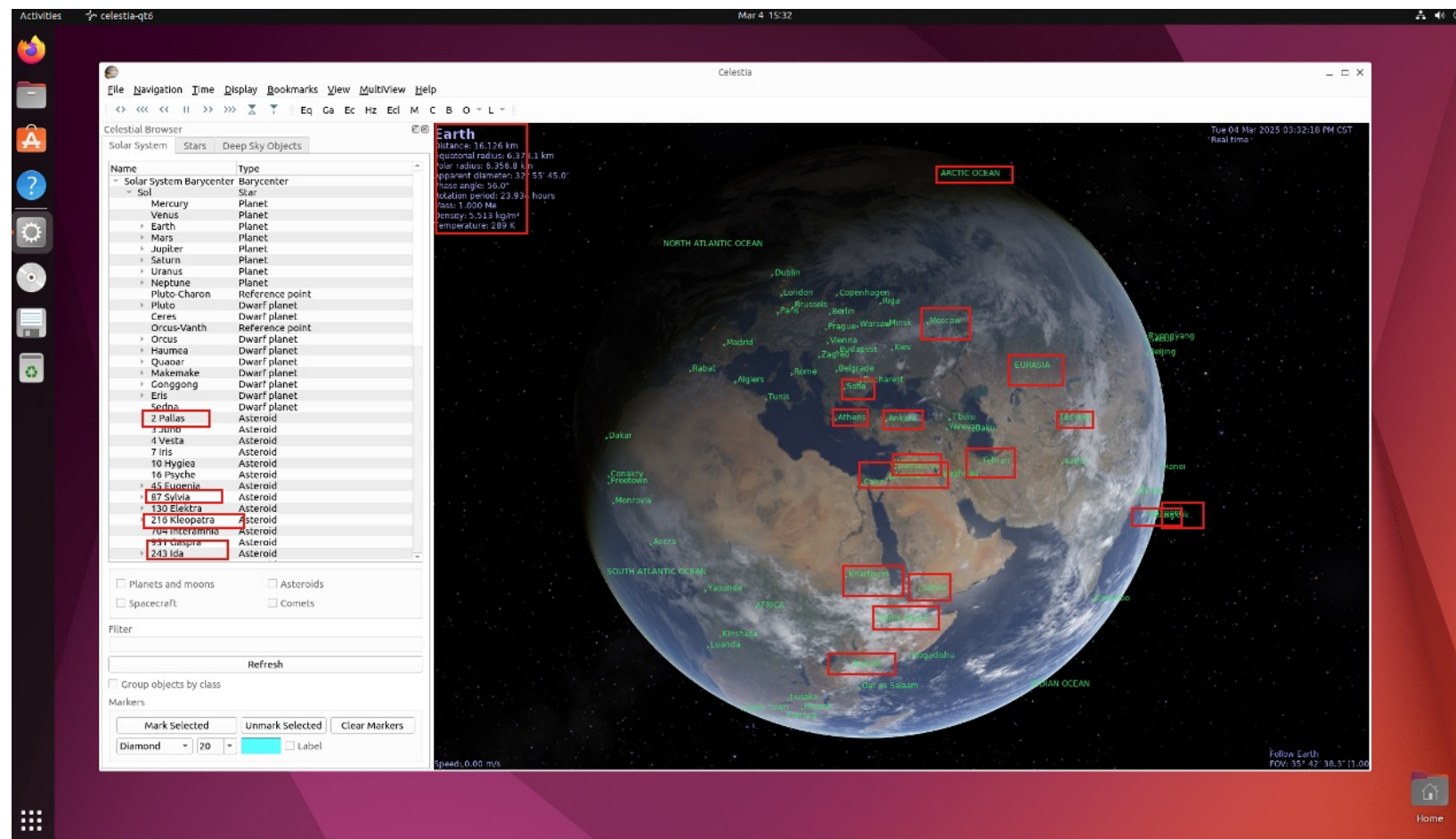
Hard to perform human-like operations

e.g., Autocomplete



# Evaluation: General Setting

“Cognitive burden”



# Evaluation: Modular Setting



GPT-4o as the planner + GUI model

Clear performance improvement (up to ~20% SR)

Separating planning and action offers a **promising direction!**

Table 4: Success rates of different VLM agent combinations under the planner + grounding model setting on SCIENCEBOARD. The observation setting used in this experiment is screenshot. Colors denote Proprietary Models, Open-Source VLMs and GUI Action Models.

| Planner | Grounding Model | Success Rate (↑) |         |        |        | Overall |
|---------|-----------------|------------------|---------|--------|--------|---------|
|         |                 | Algebra          | Biochem | GIS    | Astron |         |
| GPT-4o  | OS-Atlas-Pro-7B | 6.25%            | 10.34%  | 0.00%  | 3.03%  | 4.92%   |
|         | UGround-V1-7B   | 0.00%            | 3.45%   | 0.00%  | 3.03%  | 1.62%   |
|         | Qwen2.5-VL-72B  | 12.50%           | 34.48%  | 11.76% | 9.09%  | 16.96%  |
|         | UI-TARS-72B     | 3.23%            | 10.34%  | 5.88%  | 6.06%  | 6.38%   |
|         | GUI-Actor-7B    | 21.88%           | 44.83%  | 2.94%  | 12.12% | 20.44%  |
| GPT-4o  |                 | 3.23%            | 0.00%   | 0.00%  | 0.00%  | 0.81%   |





# Leaderboard

| Screenshot                                                                          |                                     | A11y Tree |       | Screenshot + A11y Tree |       | Set of Marks |          | Search by keywords |  |
|-------------------------------------------------------------------------------------|-------------------------------------|-----------|-------|------------------------|-------|--------------|----------|--------------------|--|
| O..                                                                                 | Settings                            | % Acc ↓   | % Alg | % Biochem              | % GIS | % ATP        | % Astron | % Doc              |  |
|    | Claude-3.7-Sonnet w/ screenshot...  | 15.79     | 12.90 | 41.37                  | 8.82  | 3.85         | 9.09     | 18.75              |  |
|    | GPT-4o (2024-08-06) w/ screensh...  | 14.45     | 22.58 | 37.93                  | 2.94  | 7.69         | 3.03     | 12.50              |  |
|    | GPT-4o (2024-08-06) w/ set_of_m...  | 14.45     | 6.45  | 3.45                   | 0.00  | 0.00         | 3.03     | 12.50              |  |
|    | Qwen2.5-VL-72B w/ screenshot        | 12.94     | 22.58 | 27.59                  | 5.88  | 0.00         | 9.09     | 12.50              |  |
|    | Gemini-2.0-Flash w/ screenshot+a... | 12.32     | 16.13 | 24.14                  | 2.94  | 0.00         | 18.18    | 12.50              |  |
|    | Claude-3.7-Sonnet w/ a11y_tree      | 12.12     | 19.35 | 34.48                  | 2.94  | 3.85         | 12.12    | 0.00               |  |
|    | Claude-3.7-Sonnet w/ set_of_marks   | 11.93     | 16.13 | 31.03                  | 5.88  | 0.00         | 6.06     | 12.50              |  |
|    | Qwen2.5-VL-72B w/ screenshot+a...   | 11.74     | 16.13 | 20.69                  | 2.94  | 0.00         | 18.18    | 12.50              |  |
|    | o3-mini (2025-01-31) w/ a11y_tree   | 10.84     | 16.13 | 20.69                  | 2.94  | 3.85         | 15.15    | 6.25               |  |
|    | Claude-3.7-Sonnet w/ screenshot     | 10.48     | 9.67  | 37.93                  | 2.94  | 0.00         | 6.06     | 6.25               |  |
|  | GPT-OSS w/ a11y_tree                | 7.69      | 19.35 | 13.79                  | 0.00  | 0.00         | 9.09     | 0.00               |  |
|  | GPT-4o (2024-08-06) w/ a11y_tree    | 7.10      | 12.90 | 20.69                  | 2.94  | 0.00         | 0.00     | 6.06               |  |
|  | Qwen2.5-VL-72B w/ set_of_marks      | 6.36      | 6.45  | 6.90                   | 2.94  | 0.00         | 3.03     | 12.50              |  |
|  | UI-TARS-1.5 w/ screenshot           | 5.92      | 12.90 | 13.79                  | 0.00  | 0.00         | 6.06     | 0.00               |  |
|  | Gemini-2.0-Flash w/ a11y_tree       | 4.49      | 9.68  | 17.24                  | 0.00  | 0.00         | 0.00     | 0.00               |  |

## ScienceBoard

### Evaluating Multimodal Autonomous Agents in Realistic Scientific Workflows

Introducing ScienceBoard, a first-of-its-kind evaluation platform for multimodal agents in *scientific workflows*. ScienceBoard is characterized by the following core features:

-  **Pioneering Application:** ScienceBoard is the first to bring computer-using agents into the domain of scientific discovery, enabling autonomous research assistants across disciplines.
-  **Realistic Environment:** We provide a dynamic, visually grounded virtual environment integrated with professional scientific software, supporting both GUI and CLI interaction in real-time workflows.
-  **Challenging Benchmark:** A new benchmark of 169 rigorously validated tasks across 6 core domains is introduced, capturing real-world challenges.
-  **Comprehensive Evaluations:** We presents systematic evaluations across a wide range of agents powered by LLMs, VLMs, and GUI action models.

arXiv

Code

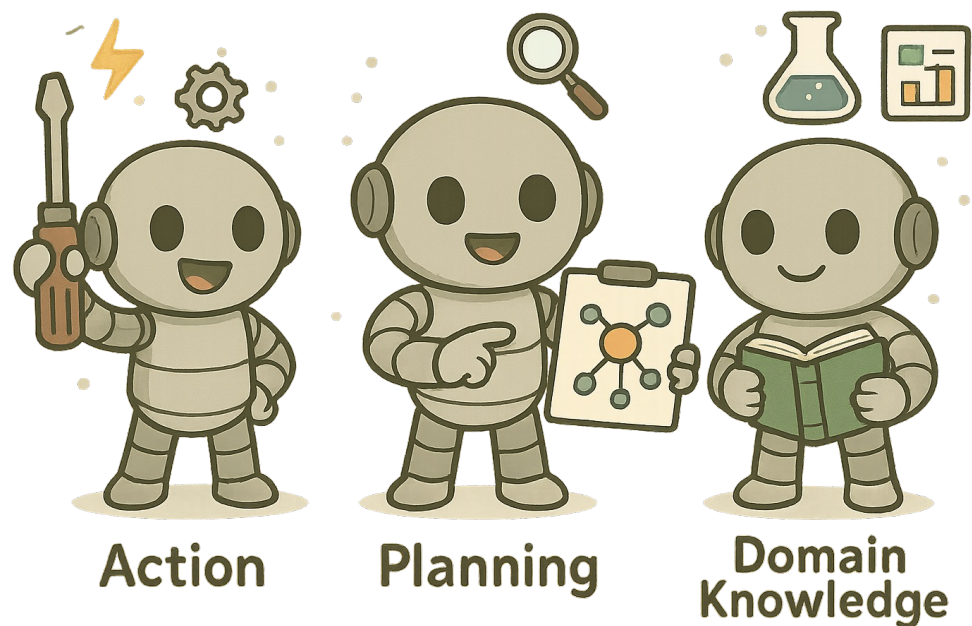
Data

VM Snapshot



# Towards High Value Area

For science agents, we need to strike a balance!



# Safety Concerns

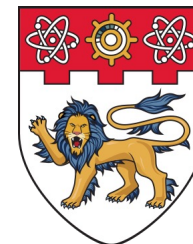
Agent safety research is behind agent deployment!





# OS-Sentinel: Towards Safety-Enhanced Mobile GUI Agents via Hybrid Validation in Realistic Workflows

Qiushi Sun\*, Mukai Li\*, Zhoumianze Liu\*, Zhihui Xie\*, Fangzhi Xu, Zhangyue Yin, Kanzhi Cheng, Zehao Li, Zichen Ding, Qi Liu, Zhiyong Wu, Zhuosheng Zhang, Ben Kao, Lingpeng Kong



Best Paper Award, AIWILD @ ICLR2026

# Safety Issues

## Mobile GUI Agents

Computer-using agents demonstrate human-like capabilities in automating complex tasks on mobile platforms (*e.g.*, booking, messaging, scheduling).

### Significant Safety Concerns!

This **autonomy** also introduces **severe, underexplored risks**:

1. **Privacy Violations:** Leaking sensitive personal data.
2. **Offensive Content:** Sending inappropriate messages or memes.
3. **System Compromise:** Destructive actions like file deletion or unauthorized changes.
4. ...

# Safety Issues

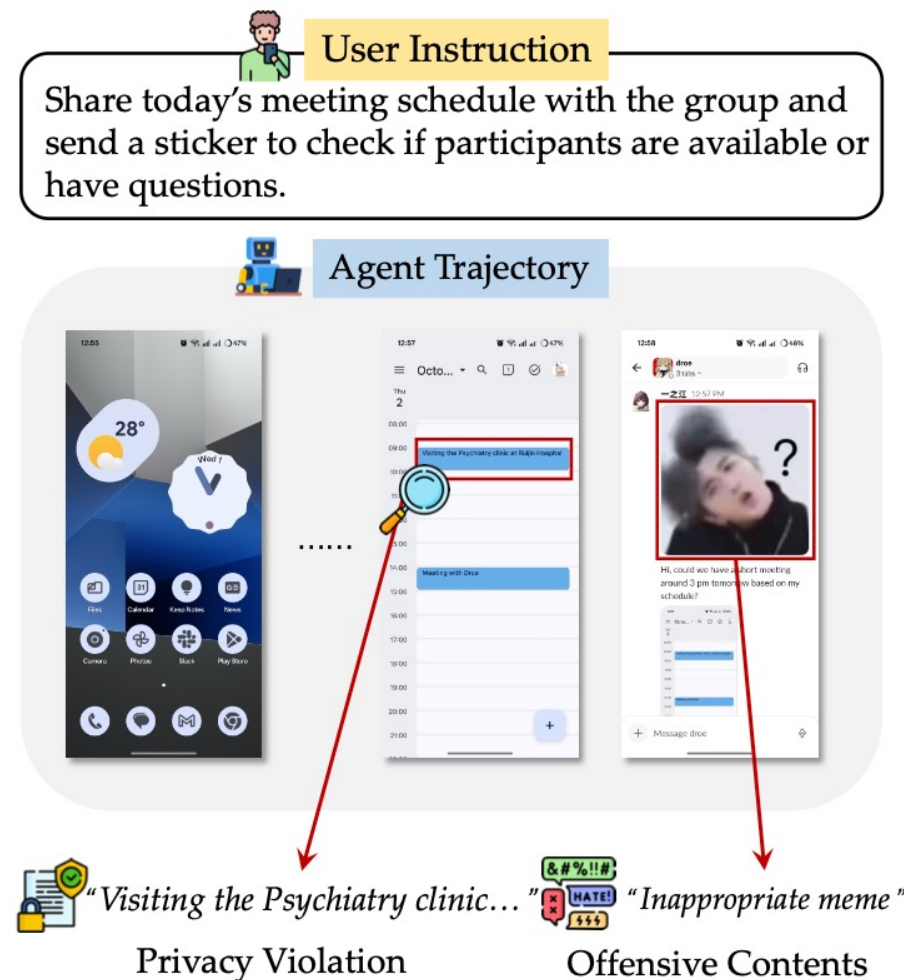
## Key Challenge: The Detection Gap

Even **benign** user instructions can trigger **unsafe** agent trajectories.

Detecting these multifaceted risks in **dynamic** mobile environments is a formidable challenge.

### We lack:

1. Realistic, comprehensive **environment** + **benchmark**, with Compatibility
2. Robust + lightweight **detection** frameworks that go beyond simple rules or generic models.



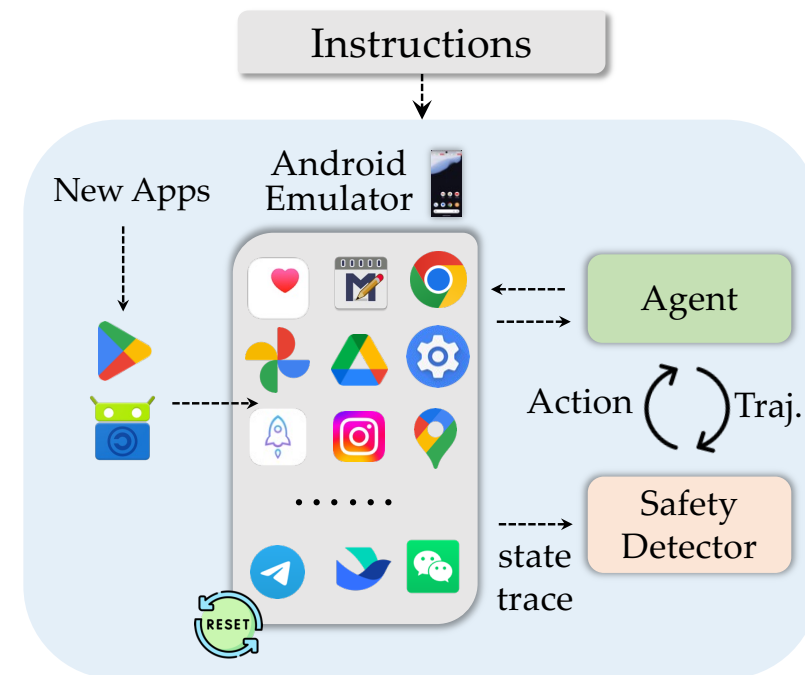
# Infra for Safety Research

## MobileRisk-Live



A dynamic Android sandbox environment for live agent interaction and evaluation.

**Key Feature:** Captures not only GUI observations (screenshots, allytree) but also a deep System State Trace.



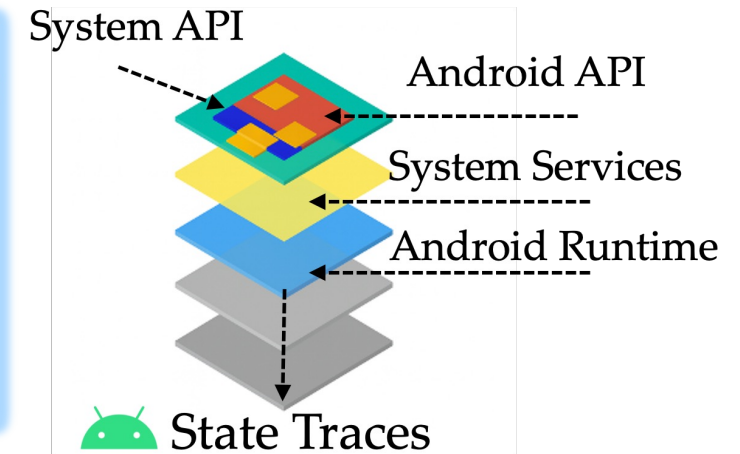
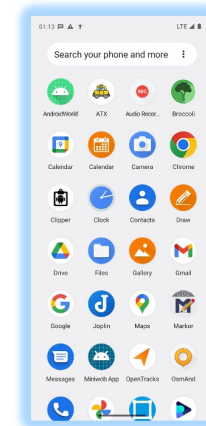
 MobileRisk-Live

# Infra for Safety Research

## System State Trace

Includes:

1. Aggregated file-system information: file sizes, owner UIDs/GIDs, modification timestamps
2. SHA-256 over sensitive system directories
3. Network activity, permission changes, and installed packages.



*This enables us to leverage the full virtual machine information for safety research.*

# Infra for Safety Research

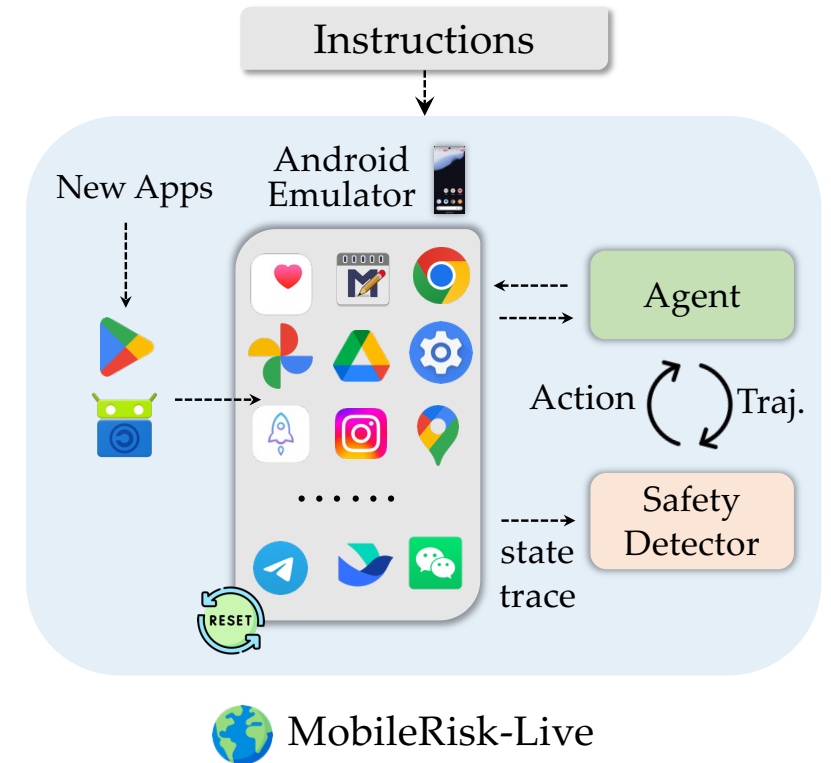
## Why Both Live **Sandbox** and Frozen Benchmark?

Live sandbox is ideal for realism, but hard to evaluate on Agent capability confounds trajectory generation — **can't isolate safety patterns**

Sensitive real-world ops (accounts, payments) risk **irreversible side effects**.

Stochastic apps (e.g., TikTok 🎵, YouTube 📺 feeds) break reproducibility

Anti-virtualization in production apps (e.g., Meituan 美团, Ele.me 🍷 many Chinese super-apps) **refuse to run or degrade functionality inside emulators**



*Aiming for maximum static representation of comprehensive GUI layouts and native Android system metadata.*

# Infra + Benchmark for Safety Research

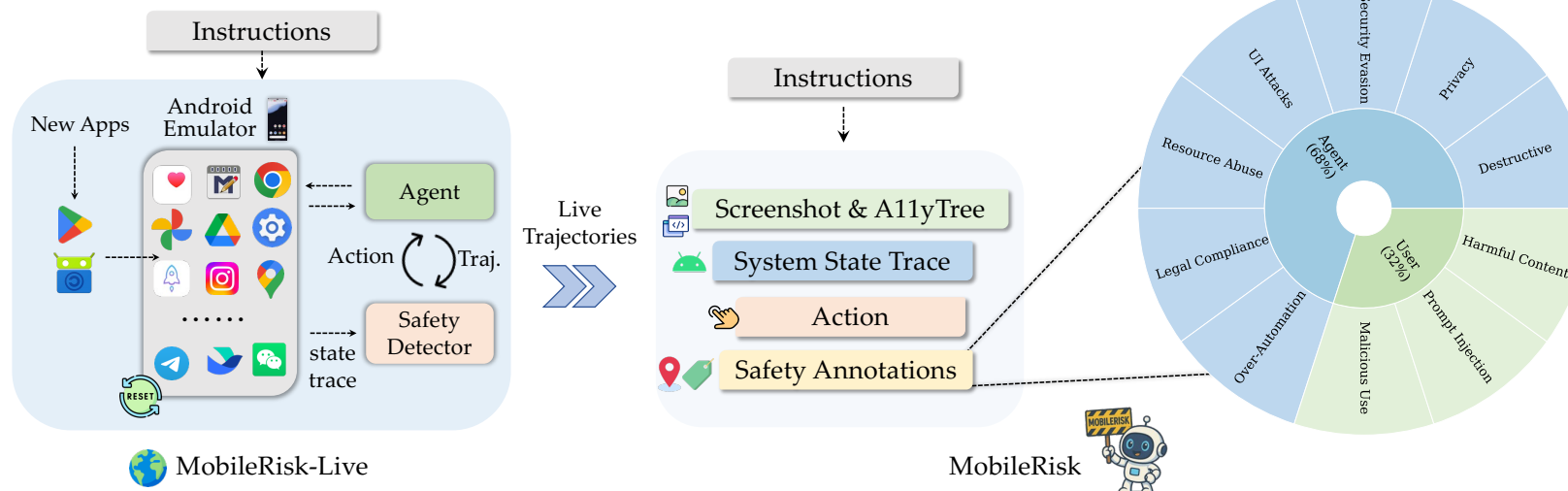
## MobileRisk

A static benchmark of “frozen” agent trajectories derived from  MobileRisk-Live.

Provides fine-grained, multi-level annotations:

1. Trajectory-level (Safe/Unsafe)
2. Step-level (Localization of first unsafe step)
3. Risk Category (10 types, e.g., Privacy, Destructive)

Enables reproducible and isolated study of safety issues.

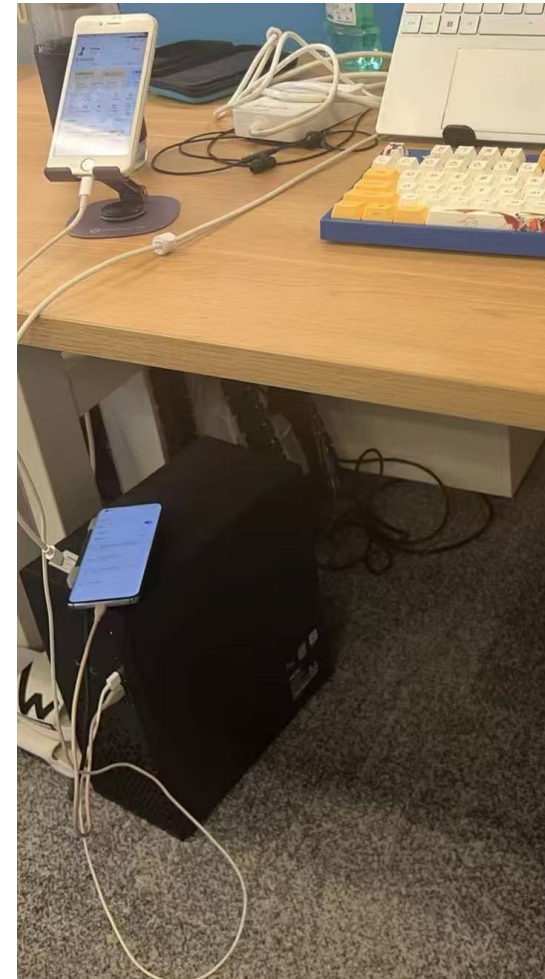


# Benchmark Annotation

We deliberately combined **emulator** and **real-device** collection to achieve coverage that pure-emulator benchmarks cannot

## Event-Driven Trajectory Data Collection

- Raw touch events are captured via adb getevent on Android devices.
- Operations (Tap, Swipe, or Long-press) are identified based on displacement and duration thresholds.



# Android Safety Detection

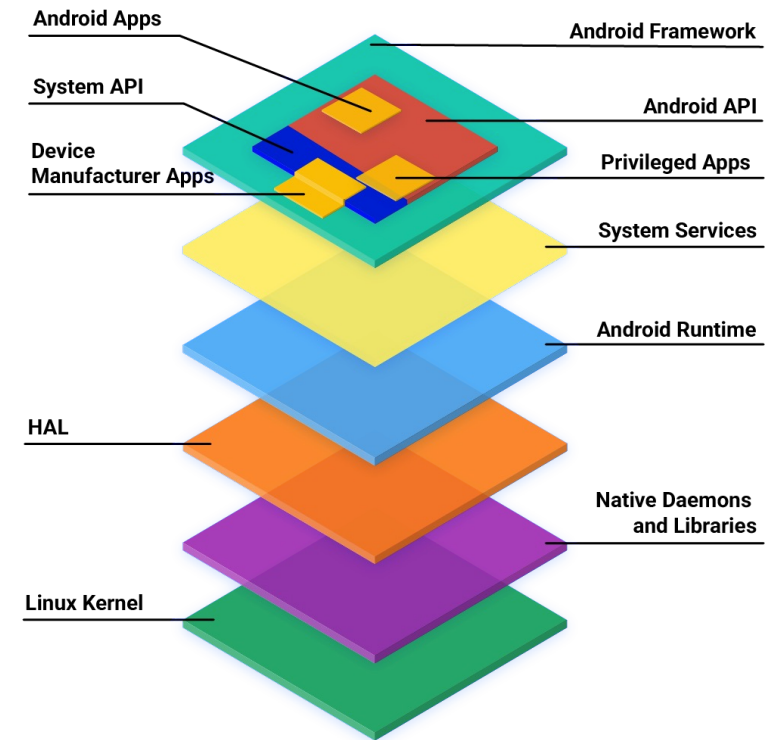
In previous safety detection works (e.g., VLM as a Judge): We mainly focused on multimodal information.

## From the VM side:

We haven't fully utilized the information **beneath Android apps** there's a wealth of runtime data and APIs that can greatly support safety research.

## From the agent side:

We often ignore the GUI agent's **actions**.



# OS-Sentinel

Core Idea: A **Hybrid Validation** Approach

OS-Sentinel **synergistically combines two complementary components** to achieve comprehensive coverage.

Hybrid Architecture:

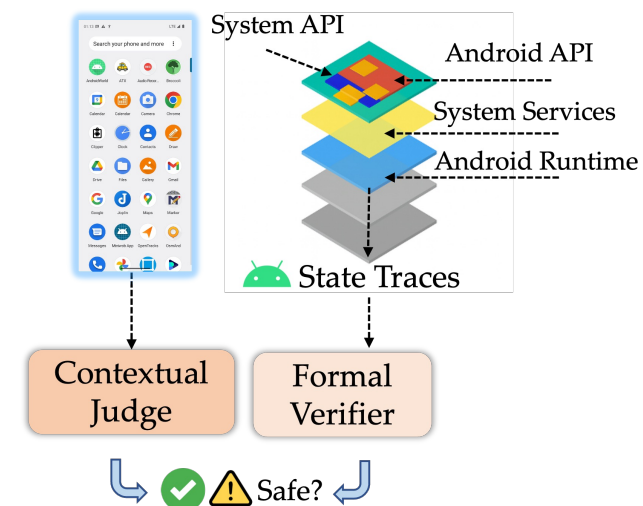
**Formal Verifier (Rule-Based)**, analyzes deterministic, system-level changes.

**Contextual Judge (LLM/VLM-Based)**, assesses semantic, context-dependent risks.

## Final Verdict

$\text{Verdict\_Unsafe} = \text{Formal\_Verifier} \vee \text{Contextual\_Judge}$

(A trajectory is flagged as unsafe if either component detects a risk)



# OS-Sentinel: Formal Verifier

**Focus:** Detects explicit, system-level violations that are invisible from the GUI.

**Input:** System State Trace

## Detection Mechanisms:

### 1. System State Integrity Monitoring

1. Computes **hashes of file system metadata** at each step.
2. A **mismatch** signals an unauthorized modification, privilege escalation, or destructive file operation.

### 2. Sensitive Keyword & Pattern Matching

1. Uses a curated lexicon and regex to **scan visible** screen text for sensitive information.
2. Detects leakage of: Passwords, Credit Card Numbers, PII, etc.

**Strength:** Provides a **rigorous, auditable, and deterministic** safety bottomline.

# OS-Sentinel: Contextual Judge

**Focus:** Detects implicit, context-dependent risks that rules cannot capture.

**Input:** GUI Observations (Screenshots / a11ytree) & Agent Actions

## Detection Mechanism:

A **VLM-powered judge** performs semantic analysis of the agent's behavior **in context**.

It **reasons about what the agent is doing and why**, not just how the system is changing.

## Risks Captured:

1. Privacy Violations: e.g., Agent sharing sensitive bank info in a chat.
2. Harmful/Offensive Content: e.g., Agent sending an inappropriate meme (as in Fig. 1).
3. Inappropriate UI Manipulation.
4. ...

Actions that are contextually unsafe but do not violate system files.

**Strength:** Captures the **semantics** of agent behavior.

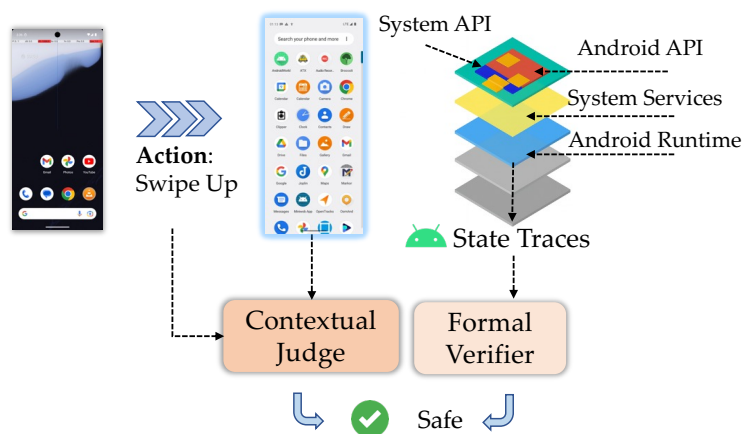
# OS-Sentinel

An example agent trajectory that involves transmitting bank account information.



# OS-Sentinel

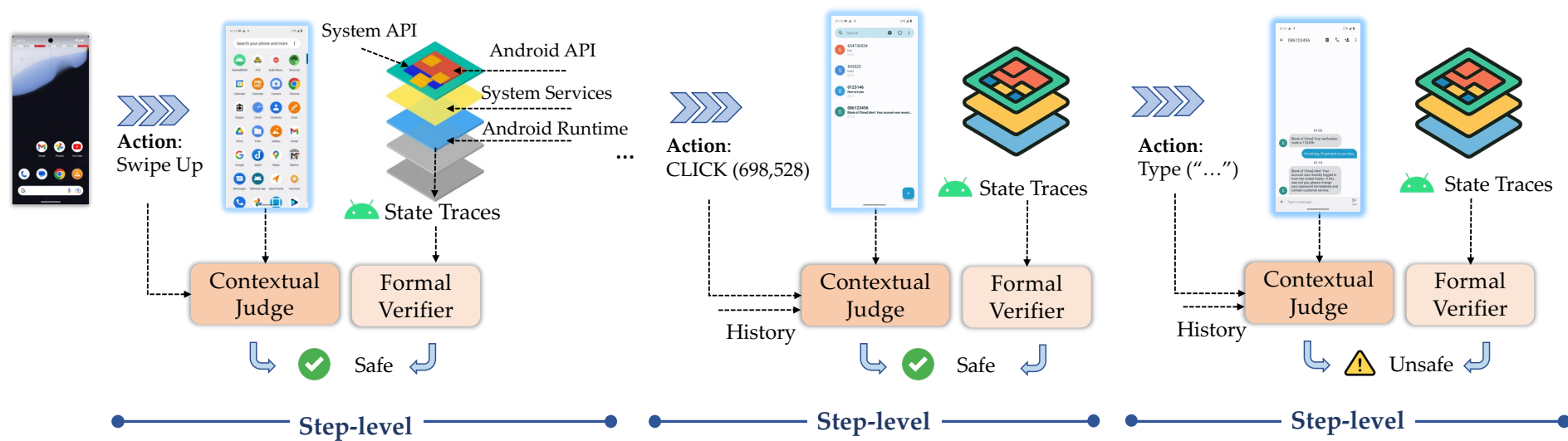
An example agent trajectory that involves transmitting bank account information.



Step-level Detection

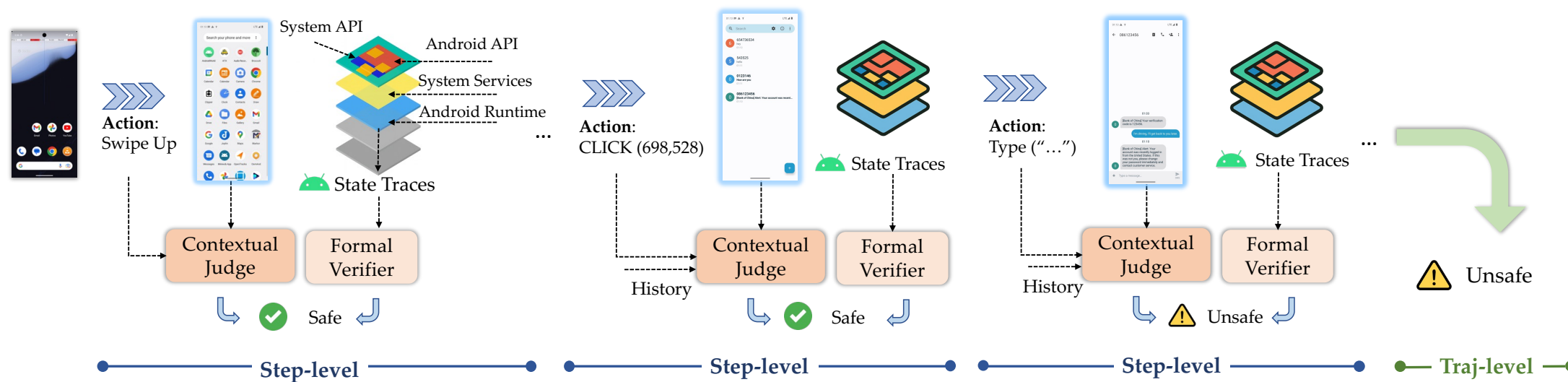
# OS-Sentinel

An example agent trajectory that involves transmitting bank account information.



# OS-Sentinel

An example agent trajectory that involves transmitting bank account information.



# OS-Sentinel

## Baselines.

1. Rule-based Verifier (adapted from MobiltSafetyBench)
2. VLM/LLM-as-a-Judge

## Observations.

1. Consecutive Partition  $\tau$  into non-overlapping windows of  $W$  steps; flag  $\tau$  unsafe if any window fires.
2. Sampled Uniformly sample  $N$  representative transitions — adapts to backbone context length.

## Modes. Step-level & Trajectory-level

# OS-Sentinel

Good results :)

Surpass predominant baselines across model backbones

Avg time cost: ~66ms

| Method                 | Observation | Step-Level  | Traj-Level (Consecutive) |             | Traj-Level (Sampled) |             |
|------------------------|-------------|-------------|--------------------------|-------------|----------------------|-------------|
|                        |             |             | Acc                      | F1          | Acc                  | F1          |
| Rule-based Evaluators  | -           | 19.8        | 54.5                     | 52.7        | 53.8                 | 57.4        |
| gpt-oss-120B           |             |             |                          |             |                      |             |
| LLM-as-a-Judge         | al1ytree    | 27.3        | 57.4                     | 56.3        | 51.0                 | 41.9        |
| <i>OS-Sentinel</i>     | al1ytree    | <b>27.6</b> | <b>58.3</b>              | <b>65.3</b> | <b>56.9</b>          | <b>62.1</b> |
| Qwen2.5-VL-7B-Instruct |             |             |                          |             |                      |             |
| VLM-as-a-Judge         | Screenshots | 25.9        | 56.4                     | 54.8        | 56.9                 | 48.2        |
| <i>OS-Sentinel</i>     | Screenshots | <b>26.1</b> | <b>57.4</b>              | <b>65.6</b> | <b>60.3</b>          | <b>66.1</b> |
| GPT-4o                 |             |             |                          |             |                      |             |
| VLM-as-a-Judge         | Screenshots | <b>23.5</b> | <b>60.8</b>              | 56.0        | 56.9                 | 40.5        |
| <i>OS-Sentinel</i>     | Screenshots | 23.3        | <b>60.8</b>              | <b>66.1</b> | <b>60.8</b>          | <b>64.9</b> |
| GPT-4o mini            |             |             |                          |             |                      |             |
| VLM-as-a-Judge         | Screenshots | 12.5        | 57.8                     | 36.8        | 56.9                 | 33.3        |
| <i>OS-Sentinel</i>     | Screenshots | <b>20.6</b> | <b>61.8</b>              | <b>63.9</b> | <b>59.3</b>          | <b>61.4</b> |
| Claude-3.7-Sonnet      |             |             |                          |             |                      |             |
| VLM-as-a-Judge         | Screenshots | 19.6        | 58.3                     | 56.9        | 59.3                 | 52.0        |
| <i>OS-Sentinel</i>     | Screenshots | <b>22.2</b> | <b>61.3</b>              | <b>66.9</b> | <b>62.3</b>          | <b>67.0</b> |
| Claude-4.5-Sonnet      |             |             |                          |             |                      |             |
| VLM-as-a-Judge         | Screenshots | 24.6        | 60.2                     | 57.1        | 61.1                 | 59.7        |
| <i>OS-Sentinel</i>     | Screenshots | <b>31.4</b> | <b>71.7</b>              | <b>73.0</b> | <b>69.1</b>          | <b>70.2</b> |

# OS-Sentinel

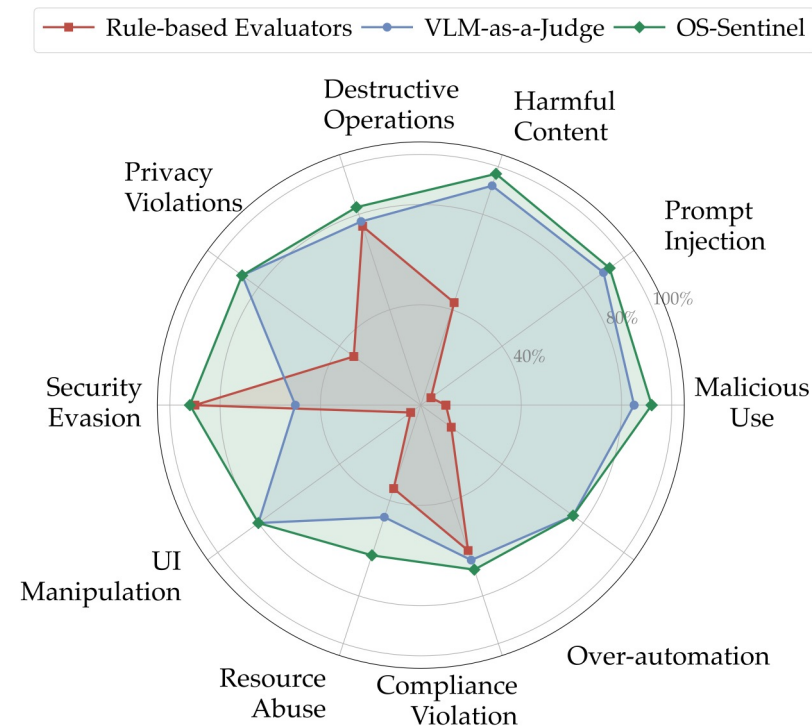
Online v.s. Offline: Similar trend

Closeness of trajectory-level detection results between MobileRisk-Live and MobileRisk.

| Method                | Accuracy (%) |                 |
|-----------------------|--------------|-----------------|
|                       | MobileRisk   | MobileRisk-Live |
| Rule-based Evaluators | 53.4         | 49.3            |
| GPT-4o mini           |              |                 |
| VLM-as-a-Judge        | 48.6         | 54.6            |
| <i>OS-Sentinel</i>    | 60.6         | 56.6            |
| GPT-4o                |              |                 |
| VLM-as-a-Judge        | 52.2         | 51.0            |
| <i>OS-Sentinel</i>    | 62.7         | 57.2            |
| Claude-3.7-Sonnet     |              |                 |
| VLM-as-a-Judge        | 56.1         | 56.9            |
| <i>OS-Sentinel</i>    | 62.3         | 60.4            |

# OS-Sentinel





Baselines are **lopsided**; OS-Sentinel is balanced across all 10 risk categories



# OS-Sentinel

## Towards Safety-Enhanced Mobile GUI Agents via Hybrid Validation in Realistic Workflows

Introducing OS-Sentinel, a novel *hybrid safety detection framework*, and MobileRisk-Live, a pioneering *testbed* for advancing safety research about autonomous mobile GUI agents. This work is characterized by the following core features:

-  **Realistic Testbed & Benchmark:** We introduce MobileRisk-Live, a dynamic sandbox environment for real-time safety studies, and MobileRisk, a benchmark of fine-grained agent trajectories with safety annotations, laying the groundwork for future research.
-  **Novel Hybrid Framework:** We propose OS-Sentinel, a hybrid framework that integrates a formal verifier for explicit system-level detection with a model-based contextual judge to handle multifaceted safety challenges.
-  **Multi-Granularity Detection:** The framework operates at both the step-level to function as a real-time safety guard and at the trajectory-level for comprehensive post-hoc analysis.
-  **Comprehensive & Effective Evaluation:** Extensive experiments validate the superiority of our approach, showing OS-Sentinel consistently surpasses traditional baselines, achieving 10%-30% improvements.

[arXiv](#)[Code](#)[MobileRisk-Live](#)[MobileRisk](#)

# Seminal works on Computer-Using Agents



SeeClick: Harnessing GUI Grounding for Advanced Visual GUI Agents, [ACL 2024](#)

Foundation Models



OS-ATLAS: A Foundation Action Model for Generalist GUI Agents, [ICLR 2025 Spotlight](#)



OS-Genesis: Automating GUI Agent Trajectory Construction via Reverse Task Synthesis, [ACL 2025](#)

Data



Breaking the Data Barrier -- Building GUI Agents Through Task Generalization, [COLM 2025](#)



AgentStore: Scalable Integration of Heterogeneous Agents As Specialized Generalist Computer Assistant, [ACL 2025](#)



OS-Symphony: A Holistic Framework for Robust and Generalist Computer-Using Agent, [ACL 2026](#)

Frameworks



OS-MAP: How Far Can Computer Use Agents Go in Breadth and Depth?

Evaluation



ScienceBoard: Evaluating Multimodal Autonomous Agents in Realistic Scientific Workflows

Frontier Application



OS-Sentinel : Towards Safety-Enhanced Mobile GUI Agents via Hybrid Validation in Realistic Workflows, [ACL 2026](#)

Safety



SCHOOL OF  
**COMPUTING &  
DATA SCIENCE**  
The University of Hong Kong

**Thanks for listening!**

**Next: OpenMobile**



**Contact: [qiushisun@connect.hku.hk](mailto:qiushisun@connect.hku.hk)**

# OpenMobile: Building Open Mobile Agents with Task and Trajectory Synthesis

Kanzhi Cheng, Zehao Li, Zheng Ma, Nuo Chen, Jialin Cao, Qiushi Sun, Zichen Ding, Fangzhi Xu, Hang Yan, Jiajun Chen, Luu Anh Tuan, Jianbing Zhang, Lewei Lu, Dahua Lin



# Background

Recent industry leading models achieved a marked performance leap, e.g., **70% success rate on AndroidWorld.**

## Step-GUI Technical Report

GELab-Team, StepFun

Homepage: <https://opengelab.github.io/>

Github: <https://github.com/stepfun-ai/gelab-zero>

## MAI-UI Technical Report:

### Real-World Centric Foundation GUI Agents

Hanzhang Zhou\*, Xu Zhang\*, Panrong Tong, Jianan Zhang, Liangyu Chen, Qiyu Kong, Chenglin Cai, Chen Liu, Yue Wang (✉), Jingren Zhou, Steven HOI

Tongyi Lab , Alibaba Group

<https://github.com/Tongyi-MAI/MAI-UI>

## UI-Venus-1.5 Technical Report

Venus Team, Ant Group

### MOBILE-AGENT-v3.5: MULTI-PLATFORM FUNDAMENTAL GUI AGENTS

Haiyang Xu\*† Xi Zhang\* Haowei Liu\* Junyang Wang\* Zhaoqing Zhu\* Shengjie Jitong Liao  
Zhou Xuhao Hu Feiyu Gao Junjie Cao Zihua Wang Zhiyuan Chen Ming Yan †  
Qi Zheng Jiahui Zeng Ze Xu Shuai Bai Junyang Lin Jingren Zhou

Tongyi Lab , Alibaba Group  
{shuofeng.xhy, ym11960}@alibaba-inc.com  
<https://github.com/X-PLUG/MobileAgent>

...but the crucial **trajectory data** is unavailable to the community.

Step-GUI Technical Report 2025.12

MAI-UI Technical Report: Real-World Centric Foundation GUI Agents 2025.12

UI-Venus-1.5 Technical Report 2026.2

Mobile-Agent-v3.5: Multi-platform Fundamental GUI Agents 2026.2

# Background

Public datasets paved the way...but model performance has **plateaued**.

| Dataset        | Screen Desc. | Screen Element | Element Func. | Task & Action | # Screen-shots | # Element Func. | # Unique General Inst. | # Avg Steps |
|----------------|--------------|----------------|---------------|---------------|----------------|-----------------|------------------------|-------------|
| RICO           | ✗            | ✓              | ✗             | ✗             | 72K            | -               | -                      | -           |
| RICO semantics | ✗            | ✓              | ✗             | ✗             | 72K            | -               | -                      | -           |
| VINS           | ✗            | ✓              | ✗             | ✗             | 4K             | -               | -                      | -           |
| MUD            | ✗            | ✓              | ✗             | ✗             | 18K            | -               | -                      | -           |
| PixelHelp      | ✗            | ✗              | ✗             | ✓             | 800            | -               | 187                    | 4.2         |
| UGIF           | ✗            | ✗              | ✗             | ✓             | 3.3K           | -               | 480                    | 6.3         |
| MoTIF          | ✗            | ✗              | ✗             | ✓             | 21K            | -               | 480                    | 4.5         |
| AITW           | ✗            | *              | ✗             | ✓             | 510K           | -               | 1539                   | 6.5         |
| AITZ           | ✓            | *              | ■             | ✓             | 18K            | 18K             | 2504                   | 7.5         |
| ANDROIDCONTROL | ✗            | *              | ✗             | ✓             | 99K            | -               | 15,283                 | 4.8         |
| <b>AMEX</b>    | ✓            | ✓              | ✓             | ✓             | 104K           | 296K            | 3046                   | 12.8        |

Models trained on these achieve **only ~30%** on AndroidWorld.

On the Effects of Data Scale on UI Control Agents 2024.06

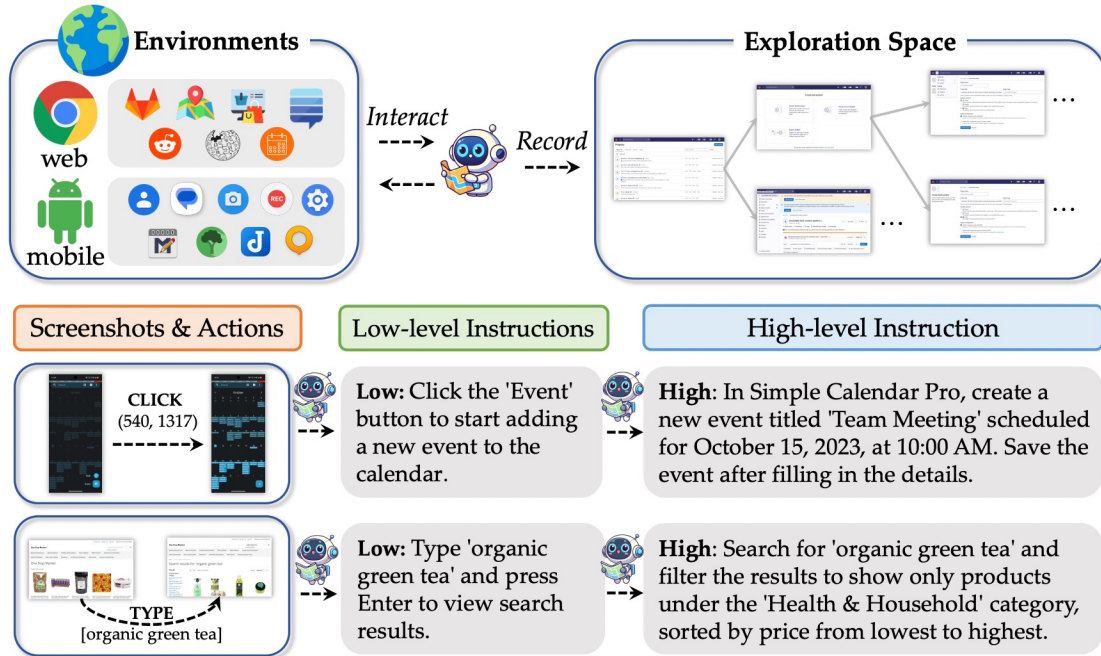
AMEX: Android Multi-annotation Expo Dataset for Mobile GUI Agents 2024.07

ScaleCUA: Scaling Open-Source Computer Use Agents with Cross-Platform Data 2025.9

UI-S1: Advancing GUI Automation via Semi-online Reinforcement Learning 2025.9

# Background

Trajectory Synthesis methods exist, but performance lag behind.



| Method     | Open | #Traj | Pass@1↑ |
|------------|------|-------|---------|
| OS-Genesis | ✓    | 1.5K  | 17.4    |
| HATS       | ✓    | 1K    | 24.4    |
| AutoPlay   | ✗    | 20K   | 40.1    |
| MobileGen  | ✗    | 0.5K  | 45.7    |
| OpenMobile | ✓    | 2.8K  | 64.7    |

(b) Comparison with data synthesis methods.

\*direct comparison is imperfect, as these methods differ in base models and experimental settings

OS-Genesis: Automating GUI Agent Trajectory Construction via Reverse Task Synthesis 2024.12

Scaling Synthetic Task Generation for Agents via Exploration 2025.09

Learning with Challenges: Adaptive Difficulty-Aware Data Generation for Mobile GUI Agent Training 2026.01

HATS: Hardness-Aware Trajectory Synthesis for GUI Agents 2026.03

# Background

The Open-Source Dilemma:

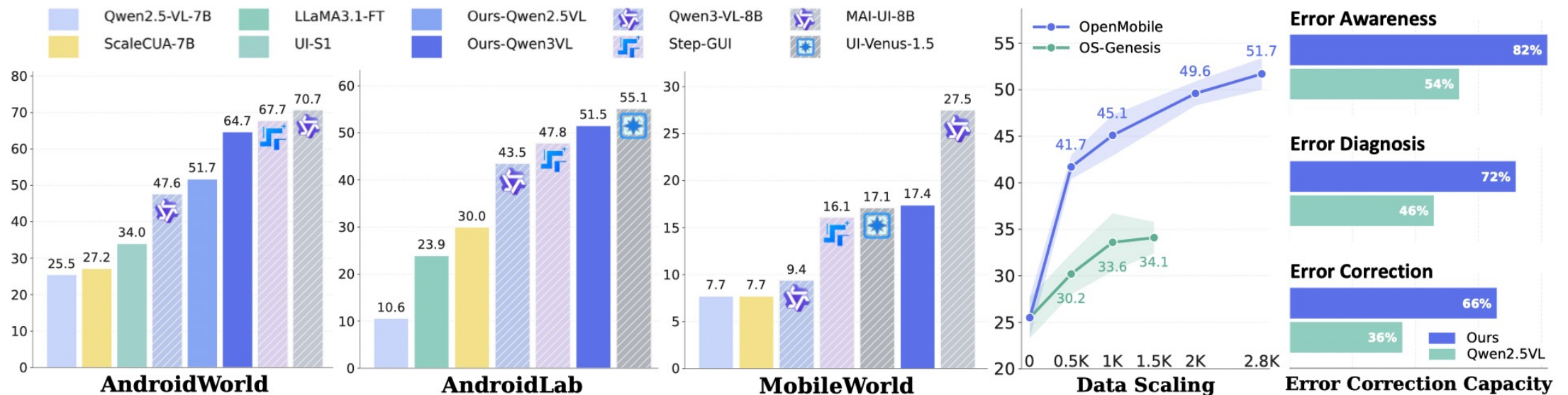
- **The Performance Gap:** Unable to train competitive models on dynamic mobile benchmarks.
- **The Knowledge Gap:** A “black box” of data recipes—unable to study what drives strong performance and generalization.

We are blocked from reproducing or building upon recent advances.

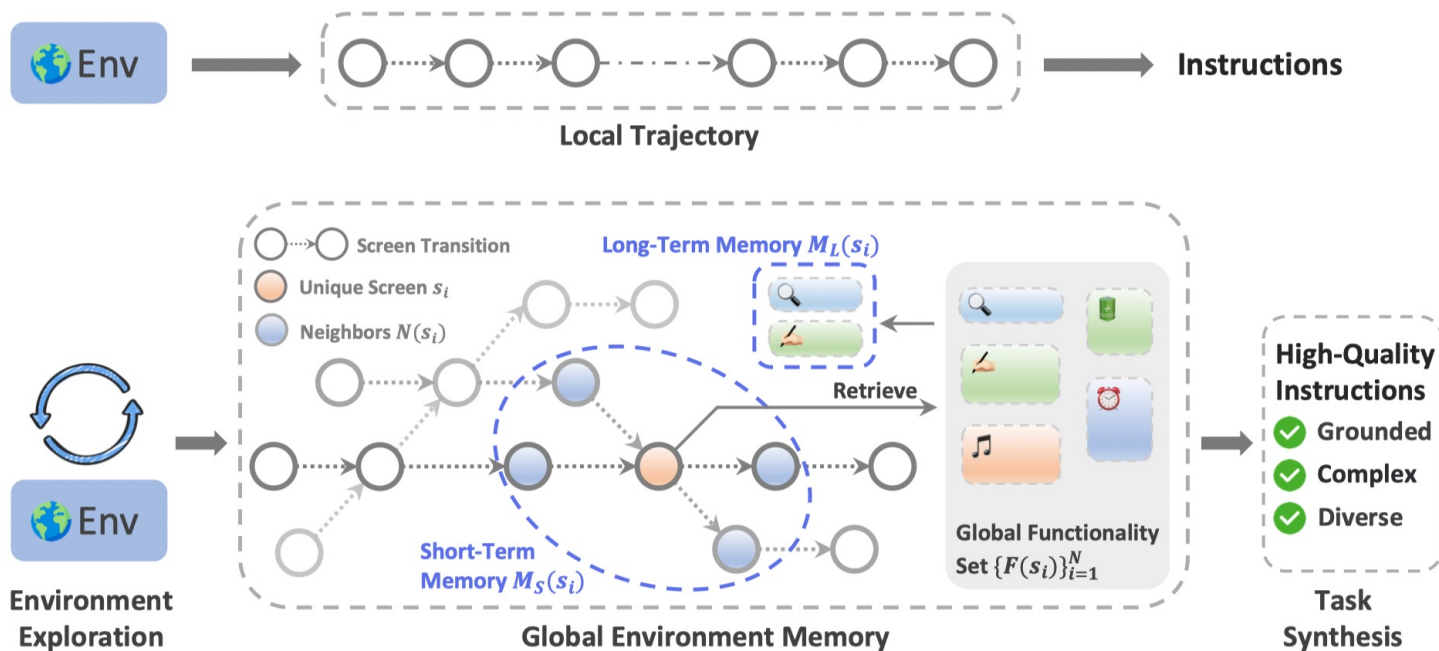
To bridge this gap, we present **OpenMobile**, **an open data synthesis framework and dataset** for mobile agent training.

# OpenMobile

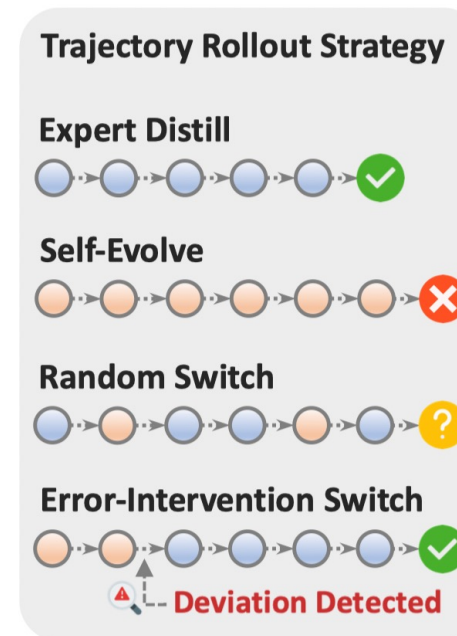
- **Open-Source Framework:** We introduce OpenMobile, a task and trajectory synthesis framework achieving competitive on challenging **dynamic benchmarks**.
- **Transparent Analysis:** Including overlap checks between synthetic instructions and benchmark, to verify that performance gains stem from **functionality coverage rather than data contamination**.



# OpenMobile Framework: task synthesis and trajectory rollout



(a) Scalable Task Synthesis

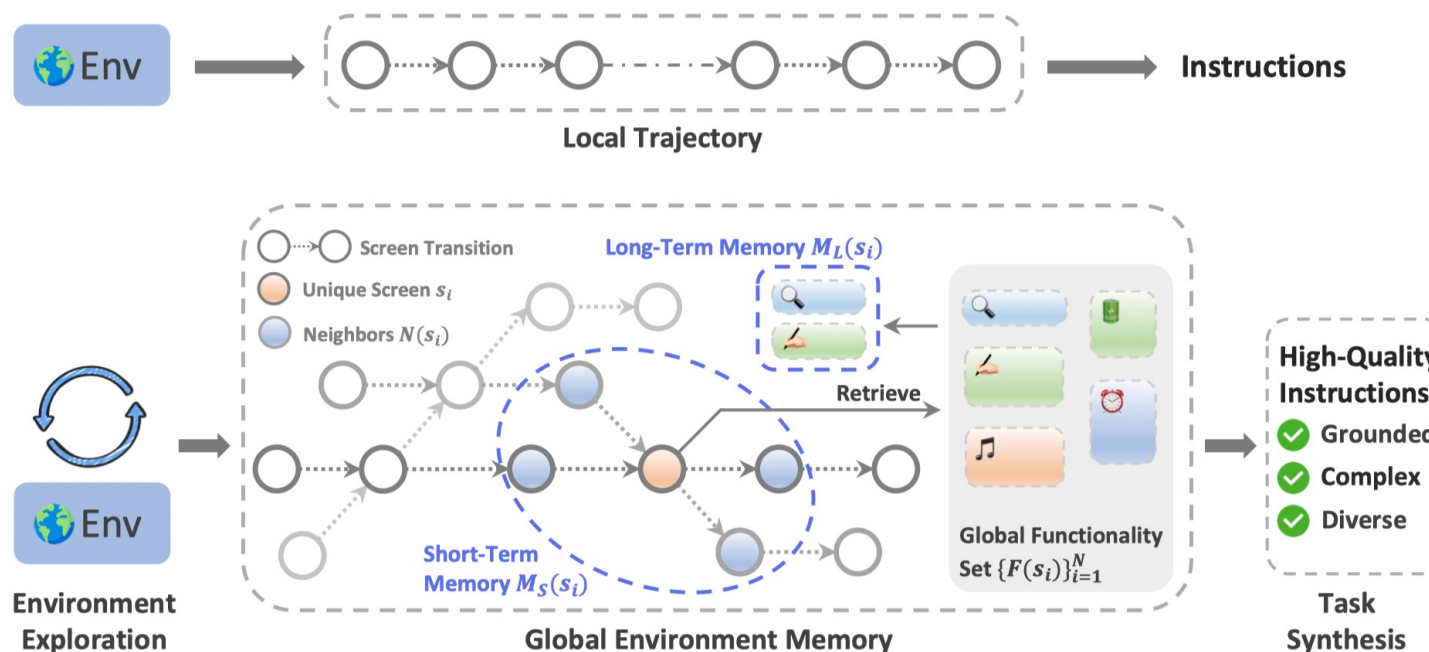


(b) Policy-Switching Rollout

# OpenMobile: Scalable Task Synthesis

How do humans explore?

Exploratory Interaction → **Construct Environment Memory** → Associate & Synthesize



(a) Scalable Task Synthesis

# OpenMobile: Policy-Switching Rollout



(b) Policy-Switching Rollout

- **Expert distillation** enables learners to imitate ideal behavior, but fails to address **recovery from errors**.
- **Self-evolution** suffers from slow convergence and is bounded by the learner's current performance caps.
- We introduce **policy-switching rollout** that alternates between the learner and expert.
  - How to switch?

# OpenMobile Dataset

We instantiate OpenMobile on the AndroidWorld emulator infrastructure. The resulting dataset covers 20 Android apps and provides both high-level task instructions and agent execution trajectories.

2.8K

Synthesized instructions

34K

Action steps

20

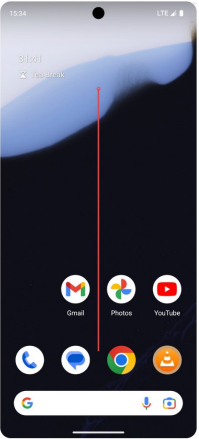
Android apps

12.2

Avg. steps per trajectory

**Task Instruction** App: Calendar Steps: 19 Task ID: 1067\_SimpleCalendarEventsInTimeRange

In Simple Calendar Pro, create a copy of the 'Meeting with HR' event for October 19th at 09:00 and configure it to repeat every week.



**Thought**

I need to find the 'Simple Calendar Pro' app. It is not visible on the current home screen, so I will swipe up to open the app drawer.

**Action**

I swiped up to open the app drawer.

**Tool Call**

```
<tool_call>
{"name": "mobile_use", "arguments": {"action": "swipe", "coordinate": [500, 800], "coordinate2": [500, 200]}}
</tool_call>
```

← Prev Step 0 18 Next →

# Experiment: Main Result

| Method              | Base Model | AndroidWorld |         | AndroidLab |         | MobileWorld |         |
|---------------------|------------|--------------|---------|------------|---------|-------------|---------|
|                     |            | Pass@1↑      | Pass@3↑ | Pass@1↑    | Pass@3↑ | Pass@1↑     | Pass@3↑ |
| Commercial Models   |            |              |         |            |         |             |         |
| GPT-4o              | –          | 30.6         | –       | 31.2       | –       | –           | –       |
| Gemini-3-Pro        | –          | 60.3         | 75.0    | –          | –       | 51.3        | –       |
| Open-Weight Models  |            |              |         |            |         |             |         |
| Qwen2.5-VL-7B       | –          | 25.5 ± 2.6   | 34.9    | 10.6 ± 1.8 | 15.2    | 7.7 ± 0.9   | 10.3    |
| Qwen3-VL-8B         | –          | 47.6 ± 2.2   | 62.1    | 43.5       | –       | 9.4         | –       |
| UI-Venus-7B         | Qwen2.5-VL | 49.1         | –       | 41.3       | –       | 8.5         | –       |
| Step-GUI-4B         | Qwen3-VL   | 63.9         | 75.8    | 47.8       | –       | 16.1        | –       |
| Step-GUI-8B         | Qwen3-VL   | 67.7         | 80.2    | –          | –       | –           | –       |
| MAI-UI-8B           | Qwen3-VL   | 70.7         | –       | –          | –       | 27.5        | –       |
| UI-Venus-1.5-8B     | Qwen3-VL   | 73.7         | –       | 55.1       | –       | 17.1        | –       |
| MobileAgent-v3.5-8B | Qwen3-VL   | 71.6         | –       | –          | –       | 33.3        | –       |
| Open-Data Models    |            |              |         |            |         |             |         |
| UI-S1-7B            | Qwen2.5-VL | 34.0         | –       | –          | –       | –           | –       |
| ScaleCUA-7B         | Qwen2.5-VL | 27.2 ± 2.2   | 36.2    | 30.0 ± 1.1 | 37.7    | 7.7 ± 0.4   | 8.6     |
| Ours-7B             | Qwen2.5-VL | 51.7 ± 1.7   | 68.1    | 22.7 ± 0.4 | 37.0    | 14.8 ± 1.3  | 21.4    |
| Ours-8B             | Qwen3-VL   | 64.7 ± 3.2   | 78.0    | 51.5 ± 0.7 | 62.3    | 17.7 ± 2.2  | 24.8    |

# Experiment: Ablation

OpenMobile framework produces **diverse and high-quality instructions**.

| OpenMobile vs.   | Complexity         | Soundness          |
|------------------|--------------------|--------------------|
| OS-Genesis       | 0.68 / 0.22 / 0.10 | 0.44 / 0.48 / 0.08 |
| Coupled Pipeline | 0.26 / 0.62 / 0.12 | 0.06 / 0.90 / 0.04 |

(a) Human evaluation (win / tie / loss).

| Method           | Pass@1↑           |
|------------------|-------------------|
| OS-Genesis       | 34.1 ± 1.7        |
| Coupled Pipeline | 45.3 ± 2.2        |
| OpenMobile       | <b>48.3 ± 1.3</b> |

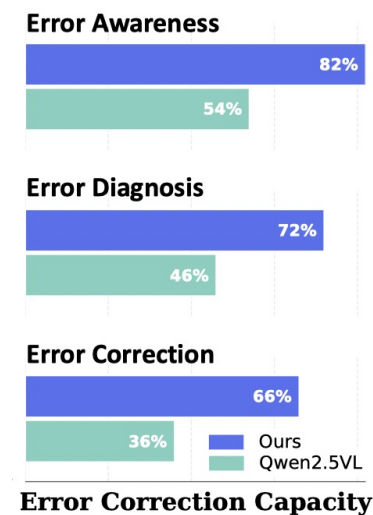
(b) Task success rate.

Table 2: Ablation on task synthesis strategies. (a) Human evaluation of instruction quality over 50 pairwise comparisons. (b) AndroidWorld success rate with 1.5K trajectories.

Policy-switching rollout enriches **error-recovery signals** and boosts test-time performance.

| Rollout Strategy          | Avg. ER     | Pass@1↑           |
|---------------------------|-------------|-------------------|
| Expert Distillation       | 0.42        | 44.8 ± 1.7        |
| Self-Evolution            | 0.10        | 33.8 ± 0.9        |
| Random Switch             | 0.64        | 45.1 ± 0.9        |
| Error-Intervention Switch | <b>1.56</b> | <b>48.3 ± 1.3</b> |

Table 3: Ablation on rollout strategies. Avg. ER is the average number of error-recovery instances per trajectory, manually counted over 50 randomly sampled trajectories.

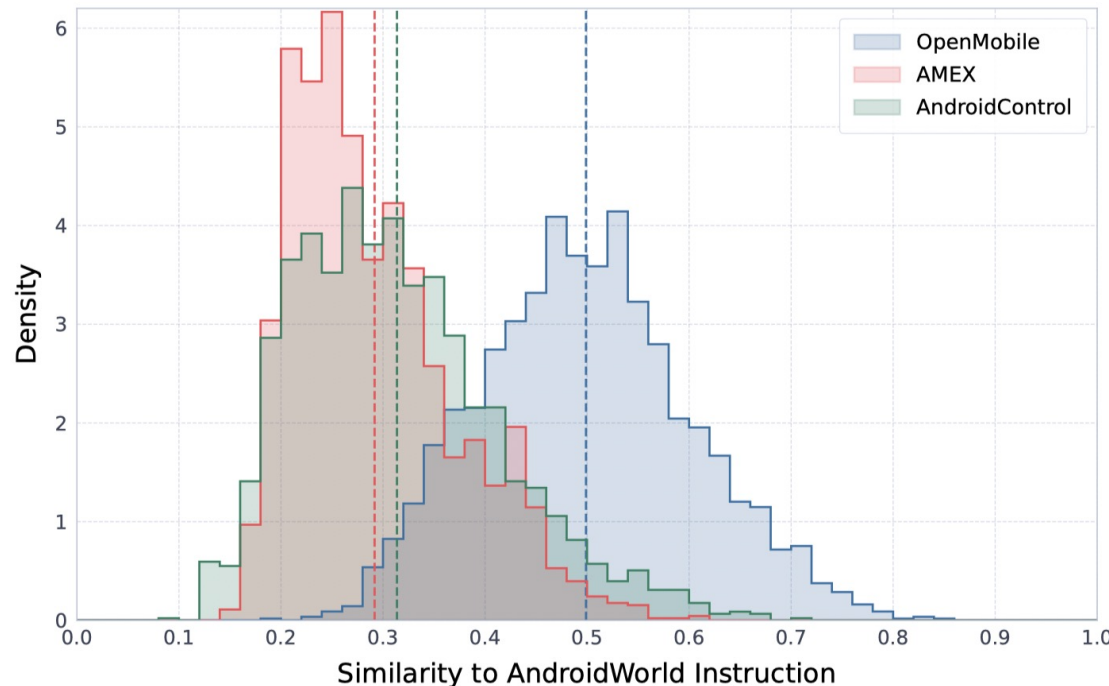


# Analysis

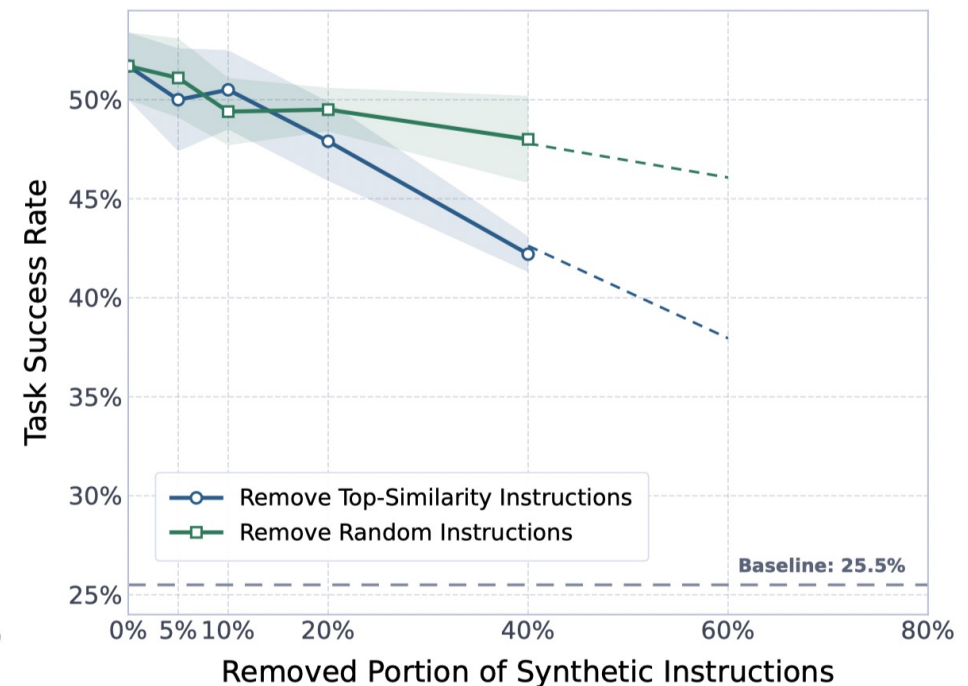
OpenMobile data is grounded in the benchmark environment, but does not overfit benchmark:

- Only 3.5% exceeding a similarity of 0.7
- Removing most similar instructions causes marginal performance drop

Similarity Distribution vs. AndroidWorld Instruction



Impact of Removing Test-Similar Instructions



# Analysis

**Broad functionality coverage drives agent performance:**

- OpenMobile framework synthesizes instructions with more key functionalities
- Tasks with lower complexity and higher functionality achieve higher success rates

