UI-Ins: Enhancing GUI Grounding with Multi-Perspective Instruction-as-Reasoning

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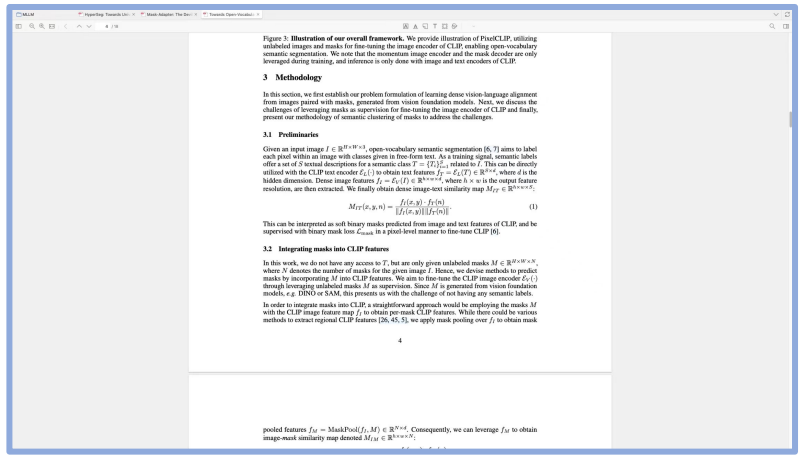
Background

What is GUI grounding?

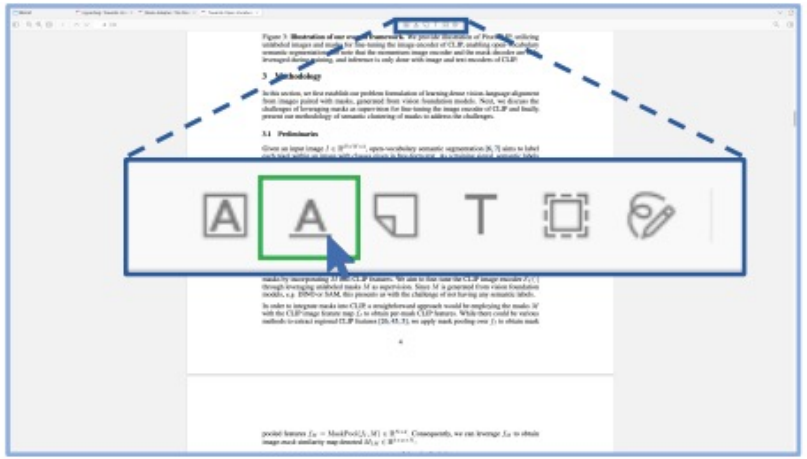


Original Image

User Instruction

Refine your search to view Charizard products from the company known for building block toys.

Grounding Model



Prediction Point

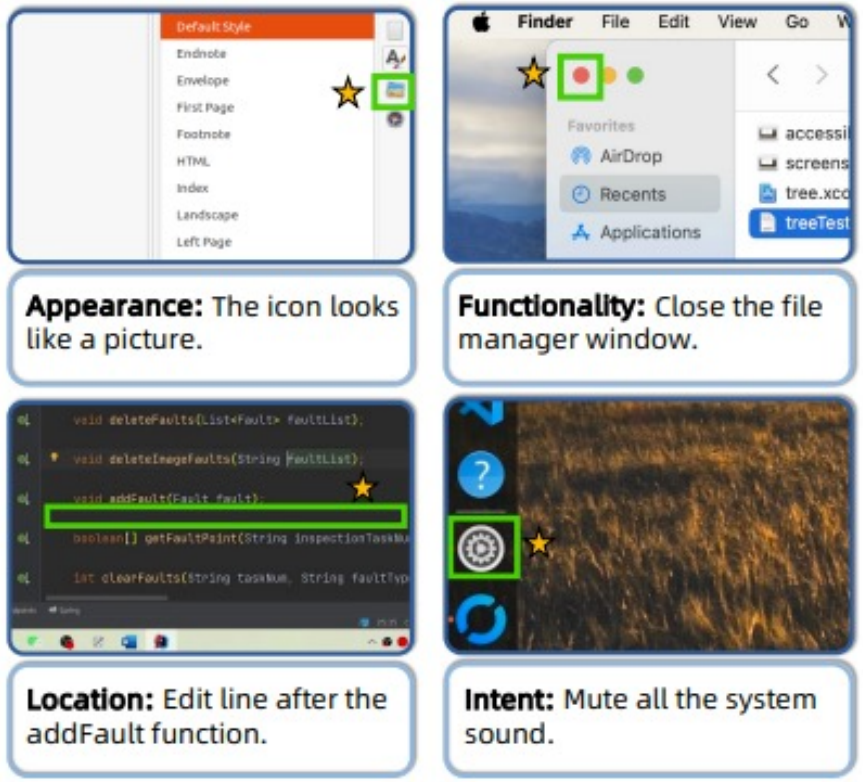
: Ground Truth : UI-Ins Prediction : Zoom in for visualization

Motivation

How does human describe and click the UI elements usually?

- Appearance description.
- Functionality description.
- Location description.
- Intent description.

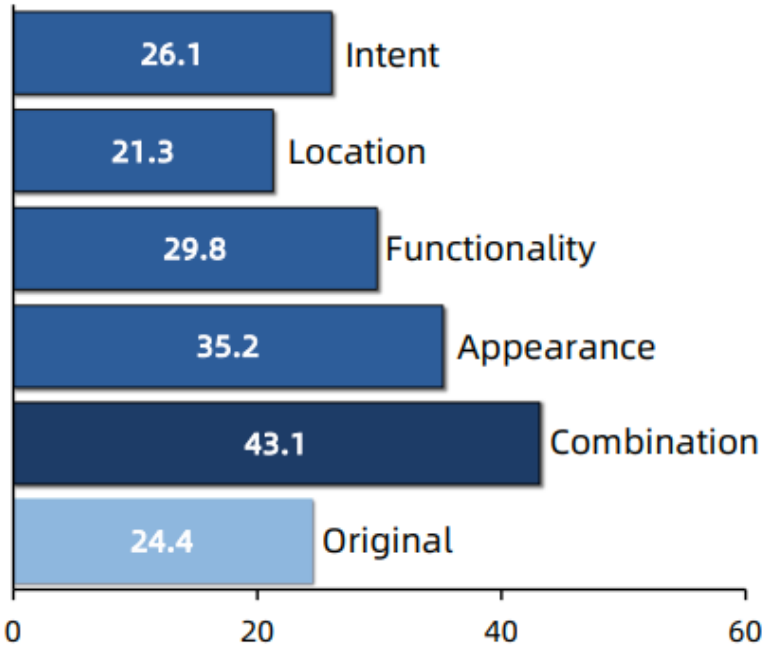
Human always choose the most effective instruction in different scenarios. But can nowadays grounding model choose the best-perform type to achieve the goal?



How much does instructions really matter?

How does the diversity of instructional perspectives affect grounding accuracy?

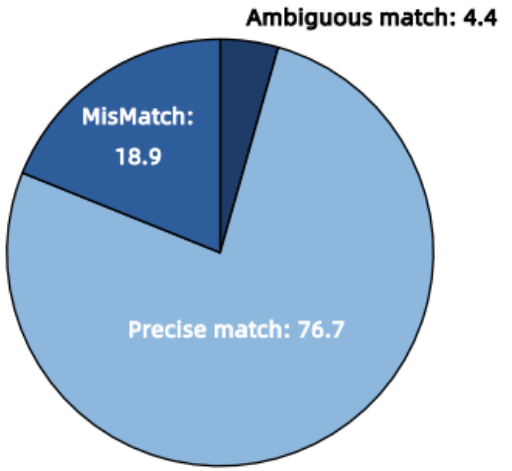
- Different instruction type can effect the model's performance significantly even on **zero-shot** setting.
- If model can always choose the best-perform instruction for each GUI grounding sample (**Combination**), model performance can achieve a **76%** relative improvement.

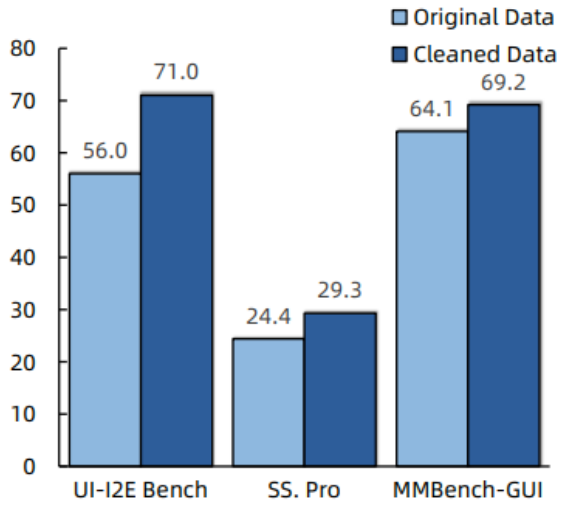


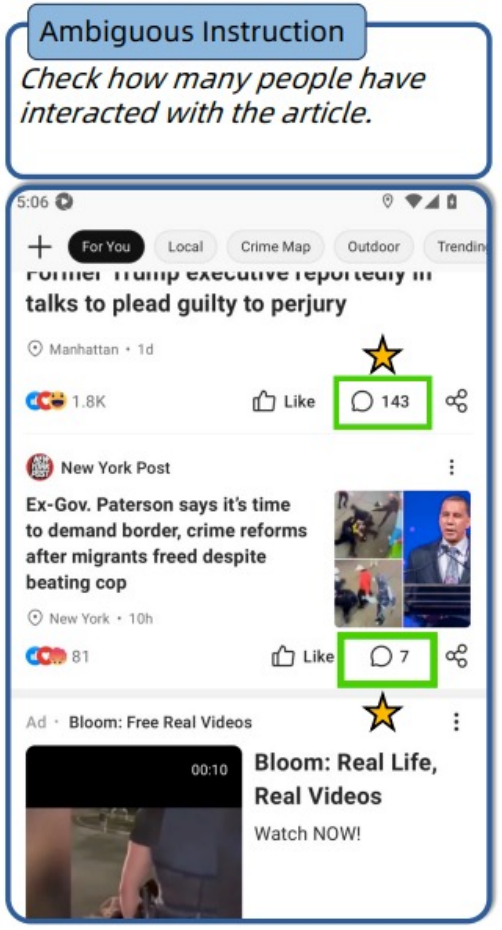
How much does instructions really matter?

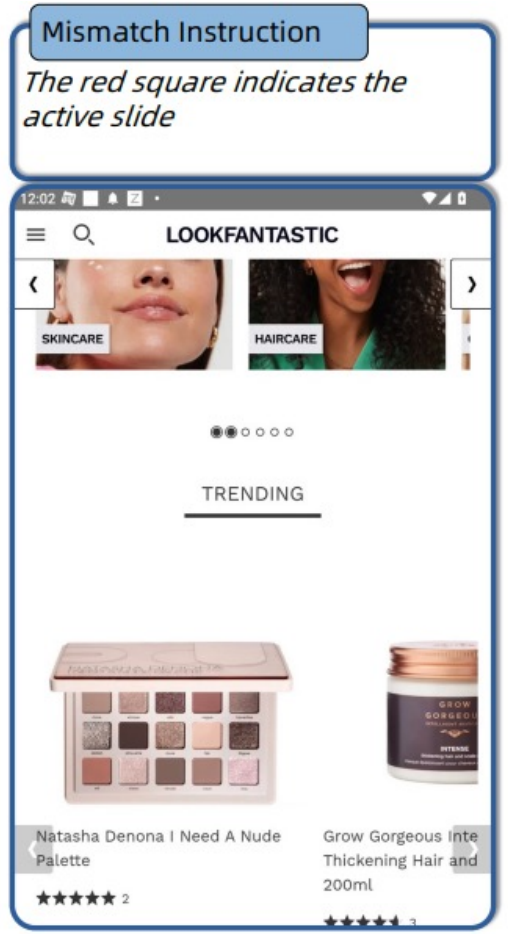
What is the state of instruction quality in GUI grounding datasets, and what is its impact?

- About **23%** samples in open-source datasets exhibit substantive flaws.
- Cleaned data can help model improve performance by simply SFT training (ori: 21w, cleaned: 18w).





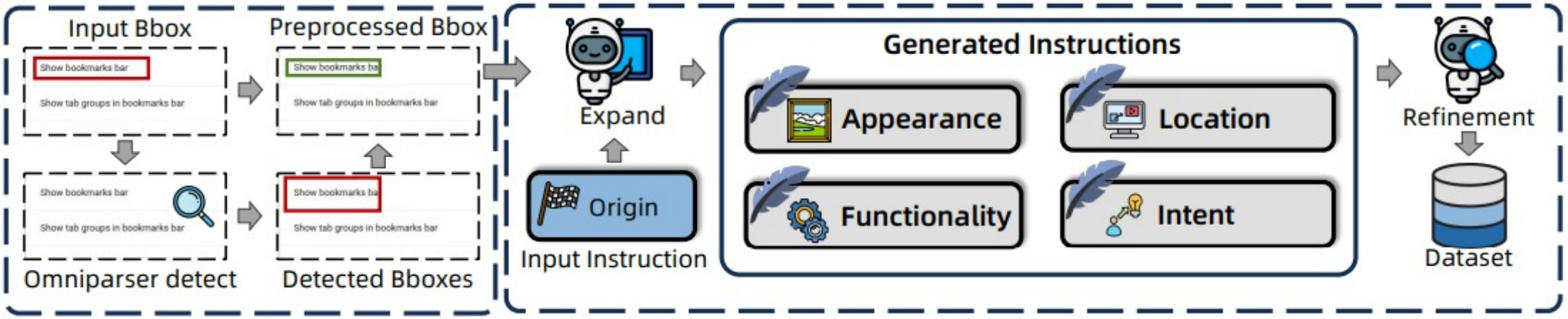




Method – Data Pipeline

How to improve the quality of GUI grounding data?

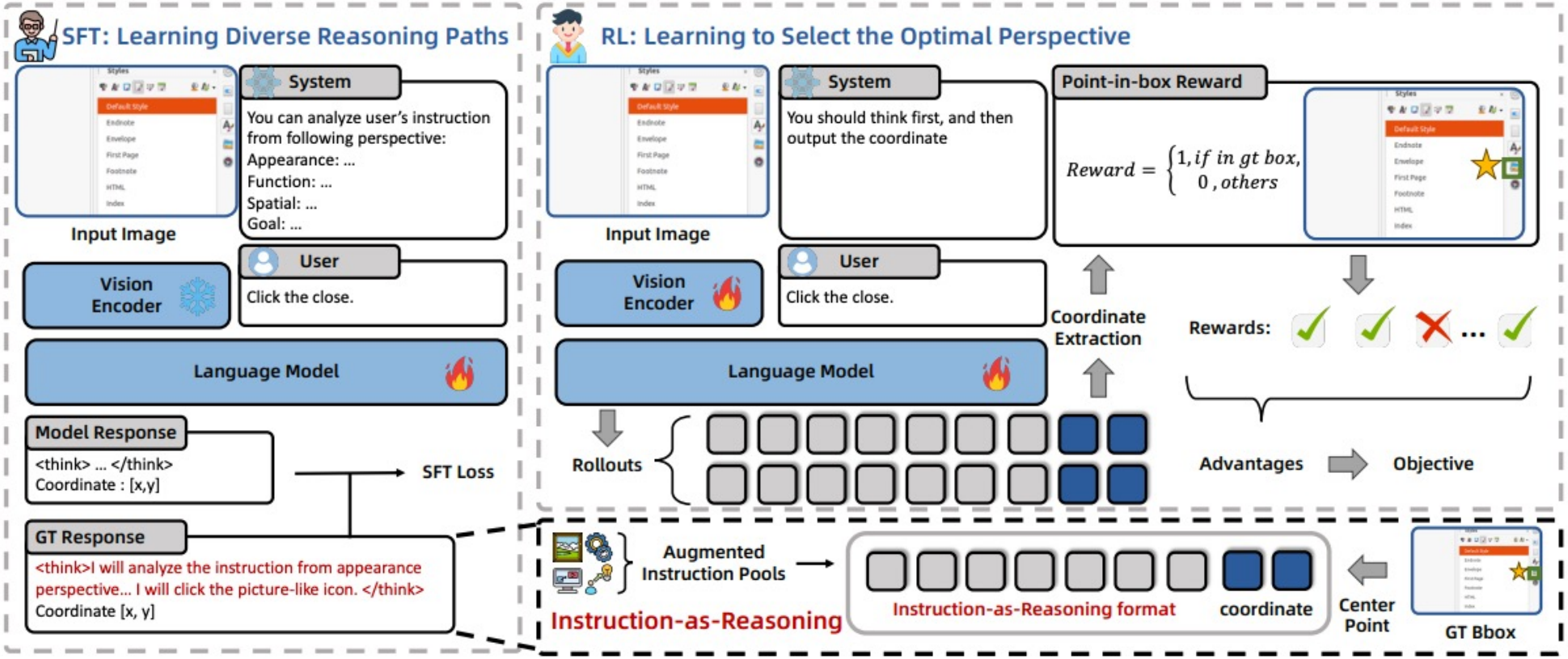
- Bbox preprocess: Use Omniparser V2 (Microsoft detection model) detect all UI elements in image, modify the GT bbox with the intersection.
- Multi-perspective instruction generation: four perspectives.
- Instruction-GT Bbox correspondence refinement: filter the inaccurate instructions.



Method – Instruction-as-Reasoning

How can model reasoning in diverse perspective?

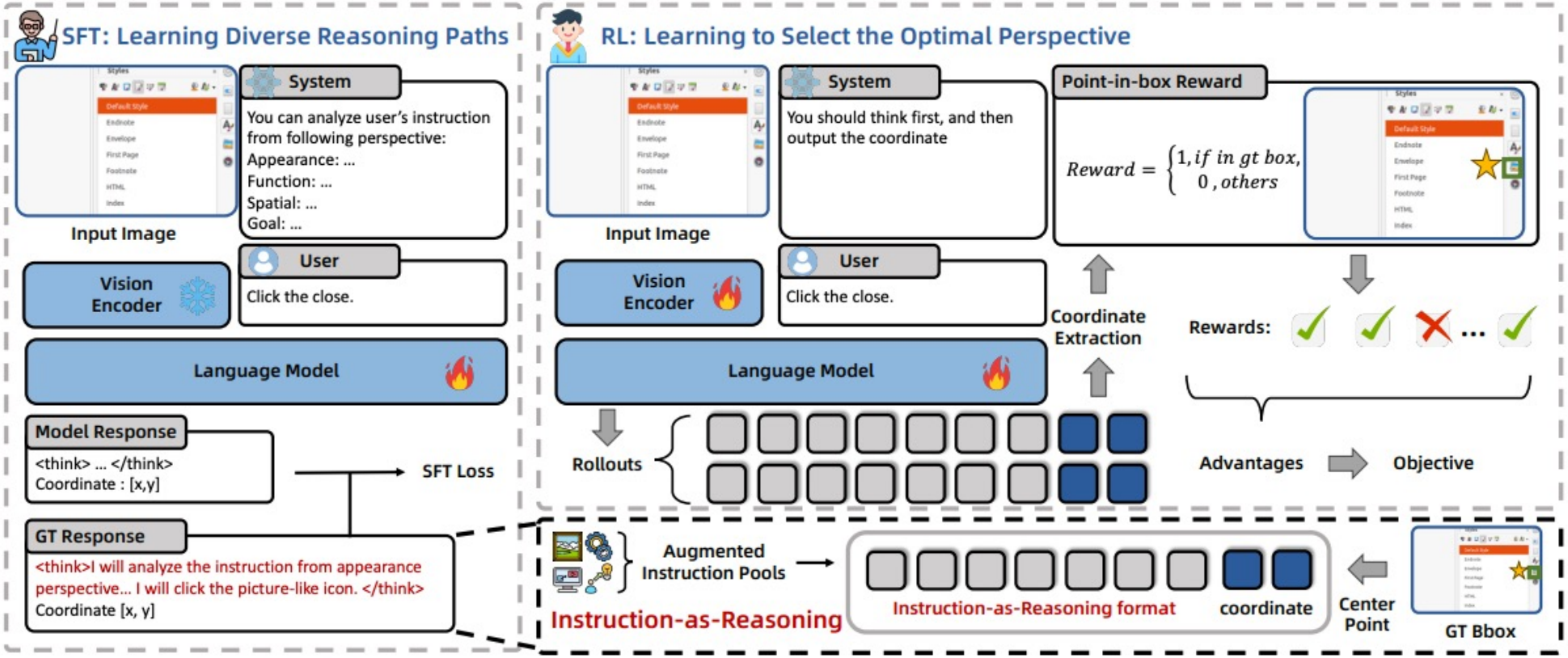
- Despite prior works treat the instructions simply as the input, we treat these diverse instructions as the reasoning pathways in SFT stage.



Method – Instruction-as-Reasoning

How can model choose the optimal reasoning pathways in different grounding scenarios?

- Model learns to select the optimal perspective by point-reward in RL stage (GRPO).



Results

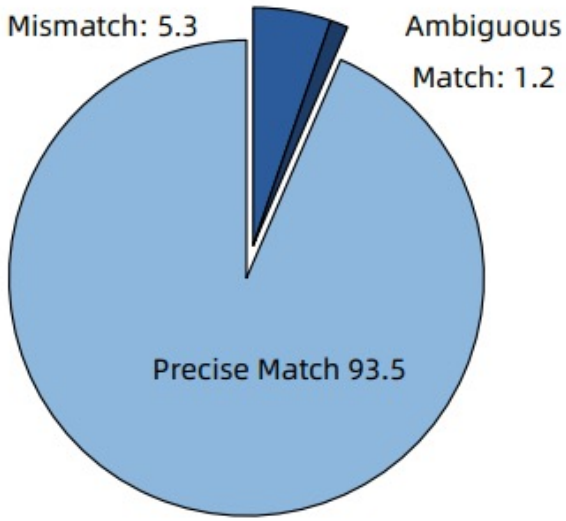
By Instruction-as-Reasoning approach, we build UI-Ins-7B and UI-Ins-32B upon Qwen2.5-VL-7B and Qwen2.5-VL-32B. We achieve state-of-the-art on grounding benchmarks and AndroidWorld.

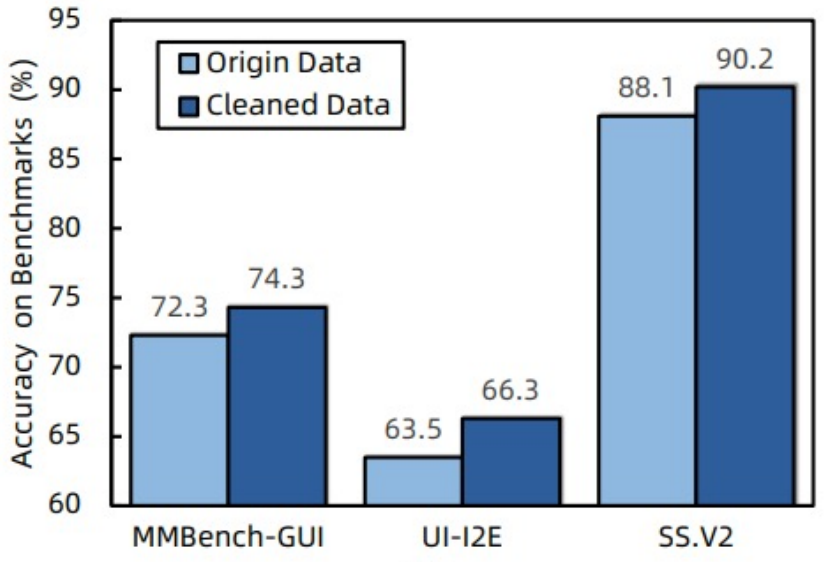
BENCHMARK	SCORE	KEY IMPROVEMENT HIGHLIGHTS
UI-I2E-Bench	**87.30%**	Significantly enhanced implicit instruction understanding
MMBench-GUI L2	**84.90%**	More robust handling of complex hierarchical instructions
ScreenSpot-Pro	**57.00%**	Excellent performance in high-resolution professional software scenarios
ScreenSpot-V2	**94.90%**	Strong cross-platform generalization (Windows/macOS/Android)
ShowDown	**73.80%**	Outstanding low-level control and instruction-following ability

Ablation – Data Quality

The effects of data processing pipeline :

- Error rate: 23.3 -> less than 8%.
- Model performance improved substantially (SFT 34w original data vs. 29w cleaned data, 1epoch only).





Ablation – Training Stage & Reasoning

- SFT+RL outperforms pure SFT and RL training.
- Reasoning is important in both SFT stage and RL stage.

Table 6: Ablation study on training stages. We report accuracy on MMBench-GUI L2 (MM), UI-I2E-Bench (I2E), Showdown (Show), ScreenSpot-Pro (Pro), and ScreenSpot-V2 (V2).

SFT	RL	MM	I2E	Show	Pro	V2
✗	✗	63.4	56.0	43.6	24.4	86.5
✗	✓	72.4	69.2	66.6	37.0	88.6
✓	✗	76.3	70.1	67.5	37.1	90.6
✓	✓	**83.1**	**81.1**	**73.1**	**52.2**	**94.0**

Table 7: Ablation on the intermediate reasoning component. Its removal results in a significant performance degradation across all benchmarks. ✓represents let the model use Instruction as Reasoning in the corresponding stage.

SFT	RL	MM	I2E	Show	Pro	V2
✗	✗	79.1	70.7	66.1	44.8	91.7
✗	✓	78.8	71.6	68.4	48.0	92.0
✓	✗	81.6	76.2	72.0	47.5	93.1
✓	✓	**83.1**	**81.1**	**73.1**	**52.2**	**94.0**

Key insights – Effect of Instruction-as-Reasoning on SFT+RL training paradigm

How does Instruction-as-Reasoning help SFT+RL training paradigm?

- The upper bound and training efficiency can be effected significantly by the base model's performance.
- Even finetune only 5k grounding data (pure coordinate response as GT) in SFT stage. The finetuned Qwen2.5-VL-7B suffers heavily policy collapse in GRPO training process, similar phenomenon also appears in JEDI-7B and UI-Tars-1.5-7B.

Model	Training type	SS.Pro
UI-tars-1.5-7B	Zero-Shot	41.8
UI-tars-1.5-7B	Zero-Shot	46.5
Qwen2.5-VL-7B	Zero-Shot	28.1
Qwen2.5-VL-7B	Zero-Shot	34.9

Table 9: Instruction-as-Reasoning prevents policy collapse in RL and achieves significant accuracy gain in RL. This table contrasts our method with a standard SFT+RL pipeline. Scores after 100 RL steps are reported.

Method	Base Model	SS.Pro
SFT (w/o IR)	Qwen2.5-VL-7B	37.0
+ RL	Qwen2.5-VL-7B	34.9↓ (5.7%)
Zero-Shot	JEDI-7B	39.5
+ RL	JEDI-7B	34.5↓ (12.7%)
SFT (w/ IR)	Qwen2.5-VL-7B	37.1
+ RL	Qwen2.5-VL-7B	46.0↑ (24.0%)

Key insights – Difference of Instruction-as-Reasoning from Free-Form Reasoning

Can all types of reasoning work in GUI grounding?

- Prior works like GUI-G1, GUI-G2, UI-R1, GTA1 demonstrated, thinking in pure RL stage can bring negative influence.
- Our experiments also validates this opinion on different base models including UI-Tars-1.5-7B and Qwen2.5-VL-7B.
- Different from Free-Form Reasoning, Instruction-as-Reasoning can bring substantially improvements on GUI grounding task.

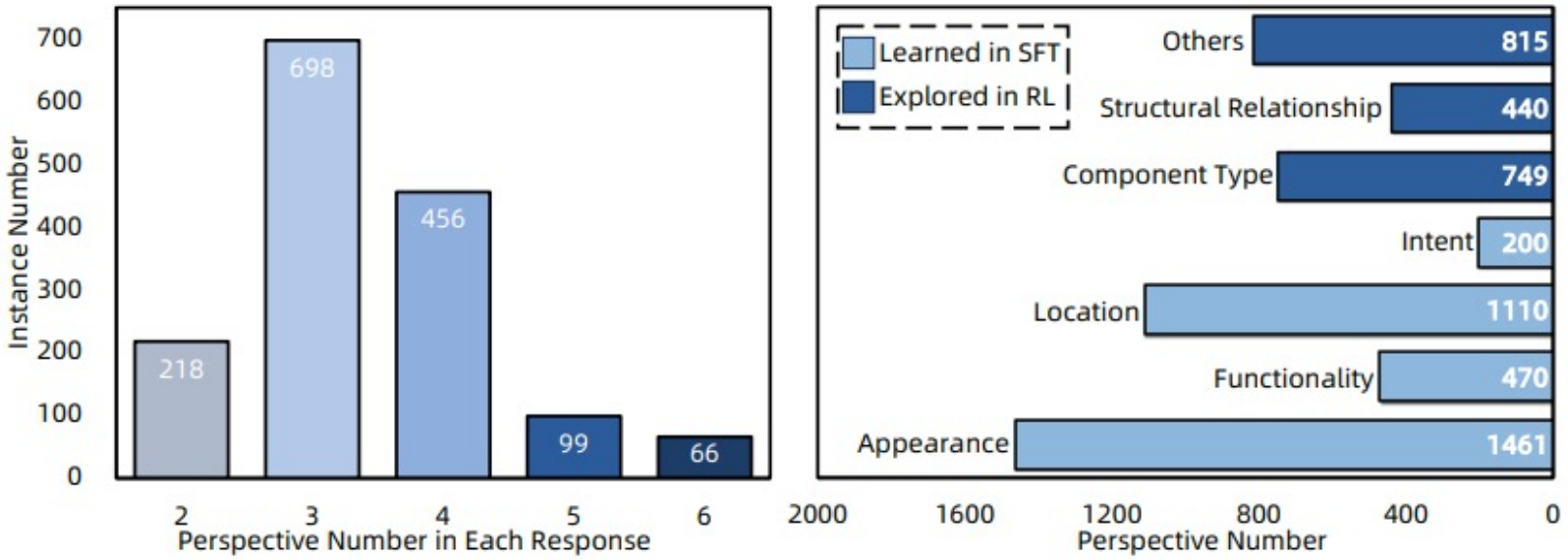
Table 8: Comparison between free-form reasoning (FFR) and Instruction as Reasoning (IR) in RL. Our Instruction-as-Reasoning is the key to unlocking effective reasoning for GUI grounding.

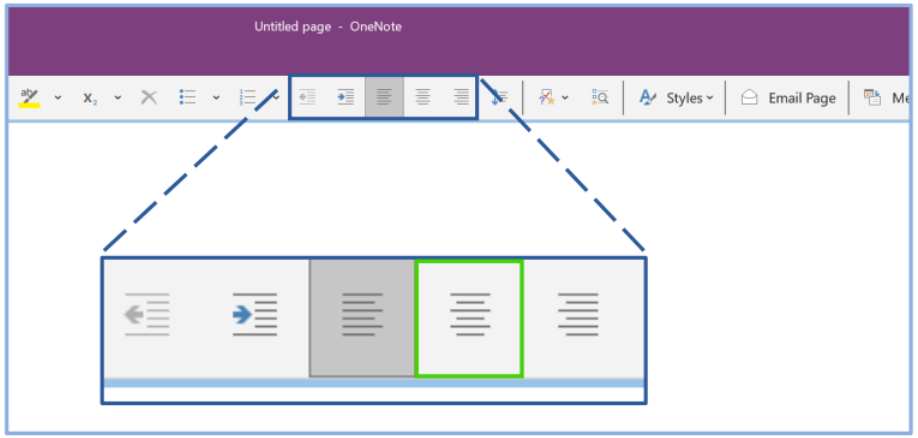
Method	Base Model	SS.Pro
Free-Form Reasoning (FFR) in RL		
RL (w/o FFR)	UI-Tars-1.5-7B	50.1
RL (w/ FFR)	UI-Tars-1.5-7B	46.9↓ (6.4)%
RL (w/o FFR)	Qwen2.5-VL-7B	36.4
RL (w/ FFR)	Qwen2.5-VL-7B	36.4↓ (0)%
Instruction-as-Reasoning (IR) in RL		
RL (w/o IR)	UI-Tars-1.5-7B	48.7
RL (w/ IR)	UI-Tars-1.5-7B	51.2↑ (5.1%)
RL (w/o IR)	Qwen2.5-VL-7B	47.5
RL (w/ IR)	Qwen2.5-VL-7B	52.2↑ (9.9%)

Visualization

UI-Ins can

- Select the optimal reasoning pathway.
- Combine different reasoning pathways.
- Explore emergent reasoning perspectives after RL.





Single Perspective Reasoning

Click the button to center the text [Functionality].

Combination Perspectives Reasoning

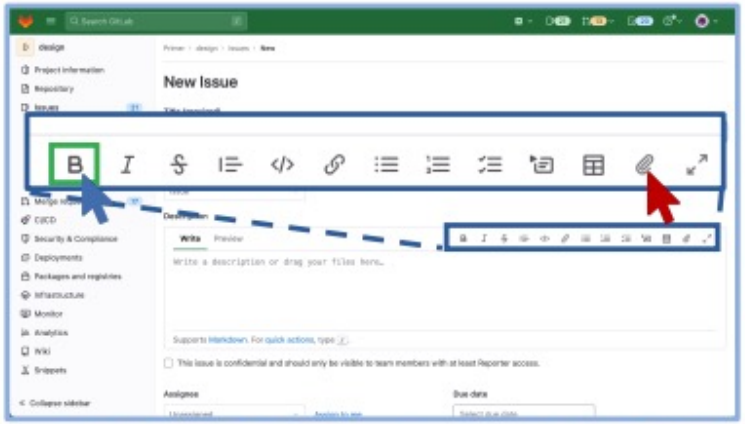
Click the button with the icon of centered horizontal lines [Appearance] to center the text [Functionality] .

Combination Perspectives and Emergent Perspective Reasoning

To the right of the currently highlighted option [Location] , click the inactive button [State] , identifiable by its icon of centrally-aligned staggered lines [Appearance] , to center the text [functionality] , which will set it as the new exclusive active state [Prediction] in alignment control group [Group Affiliation] .

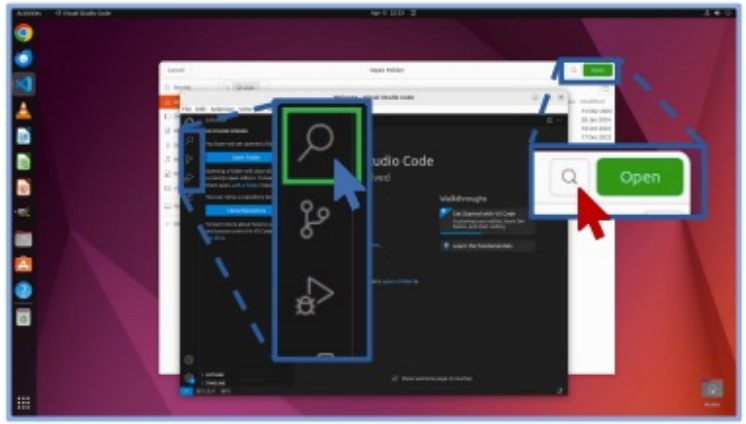
Visualization and Comparison

Make important points stand out in your issue by applying emphasis.



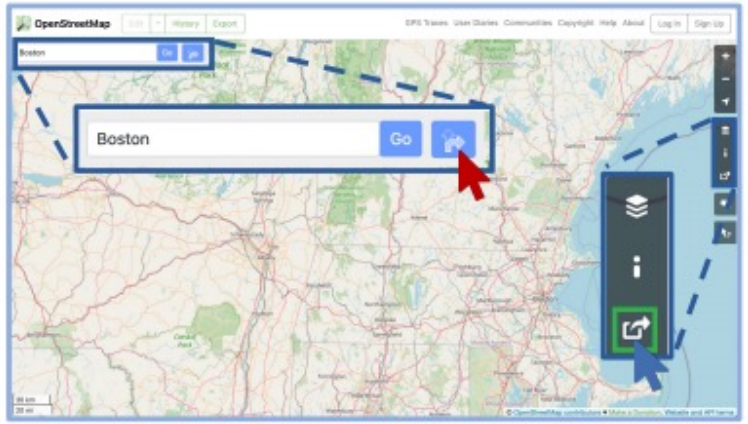
GTA1: (2394,804)
UI-Ins: <think> I will click the 'B' button in the formatting toolbar above the description box.</think>
<tool_call> [1590,801] </tool_call>

Access the search functionality to find files or text within VSCode workspace.



GTA1: (1496,164)
UI-Ins: <think> I will click the magnifying glass icon in the left sidebar.</think>
<tool_call> [962,463] </tool_call>

Create a shareable link to this specific map location showing Portland.



GTA1: (639,156)
UI-Ins: <think> I will click the button with the arrow icon pointing right and up, located on the right sidebar.think>
<tool_call> [2506,581] </tool_call>

: Ground Truth : GTA1 Prediction : UI-Ins Prediction : Zoom in for visualization

Error Analysis

- Lack of World Knowledge (a)
- Lack layout understanding capacity (b)
- Hallucination of VLMs (c) & (d)