

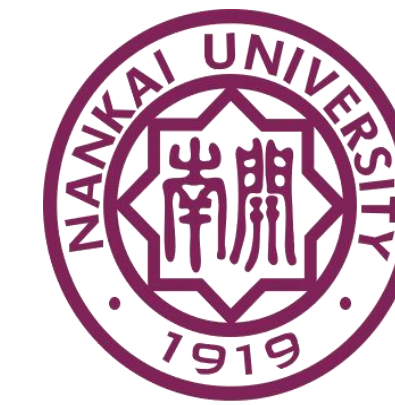


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LLM-PySC2: Starcraft II learning environment for Large Language Models

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Motivation



Limitations of Prior Work

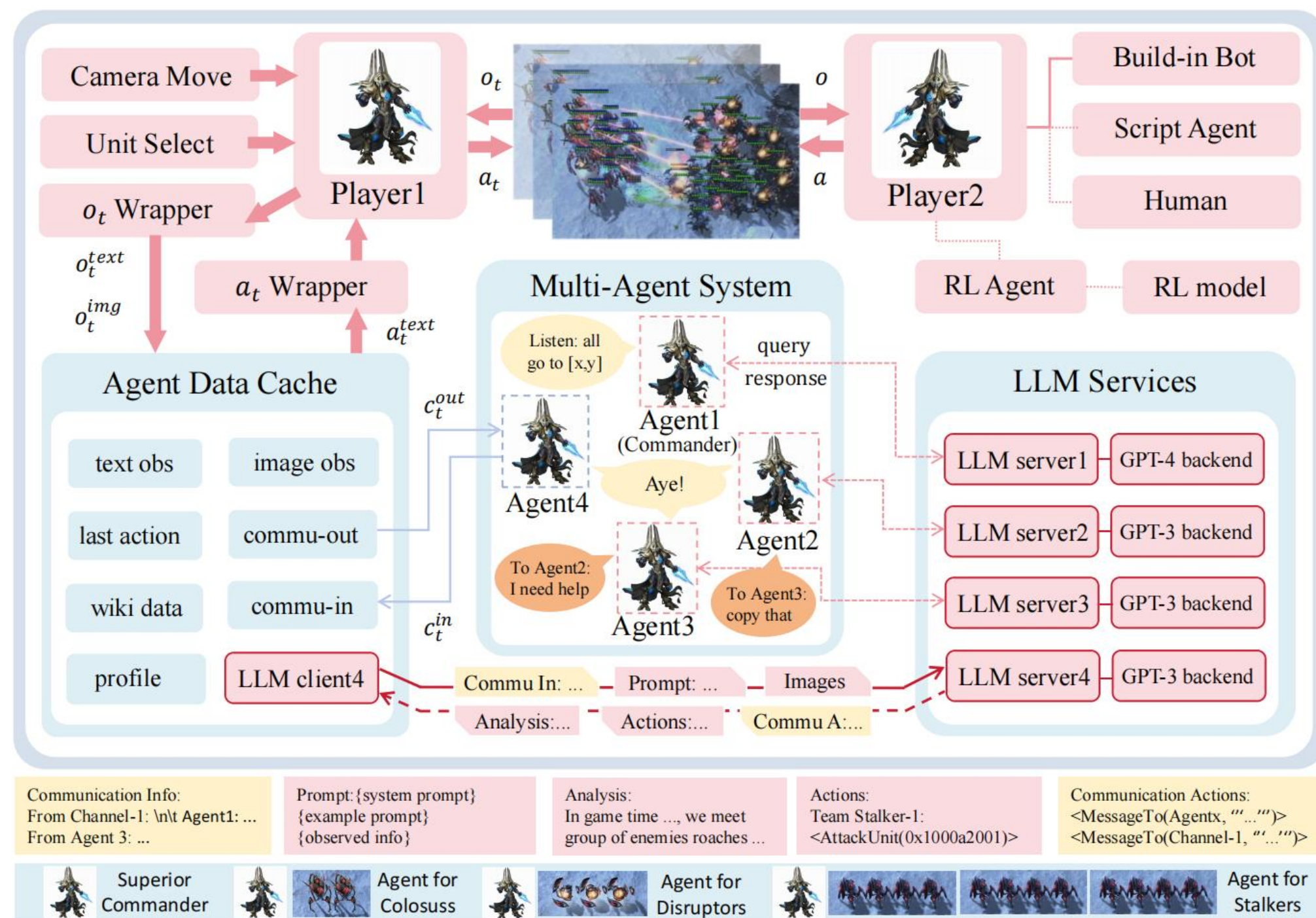
- ✗ **Over-simplified and restricted environments:** Existing SC2-LLM environments clip and oversimplify scenarios, preventing realistic evaluation of LLM decision-making.
- ✗ **Lack of multi-agent support:** Most platforms expose only a single controllable agent, making it difficult to study coordinated decision-making.
- ✗ **No full SC2 interaction:** Vector interfaces are incompatible with LLMs, hindering full-game control.



Our Method: LLM-PySC2

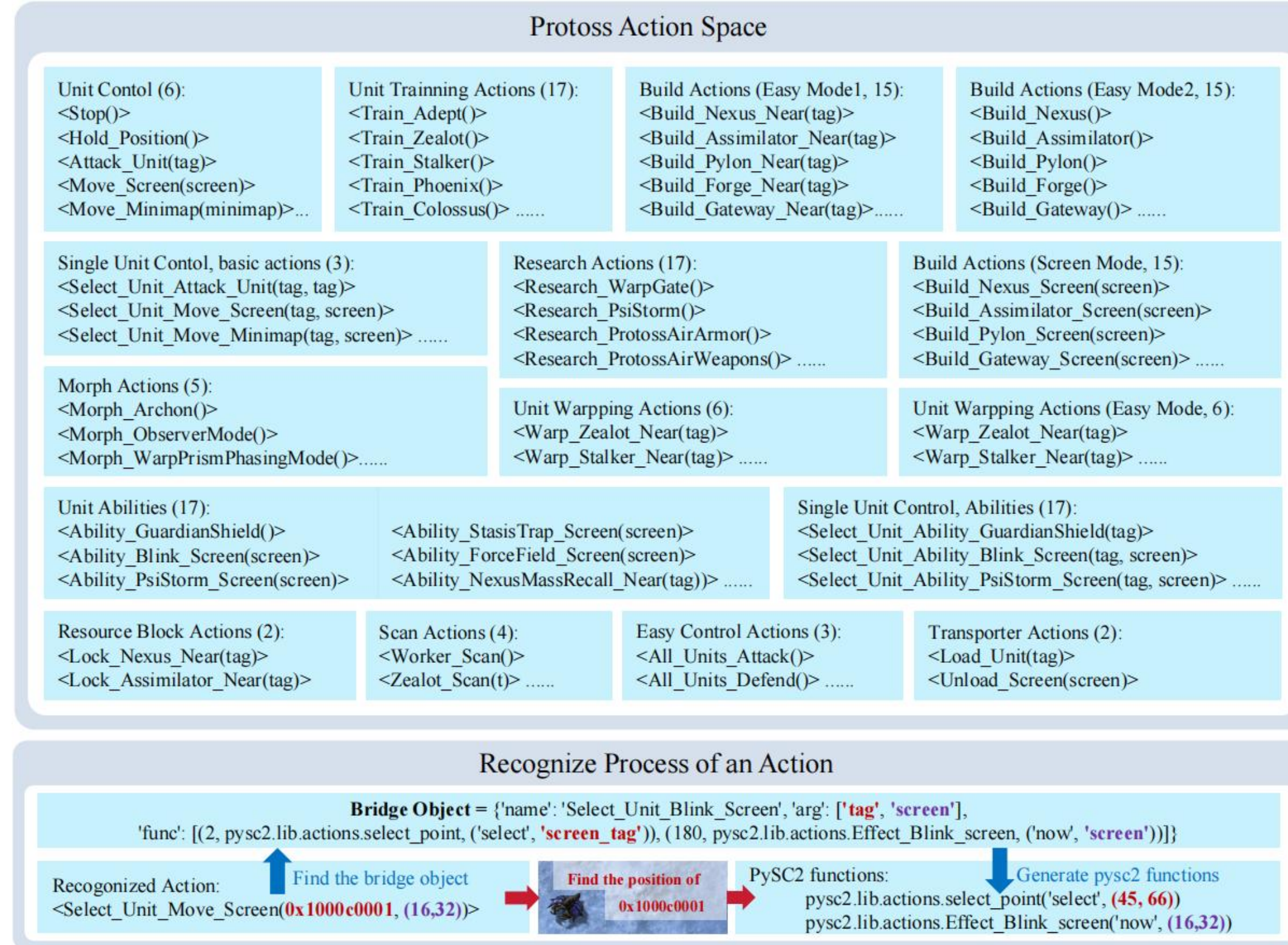
- ✓ **Full PySC2 action space:** Restores complete unit-level control for LLMs, enabling realistic and fine-grained decision-making.
- ✓ **Multi-modal observation and knowledge:** Provides text, visual inputs, and Wiki knowledge for richer situational understanding.
- ✓ **Native multi-agent collaboration:** Supports language-based coordination, role decomposition, and cooperative decision-making.
- ✓ **Asynchronous querying for scalability:** Maintains stable latency as the number of agents grows, enabling scalable multi-agent scenarios.

LLM-PySC2 framework



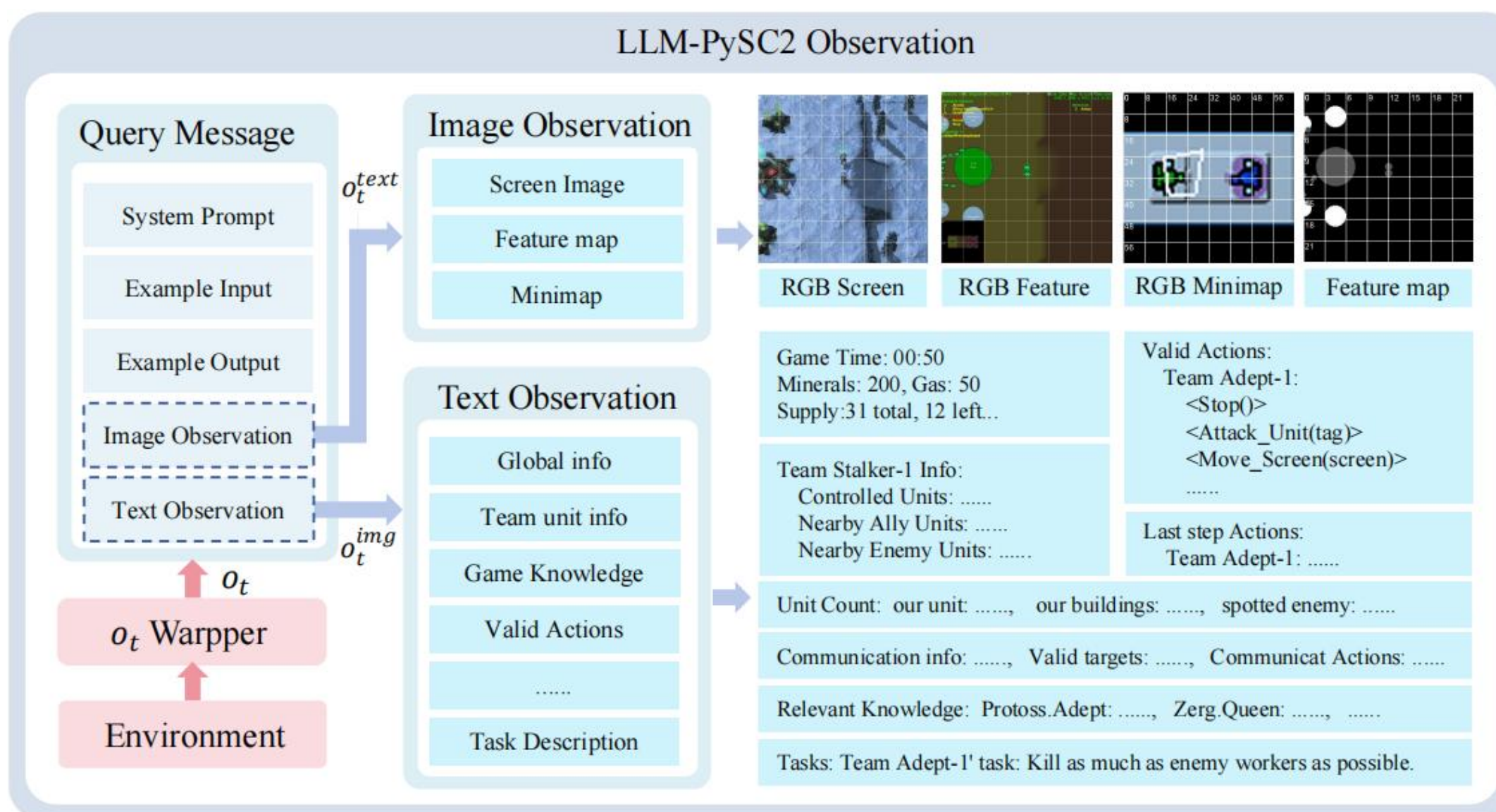
In LLM-PySC2, the original observation will be wrapped into a text- or multi-modal observation. LLM-generated text action can be recognized and transformed into PySC2 functions, enabling LLMs to interact with the StarCraft II environment and control the units.

Protoss action space and the recognition process



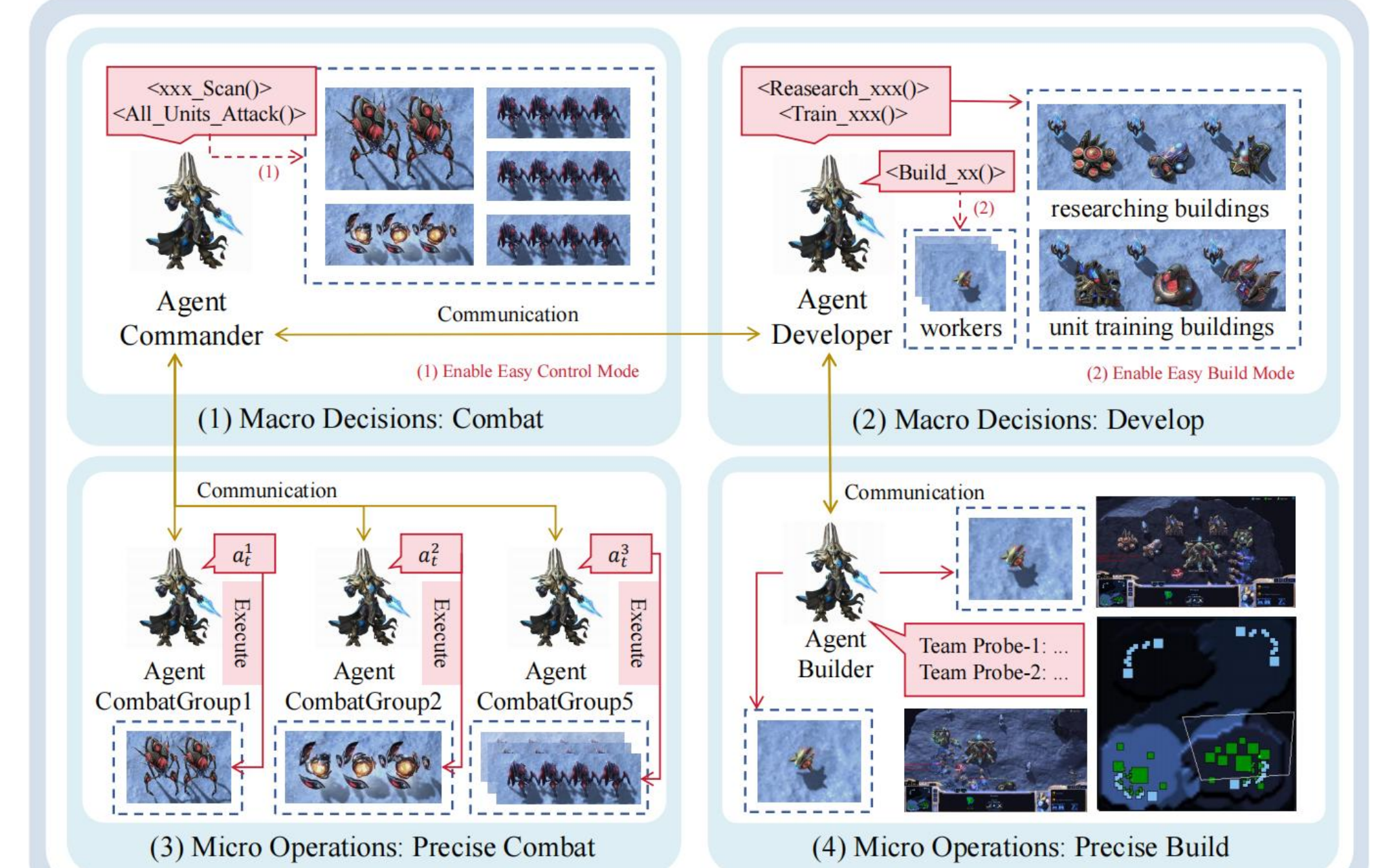
LLM-PySC2 is the first LLM decision making environment with complete pycsc2 action space. LLM controls units by output actions in the shape of `<Action_Name(args)>`. The environment transforms text action into pycsc2 functions according to a transform protocol and the relevant bridge object of the action

LLM-PySC2 observations



LLM-PySC2 provides multi-modal observation. The observation wrapper generates text and image observations that contain all the important information for decision-making, with access to images of the screen, minimap, and pycsc2 original feature maps.

LLM-PySC2 multi-agent system



Experiment Results

Table 2: Winning Rates of GPT-4o-mini in Complete StarCraft II games (with 90% Wilson Score Confidence Intervals).

Mode	Winning Rate from Level-1 to Level-7						
	L1	L2	L3	L4	L5	L6	L7
ECEB (EasyControl+EasyBuild)	100% _{0.92%}	100% _{0.92%}	80% _{0.66%}	57% _{0.42%}	30% _{0.18%}	3% _{0.1%}	0% _{0.0%}
SCEB (StandardControl+EasyBuild)	100% _{0.92%}	60% _{0.45%}	0% _{0.0%}	0% _{0.0%}	0% _{0.0%}	0% _{0.0%}	0% _{0.0%}
ECSB (EasyControl+StandardBuild)	100% _{0.92%}	80% _{0.66%}	60% _{0.45%}	17% _{0.8%}	17% _{0.8%}	0% _{0.0%}	0% _{0.0%}

Table 3: Kill/Death Rates and Winning Rates of LLMs in LLM-SMAC Tasks.

Model	Task Names / KD(WR)					
	2s3z	3s5z	1c3s5z	3s5z_vs_3s6z	2c_vs_64zg	3s_vs_3z
gpt-3.5-turbo	0.60(22%)	0.43(4%)	0.91(44%)	0.29(0%)	0.52(0%)	0.05(0%)
gpt-4o-mini	0.66(20%)	0.39(0%)	1.01(50%)	0.29(0%)	0.54(0%)	0.09(0%)
glm-4-plus	0.81(25%)	0.46(0%)	0.47(0%)	0.33(0%)	0.54(5%)	0.15(0%)
claude3-haiku	0.58(5%)	0.48(0%)	0.48(0%)	0.32(0%)	0.52(0%)	0.10(0%)
llama3.1-8b	0.19(0%)	0.23(0%)	0.18(0%)	0.14(0%)	0.49(0%)	0.00(0%)
gpt-4o	0.76(20%)	0.47(0%)	0.80(30%)	0.35(0%)	0.56(0%)	0.15(0%)

Table 4: Kill/Death Rates and Winning Rates of LLMs in LLM-PySC2 Tasks (level-1).

Model	Task Names / KD(WR)					
	task1	task2	task3	task4	task5	task6
gpt-3.5-turbo	1.23(58%)	0.13(4%)	6.63(38%)	0.38(0%)	0.61(8%)	0.28(0%)
gpt-4o-mini	1.67(70%)	0.16(0%)	3.46(0%)	0.39(0%)	0.62(20%)	0.30(0%)
glm-4-plus	0.78(30%)	0.21(5%)	153(100%)	0.38(0%)	0.60(10%)	0.30(0%)
claude3-haiku	2.19(90%)	0.19(10%)	5.25(40%)	0.34(0%)	0.75(25%)	0.33(0%)
llama3.1-8b	0.28(5%)	0.12(5%)	14.9(75%)	0.18(0%)	0.48(5%)	0.14(0%)
llama3.1-70b	0.36(15%)	0.14(0%)	58.9(95%)	0.33(0%)	0.59(15%)	0.31(0%)
llama3.1-405b	0.70(30%)	0.10(0%)	3.0k(100%)	0.28(0%)	0.56(10%)	0.32(0%)
gpt-4o	2.27(80%)	0.16(10%)	Inf(100%)	0.46(0%)	—	—
gpt-o1-mini	1.36(60%)	0.04(0%)	—	—	—	—