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Hierarchical Auto-Organizing System for Open-Ended Multi-Agent Navigation

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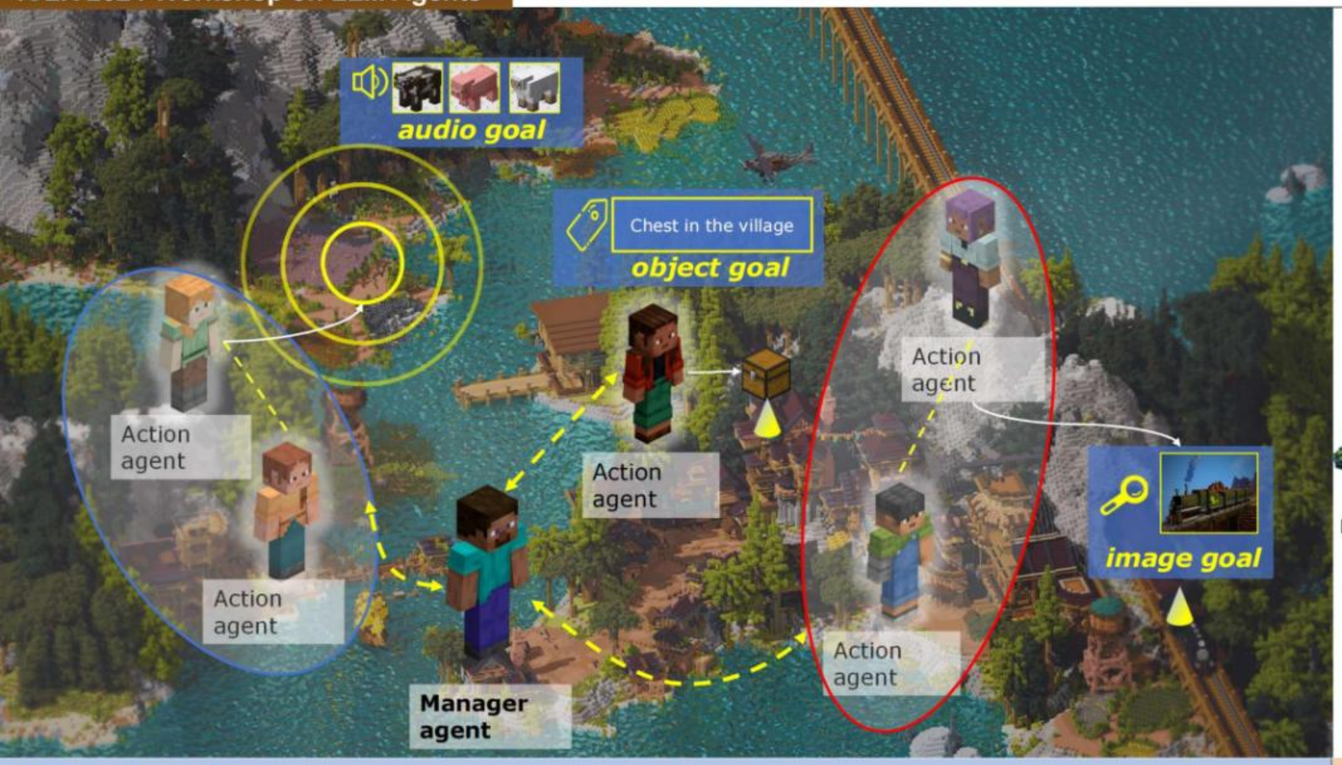

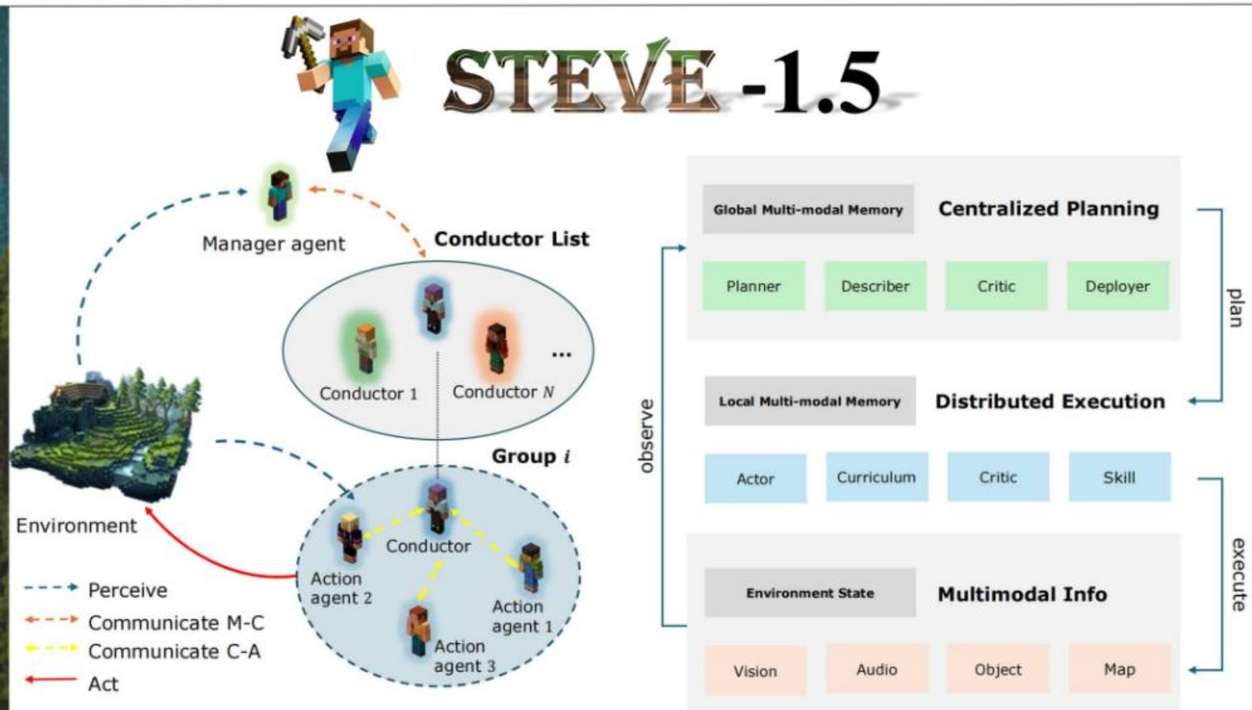

HAS framework

Motivation

- Navigating complex environments in Minecraft is challenging for multi-agent systems due to **inter-agent communication** and **task distribution** problems.
- HAS framework includes a **hierarchical** navigation system, an **auto-organizing** and intra-communication mechanism, and a **multi-modal** information platform.
- We evaluated the organizational behavior of our framework with a series of navigation tasks in Minecraft to develop embodied organizations that move embodied AI towards a more **human-like** structure.

Contribution

- We introduce HAS, a hierarchical structure for multi-agent navigation based on **LLMs** in the Minecraft environment. It utilizes **centralized planning with decentralized execution**, enabling efficient multi-modal navigation in open-ended environments.
- We design an auto-organizing and intra-communication mechanism to dynamically adjust the key role and action group based on the task allocation and maintain inter-group communication to ensure efficient collaboration.
- We achieve state-of-the-art performance on the **asynchronous multi-modal** navigation task on image, audio, and object goals in Minecraft's open-ended environment.

Experiment

Method	# agents	Image Goal		Object Goal		Audio Goal	
		# iters (↓)	success rate (↑)	# iters (↓)	success rate (↑)	# iters (↓)	success rate (↑)
Voyager	1	95	0.21	64	0.41	21	0.67
	3 / 2 / 5	45	0.47	36	0.59	6	0.85
STEVE	1	85	0.25	71	0.31	13	0.71
	5 / 5 / 4	32	0.52	29	0.57	6	0.82
HAS (Ours)	1	27	0.76	15	0.83	4	0.87
	8 / 7 / 3	**6**	**0.84**	**4**	**0.95**	**2**	**0.99**

Goal Search Comparison

Setting	# agents	Goal Search		Block Search		Map Exploration	
		# iters (↓)	success rate (↑)	# iters (↓)	# blocks (↑)	# iters (↓)	area (↑)
w/o DM	1	53	0.46	14	67	6	160
	6 / 4 / 5	22	0.64	5	237	3	624
w/o AO	1	41	0.55	35	29	6	172
	5 / 5 / 5	15	0.78	11	106	3	706
HAS (Ours)	1	15	0.82	14	68	1	201
	6 / 8 / 8	**4**	**0.93**	**2**	**367**	**1**	**1368**

Ablation studies