ROBOTICS SCIENCE AND SYSTEMS
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上海人工智能实验室
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Learning Humanoid Standing-up Control across Diverse Postures

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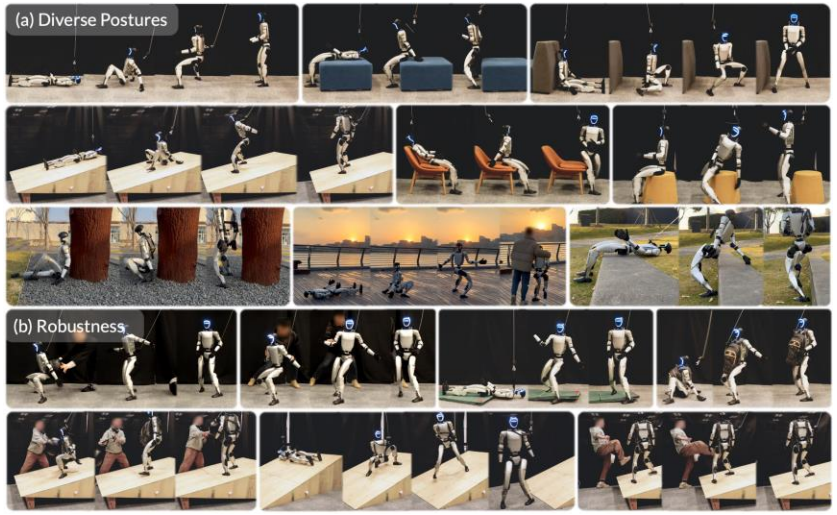
Zoom Chat | Website | Code

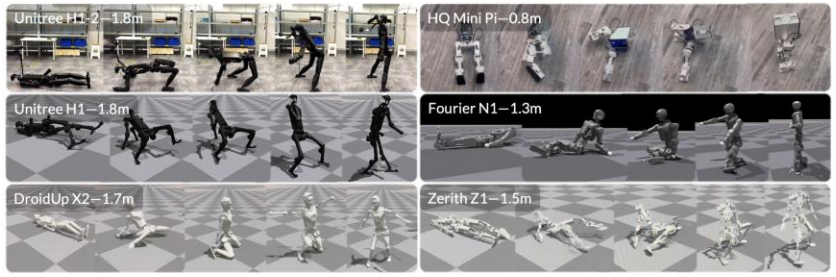
★ Outstanding Systems Paper Finalist ★

Overview 1: Generalization and Robustness



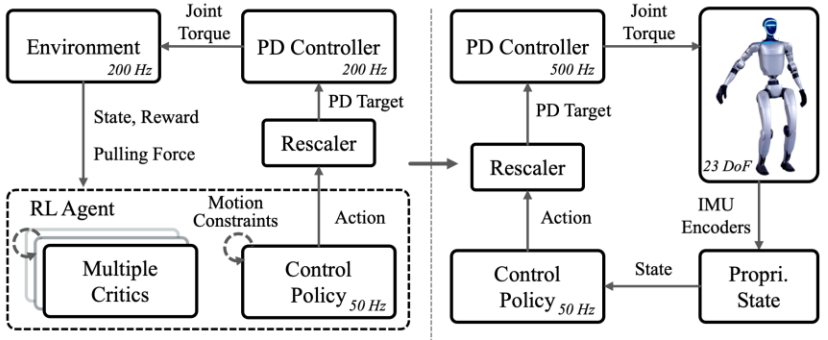
- **We propose HoST:** a general RL framework for generalized, robust and stable humanoid standing-up control, without prior motion data, real-world finetuning, and multi-stage training.

Overview 2: General to Humanoid Robots

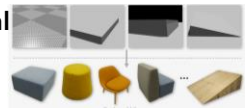


- We actively share tuning practices and deployment insights with the whole community. **With minor tuning efforts**, HoST has been easily adapted to many humanoid robots with **varying sizes and designs**, helping lower the barrier to humanoid standing-up control.

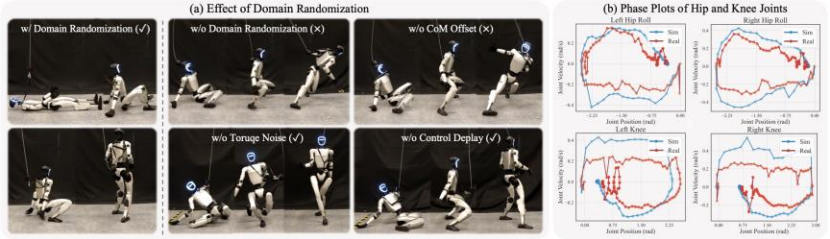
Method



- **Reward engineering burden and policy optimization difficulty** are addressed by multiple critics.
- **Violent motions** are addressed by limiting PD targets via action rescaling and **jerky motions** are addressed by L2C2 regularization.
- **To balance exploration and motion constraints,** a curriculum is used to tighten PD targets gradually. Early training is assisted by a vertical force, inspired by how parental support helps infants learn to stand.
- **To handle diverse postures and the sim-to-real gap**, we design varied simulation terrains and apply domain randomization.

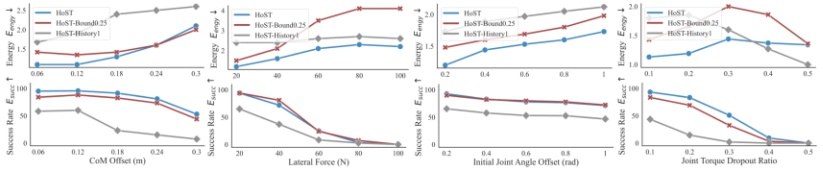


Analysis on Sim-to-real Transfer



- We find CoM randomization most effective in the sim2real gap. Phase analysis reveals torque mismatches as a key source of gap.

Analysis on Robustness and Stability



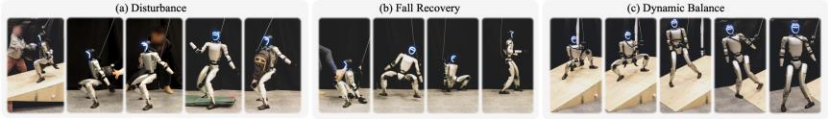
- We show greater robustness on diverse disturbances compared to HoST variants of short state histories and fixed action rescaler.

Metric	Payload Mass					Torque Dropout Ratio			
	4kg	6kg	8kg	10kg	12kg	0.05	0.1	0.15	0.2
$E_{smth}\downarrow$	1.75	1.92	1.86	1.82	1.85	2.00	2.16	2.61	/
$E_{succ}\uparrow$	3/3	3/3	3/3	3/3	3/3	3/3	3/3	3/3	0/3

- We show greater robustness on diverse disturbances compared to HoST variants of short state histories and fixed action rescaler.

Emergent Properties

- Beyond supine postures, HoST can also handle prone lying and side-lying postures on the ground.



- Our control policies demonstrate (1) robustness to external disturbances, (2) recovery after balance loss, and (3) keep balance on extremely difficult slope on Unitree G1.
- The necessity of avoiding violent motions is verified: lower motion speed leads to higher motion smoothness and low energy cost.