Towards Embodiment Scaling Laws in Robot Locomotion

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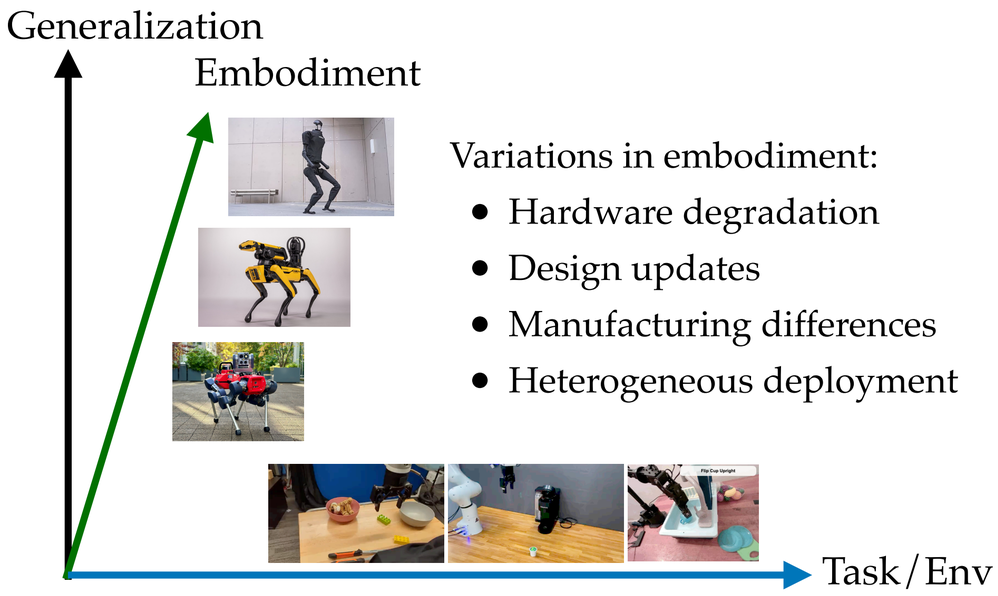
Motivation



Variations in embodiment:

- Hardware degradation
- Design updates
- Manufacturing differences
- Heterogeneous deployment

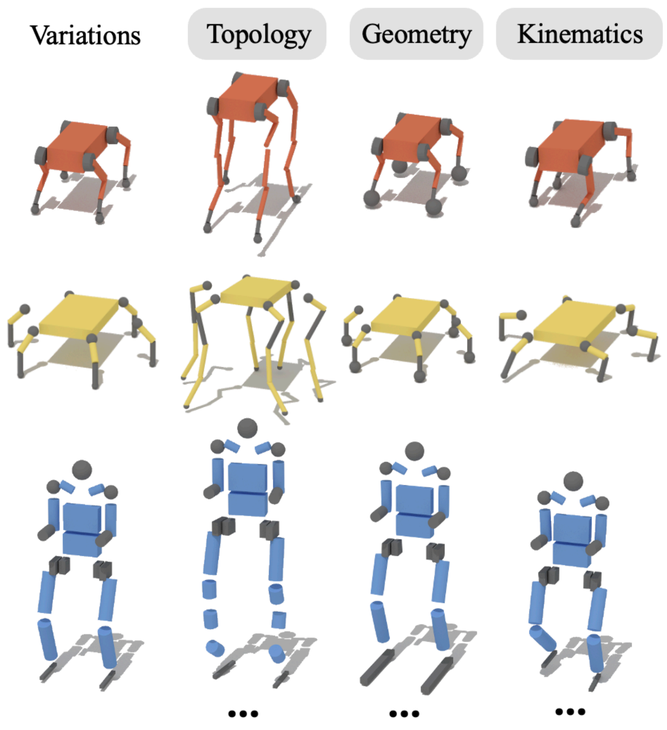
Embodiment: The Third Axis of Generalization

- Task & environment scaling → generalization
- Can scaling enable embodiment generalization?

Embodiment Scaling Law

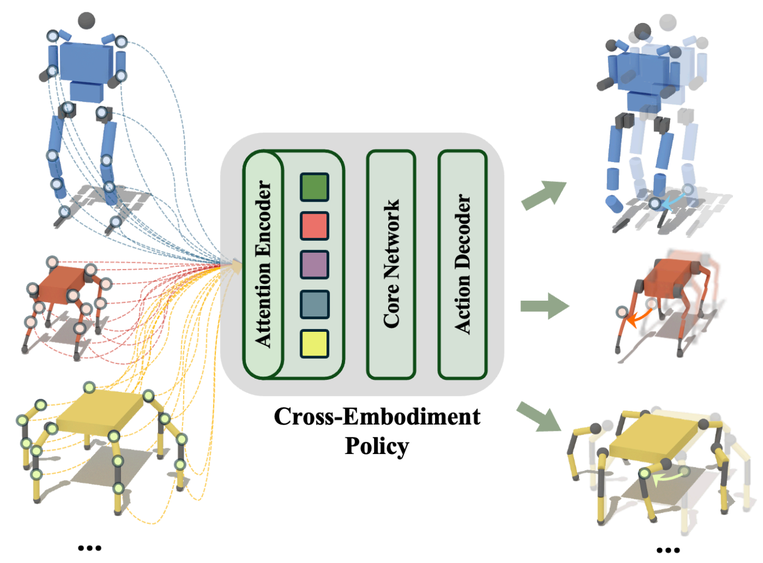
- More embodiments → better generalization

GenBot-1K



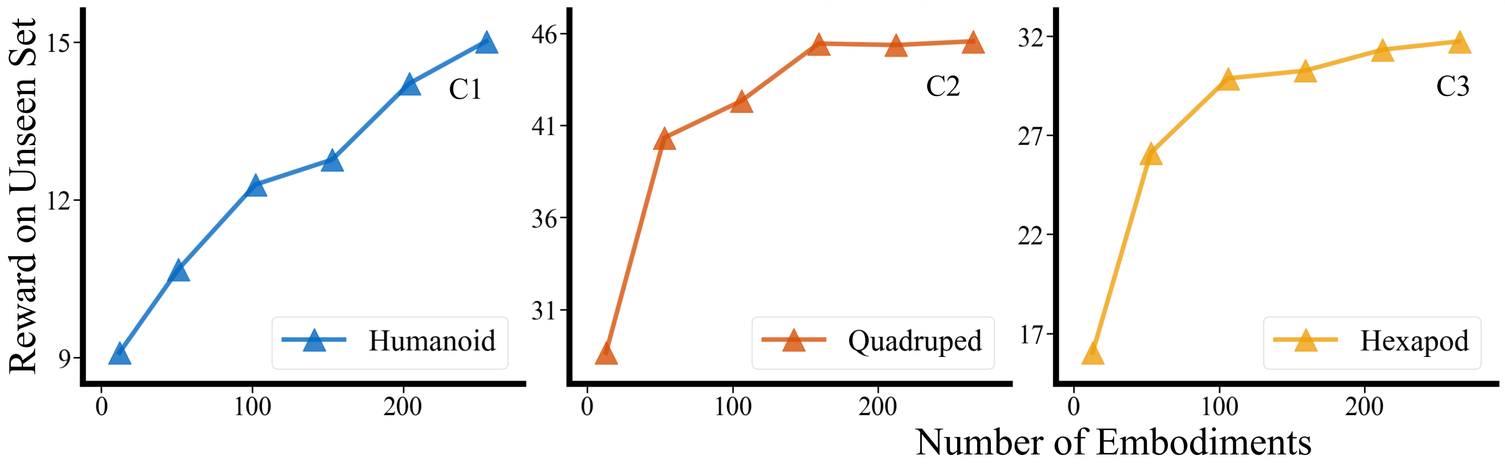
~1000 Embodiments: **Humanoids**, **Quadrupeds**, and **Hexapods**

Cross-Embodiment Learning

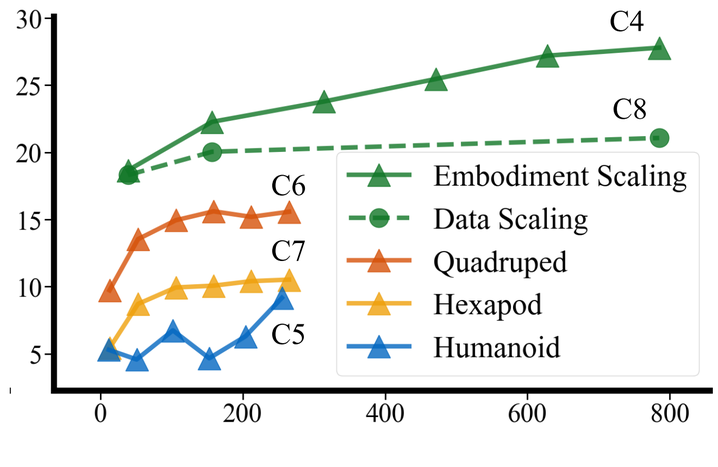


- Extended Unified Robot Morphology Architecture to multi-head architecture
- Two-stage training: (i) learning specialist policies with RL. (ii) distilling policies into the unified model.

Studying Embodiment Scaling Laws



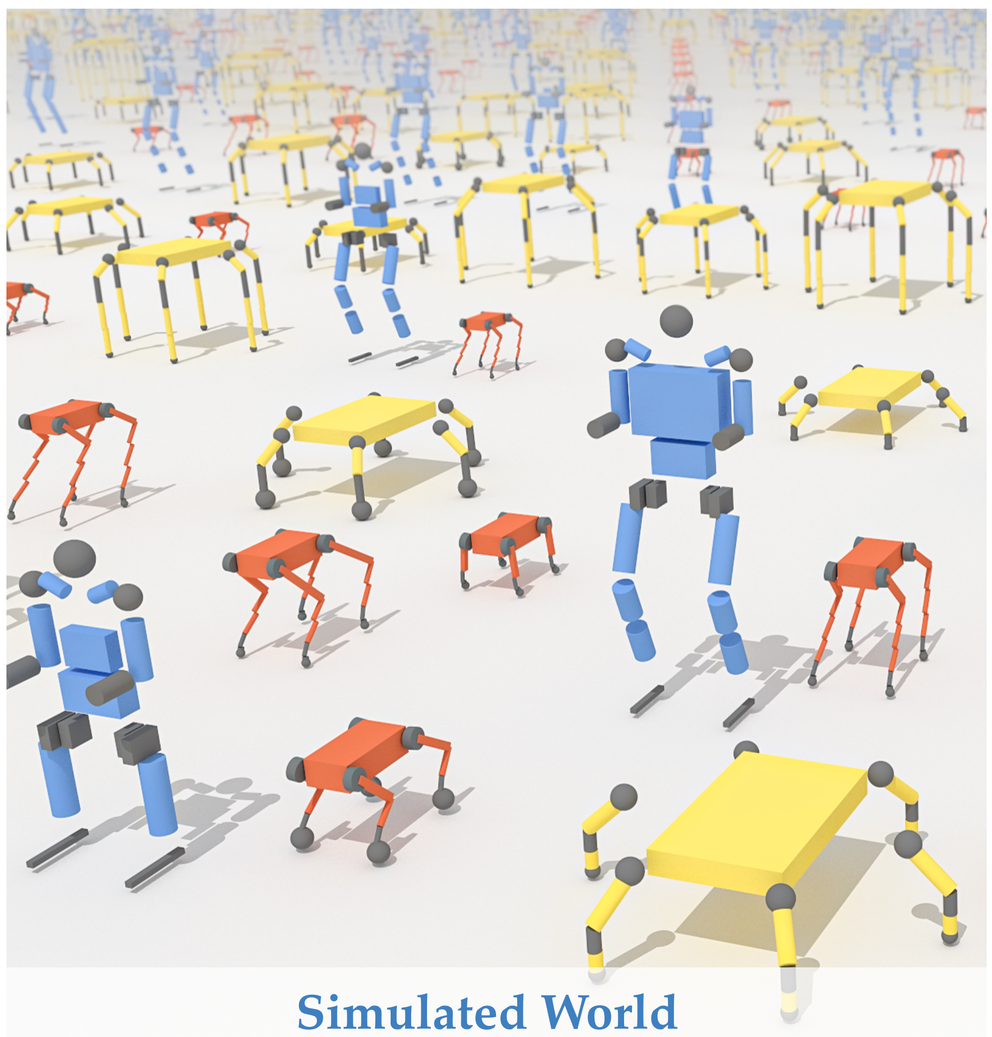
(a) Embodiment Scaling within Morphology Classes



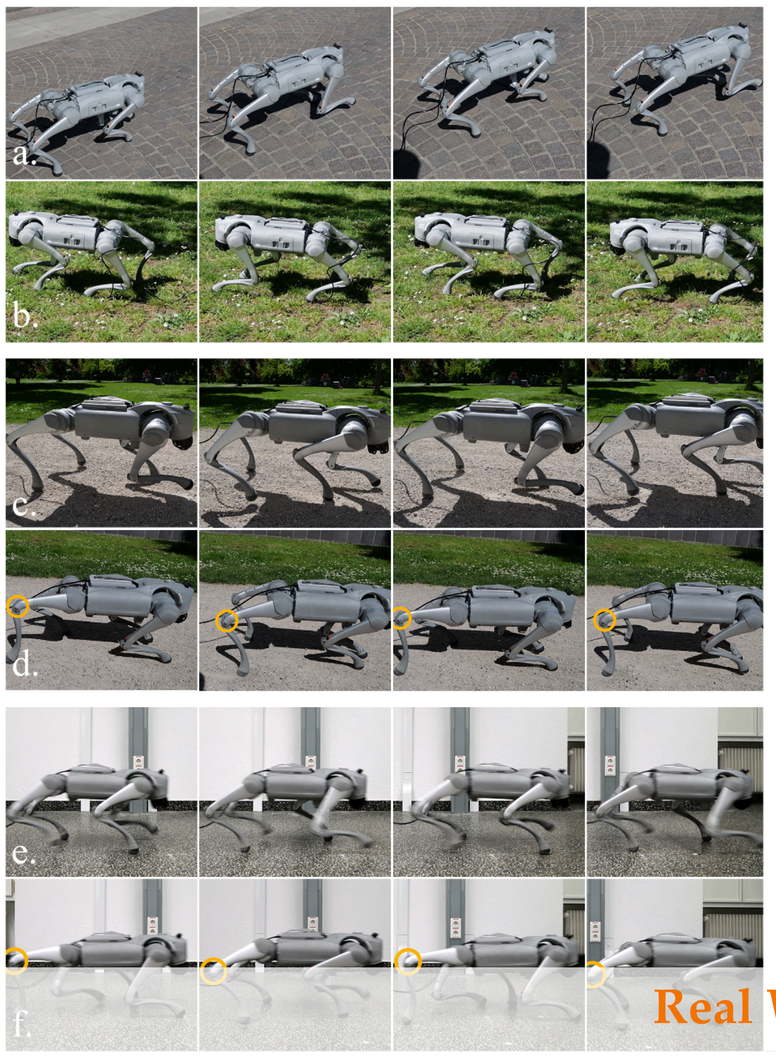
(b) Cross-Class Learning

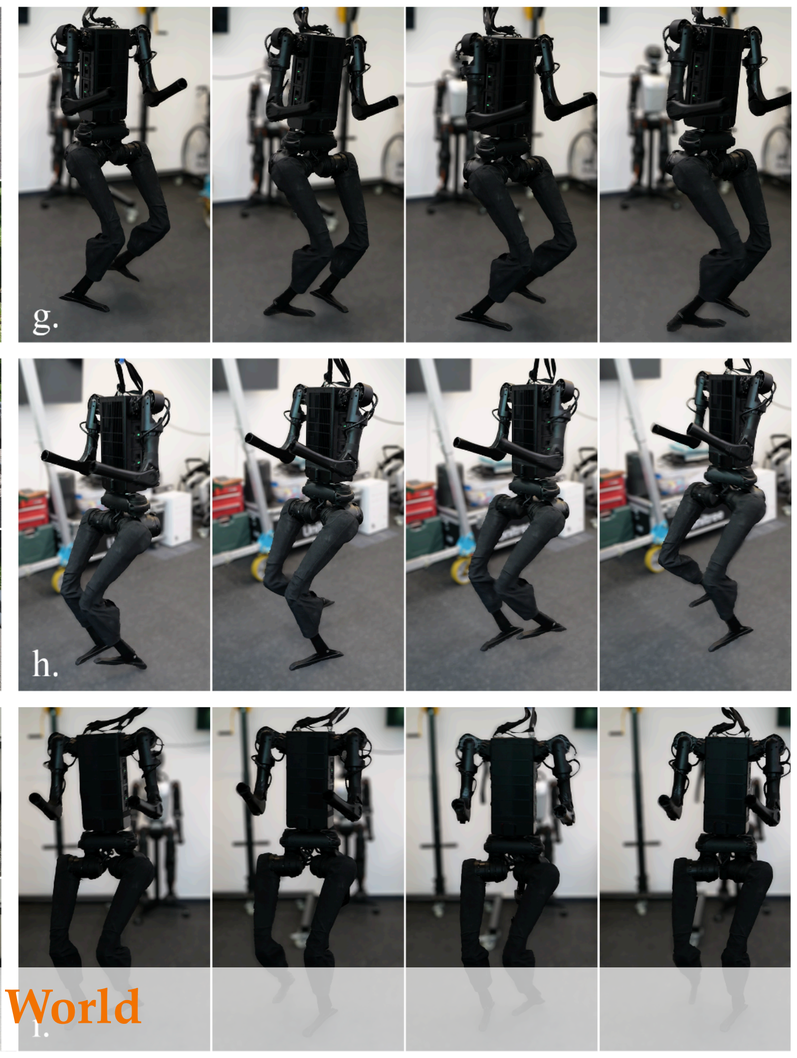
- More embodiments → better generalization to unseen embodiments (C1–C4)
- Harder embodiments require more embodiments to saturate generalization (C1 vs C2/C3)
- Cross-morphology training improves generalization (C4 vs C6/C7/C8)
- Embodiment scaling > > pure data scaling for embodiment-level generalization (C4 vs C8)

One Policy, Two Worlds, Many Robots



Simulated World





Real World