Learning to Control Self-Assembling Morphologies
A Study of Generalization via Modularity

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How to train a robot to act?
Software starts simple, but hardware remains fixed & complex!

- Self-supervision
- Curious exploration
- Learning "common sense"

shared objective

Compositionality is useful in language (Andreas et al. 2016). However, parser is fixed \( \rightarrow \) tractable.

How to implement compositionality in hardware?

Dynamic Graph Networks (DGN)

Idea 1: Separate policy for each limb with shared params

How to adapt when hardware changes?

output

Input = Local Sensory State
Output = Torques, Link, Unlink

Risks are shared!

Cylinder
Configurable Motor Joint
Potential Magnetic Joint

Primitive Agents: "limbs"

Idea 2: Neural Networks as reusable LEGO Blocks

Adapt by Finetuning?

Too slow as shape changes every iteration!

Dynamic + Graph \( \rightarrow \) Dynamic Graph Nets

Message Passing:
Children pass messages to parents for communication.

adaptation by conditioning

cut and paste

Monolithic Policy, Fixed Graph

Curriculum learning but in hardware.

Message-passing helps!

Howie Choset's Lab at MIT

[Mark Yim's Lab at UPenn]
[Modular Snake Robot - Howie Choset's Lab at CMU]