

Muhan Li

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Advisor: Prof. Sam Kriegman

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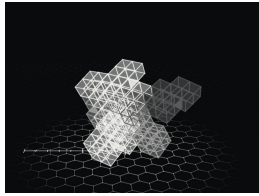
[Website](#) · [GitHub](#) · [Google Scholar](#) · [Lab](#)

Research interests: 3D generative representations · embodied AI · reinforcement learning · evolutionary design · scalable physical simulation · ML systems

Research Profile

I build computational systems that generate, represent, learn, and evolve complex embodied structures. My work covers learned 3D volumetric (voxel) representations of bodies and worlds and latent generative models of morphology. I combine them with GPU multiphysics simulation, reinforcement learning, evolutionary optimization, and sim-to-real realization, because morphology, sensing, and control are best optimized jointly. My current direction is scalable, persistent physical world construction, where bodies, sensing, behavior, and environments are generated, simulated, and evolved together.

Selected Publications



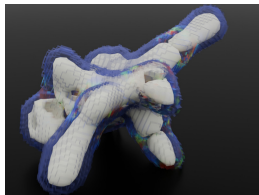
Reinforcement Learning for Freeform Robot Design

IEEE ICRA 2024

Muhan Li, David Matthews, Sam Kriegman

[Paper](#) · [Code](#) · **15 citations**

My IEEE ICRA 2024 work addresses reinforcement learning for robot design, where prior methods only resize or reorient limbs within a fixed topological template. I apply policy-gradient optimization over a voxel design space, with actions that deposit or remove bundles of atomic building blocks. These actions compose nonparametric macrostructures such as appendages, organs, and cavities, giving freeform designs arbitrary internal and external topology.



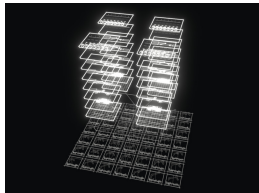
Generating Freeform Endoskeletal Robots

ICLR 2025 **Spotlight**

Muhan Li, Lingji Kong, Sam Kriegman

[Paper](#) · [Code](#) · [Website](#) · **17 citations**

For *Generating Freeform Endoskeletal Robots*, I bridge disjoint design spaces, rigid jointed robots and soft jointless ones, with endoskeletal robots: soft tissue around articulated skeletons. I train a 3D variational autoencoder on 20 million synthetic voxel designs, encoding tissue and skeleton in a continuous 512-dimensional latent space with topology-changing interpolation. PPO trains a universal graph-transformer controller conditioned on the skeletal graph, and CMA-ES searches the latent space, producing bodies that walk and cross rough terrain.



ECo-MoE: Embodiment-Conditioned Mixture of Experts Increases the Evolvability of Robots

ICML 2026

Yibin Wang, Muhan Li, Zihan Guo, Sam Kriegman

[Paper](#) · [Code](#) · [Website](#)

Together with Yibin Wang, I developed a model that encodes robot designs as latent genotypes decoded into bodies and co-optimizes their distribution with sensorimotor control. An embodiment-conditioned mixture of sensorimotor experts, gated by the decoded embodiment coordinates, stands between per-robot policies and one universal controller and keeps knowledge modular. Pretrained experts injected into the mixture steer the latent morphology distribution toward chosen structural traits, the “evo by demo” mechanism.



Creating Manufacturable Blueprints for Coarse-Grained Virtual Robots

arXiv 2026

Zihan Guo, **Muhan Li**, Shuzhe Zhang, Sam Kriegman

Paper

With Zihan Guo, I worked on realizing evolved virtual bodies, which are rarely built because evolution runs at an abstraction that discards functional physical detail. A constraint-resolution pipeline embeds the structural and functional semantics of motors, electronics, batteries, and wiring into the coarse volumetric design, producing builder-ready blueprints. The pipeline also accepts sketch-conditioned input, user-drawn or AI-generated body plans, linking generative morphology to physical construction and sim-to-real experiments.

Research Mentoring and Collaboration

Kriegman Lab, Northwestern University

- I mentor and collaborate with junior researchers on problem formulation, system design, experiments, and paper development in embodied AI and automated robot design.
- I worked closely with **Yibin Wang** on embodiment-conditioned modular control and evolutionary learning, resulting in **ECo-MoE (ICML 2026)**.
- I worked closely with **Zihan Guo** on manufacturable blueprint generation and sim-to-real realization of freeform virtual designs.

Selected Systems and Open Source

Machin

[Code](#)

*PyTorch reinforcement learning framework, **400+ GitHub stars**.*

Machin is a reusable RL framework that covers value-based, actor-critic, multi-agent, imitation, inverse-RL, and distributed training workflows. It includes distributed communication, resource discovery, and synchronization infrastructure and a heavily tested Python codebase.

RISE engine (in development)

[Code](#)

The RISE engine is a GPU-oriented voxel and multiphysics simulator that underlies the endoskeletal research and the Darwinian-world direction.

Education

Northwestern University

2023–present

PhD in Computer Science · Advisor: Prof. Sam Kriegman

Northwestern University

2020–2022

M.S. in Computer Science

Sun Yat-sen University

2016–2020

B.Eng. in Computer Science and Technology

Technical Skills

Python, C/C++, CUDA, PyTorch, Linux, distributed and GPU computing, physical simulation, sim-to-real pipelines.

Public Service

Kriegman Lab HPC system: architecture and management

Reviewer: ICML 2026

Distinctions

- Best System Design, International Aerial Robot Contest, 2018.
- First Prize of System Control, International Aerial Robot Contest, 2017.