

Yeonsu Jung

Physics-based simulation · Numerical optimization · Contact-rich robotics

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SUMMARY

Mechanical engineer (Ph.D.) and Research Associate in Applied Mathematics at Harvard. I build physics-based simulations of contact-rich and deformable systems and the numerical optimization that runs on them: differentiable simulation, trajectory optimization, inverse design and reinforcement learning. What I most want to work on is real-to-sim-to-real transfer: a simulator built from measurements of the real system, calibrated against hardware, and results that hold when they go back to it. Co-author of 14 peer-reviewed journal papers, five of them in *PNAS*, and others in *Science Robotics* and *Science Advances*.

SKILLS

Simulation	MuJoCo (C++ plugin API, MJX, MuJoCo Warp, mjlabs), Newton; my own rigid-body contact engine in C++17 with OpenMP and CUDA; discrete elastic rods; cone-complementarity contact (projected Gauss–Seidel) and penalty contact with Cundall–Strack and Hertz–Mindlin friction
Optimization	Differentiable simulation in JAX (jit, vmap, scan); trajectory optimization; sparse Newton and Gauss–Newton solvers; FIRE energy minimization on GPU; augmented Lagrangian methods; CasADi/IPOPT
Control, learning	PPO (RSL-RL, CleanRL); LQR about periodic orbits; sampling-based receding-horizon control
Software	Python, C++17, CUDA, JavaScript, MATLAB, Julia; pybind11, CMake, pytest, GitHub Actions, SLURM
Experiment	X-ray micro-CT and 3D segmentation; high-speed imaging; particle image velocimetry; apparatus design and machining

SELECTED PROJECTS

Elastic rods in joint coordinates, for robot simulators

2025–2026 · manuscript in preparation, sole author

- Derived one swing–twist rod energy with an exact, closed-form ball-joint torque, and implemented it four ways (NumPy, JAX, PyTorch inside mjlabs, a C++ plugin for MuJoCo) that agree to 2×10^{-11} . The chain converges to Euler–Bernoulli beam theory at fourth order.
- Found that MuJoCo's stock cable torque is not the gradient of an energy (off by 7.7–46.7% once the bend axis tilts) and that its RK4 is second order, not fourth, for non-planar rotations.
- Control on the verified model: a whip crack optimized by reverse-mode differentiation through MJX (tip at 68 m/s, 5.8 mm from its target); a periodic LQR that holds an unstable cracking orbit; PPO in 4,096 parallel environments (MuJoCo Warp) that rears a 16-link chain; a receding-horizon controller that rights a tumbling glider in 10 of 10 launches.

Entangled rod packings: optimization, contact engines, X-ray CT

2021–2026 · PNAS 2025 · PRL under revision

- Wrote a JAX optimizer (FIRE, on GPU) that maximizes the entanglement of up to 2,000 rods without overlap, and a C++17 engine for rigid rods in contact (cone complementarity by projected Gauss–Seidel, soft contact, OpenMP, a CUDA broad phase).
- Showed that maximally entangled packings cage themselves and hold together by friction alone. Re-ran the dynamics in MuJoCo to test which results survive a change of contact model: the cooling law does (time constant within 15%), contact lifetimes do not.
- Measured real packings by X-ray micro-CT, with a pipeline that traces about 4,600 rods in a $2000 \times 2000 \times 741$ voxel scan in 12 minutes.

Shape-morphing lattices: prediction and inverse design

2024–2026 · PNAS 2026

- Discrete elastic rod simulations that predict how rotationally 3D-printed lattices morph when heated (with the Lewis group at Harvard).
- Inverse design in JAX: a damped sparse Newton solver with stability checks follows the equilibrium out of the flat state, and Gauss–Newton fits the design to a target surface.

Calibrating a simulator against hardware

2026 · with experimental collaborators

- A simulator for chains of centimeter-scale vibration-driven robots, with hard and soft constraints. Rotational noise is fitted from tracking of single robots; the calibrated model matches 23 of 30 cells of the measured stability map. I rejected a variant that fitted better but stretched the joints beyond their measured play.

EXPERIENCE

Research Associate in Applied Mathematics

2026–present

Postdoctoral Fellow

2021–2026

Harvard John A. Paulson School of Engineering and Applied Sciences, Cambridge, MA · with L. Mahadevan

- Simulation, optimization and experiments on contact-rich filamentary systems: collision handling, nonlinear rod mechanics, reduced-order models, inverse design.
- Worked with the Harvard Microrobotics Laboratory on grasping by entanglement (*PNAS* 2022) and with the Lewis group on printed shape-morphing lattices (*PNAS* 2026).

Postdoctoral Fellow

2020–2021

Rowland Institute at Harvard, Cambridge, MA

- Modeling, fabrication and flow measurement (particle image velocimetry) of shark-skin-inspired drag-reducing surfaces.

Postdoctoral Fellow

2019–2020

Seoul National University, Seoul, South Korea

- Models and experiments for ionic-hydrogel actuators and soft electroreceptors (*Science Robotics* 2020, *Science Advances* 2021), and the mechanics of mud nests (*PNAS* 2021).

EDUCATION

2019 **Ph.D., Mechanical Engineering**, Seoul National University (advisor H.-Y. Kim). Thesis: Hydrodynamic principles of water uptake of plant roots.

2014 **M.S., Biomedical Engineering**, Gwangju Institute of Science and Technology (GIST)

2012 **B.S., Mechanical Engineering**, Pohang University of Science and Technology (POSTECH)

SELECTED PUBLICATIONS

Y. Jung, L. Mahadevan. Emergent cohesion via self-caging in maximally entangled rod packings. *Physical Review Letters*, under revision. [arXiv:2606.03952](https://arxiv.org/abs/2606.03952) (2026).

M. K. Abdelrahman, J. K. Wilt, **Y. Jung**, et al. Rotational 3D printing of active–passive filaments and lattices with programmable shape morphing. *PNAS* 123, e2537250123 (2026).

Y. Jung, T. Plumb-Reyes, H.-Y. G. Lin, L. Mahadevan. Entanglement transition in random rod packings. *PNAS* 122, e2401868122 (2025).

K. Becker, C. Teeple, N. Charles, **Y. Jung**, et al. Active entanglement enables stochastic, topological grasping. *PNAS* 119, e2209819119 (2022).

W. J. Song*, Y. Lee*, **Y. Jung***, et al. Soft artificial electroreceptors for noncontact spatial perception. *Science Advances* 7, eabg9203 (2021). *Equal contribution.

Y. Jung, S. Jung, S.-i. Lee, W. Kim, H.-Y. Kim. Avian mud nest architecture by self-secreted saliva. *PNAS* 118, e2018509118 (2021).

Full list of 14 journal papers: yeonsu-jung.github.io/publications.html

SELECTED TALKS

2026 Condensed Matter Theory Kids' Seminar, Harvard
2025 Physics of Living Systems, MIT
2024 Network Science Institute, Northeastern University
2023 Physics colloquia, Michigan Technological University and Bard College; APS March Meeting

AWARDS AND TEACHING

2021–22 Postdoctoral Fellowship Abroad, National Research Foundation of Korea
2014–16 Superior Academic Performance Scholarship, Seoul National University
2008–10 National Scholarship, National Research Foundation of Korea
2024 Teaching Fellow, Gen Ed 1190, Harvard University