Taehwa Hong

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Education

Seoul National University Aug. 2019 – Feb. 2026 (Expected)
Integrated M.S./Ph.D. in Mechanical Engineering (Advisor: Prof. Yong-Lae Park)
Thesis: *"Accelerated, High-Fidelity Simulation of Deformable Bodies for Physics Abstraction in Robot Learning"*

Seoul National University Feb. 2013 – Aug. 2019
B.S. in Mechanical and Aerospace Engineering
Leave of absence for military service (2014 – 2016)

Summary

Ph.D. candidate at Seoul National University specializing in physics-based simulation and sim-to-real transfer for robotic learning. My research focuses on bridging the reality gap in contact-rich physical interactions by proposing a unified data-driven abstraction framework. This approach decouples high-fidelity ground truth generation from runtime execution to resolve the fidelity-tractability trade-off. Key contributions include developing a neural physics engine that enables real-time, high-fidelity tactile perception and engineering a surrogate model that significantly accelerates policy training for complex dynamic systems. The framework was validated via robust zero-shot sim-to-real transfer, demonstrating photorealistic sensory synthesis and successful policy deployment on physical hardware. Currently seeking a postdoctoral position to leverage this expertise in developing scalable simulation environments for general-purpose robot learning.

Research Experience

- **Simulated Vision Tactile Sensor for Manipulation Tasks** (2025 – Present)
  Developed a Neural Physics Engine (NPE) to enable real-time, high-fidelity vision tactile simulation within physics-based simulation like MuJoCo. Trained as an approximation model on a large-scale dataset generated from calibrated Finite Element Method (FEM) simulations, the NPE predicts full-field physical deformations of vision based tactile sensors. This approach directly addresses the sim-to-real gap by accurately replicating the underlying forces and deformations observed in real-world contact interactions. The framework demonstrates the capability to generate physically-grounded data essential for advancing contact-rich robotic manipulation learning.
- **High-Fidelity Synthetic Data Generation for Vision Tactile Sensor** (2024 - 2025)
  This research addresses the data requirements for learning-based tactile perception by developing a simulation framework for vision-based tactile sensors. A highly precise FEM model of the DIGIT sensor was created in the physics-based simulator and calibrated against real-world indentation data. Using this calibrated model, a bidirectional mapping between physical contact states and visual RGB images was created by training two neural networks. A perception network estimates physical states, such as surface deformation and force distribution, from a real RGB image, while a rendering network generates a synthetic RGB image from a simulated physical state. The resulting framework provides a pipeline for generating synthetic tactile data and for adding physical annotations to existing real-world datasets.
- **Sim-to-Real Reinforcement Learning via a Data-Driven Surrogate Model** (2021 – 2024)
  This research was motivated by the challenges of applying data-intensive RL to soft robots, which include sample inefficiency and hardware fragility. The work addresses the trade-off between the physical accuracy of high-fidelity FEM simulations and the high computational speed required for RL. A sim-to-real framework was developed, beginning with a high-fidelity FEM simulation that was calibrated using real-world data. A simplified, rigid-body surrogate model was then created in a fast, physics-based simulator. The two simulation domains were bridged by training a deep learning model, combining a Transformer and a Physics-Informed Neural Network (PINN), to learn the system dynamics from the FEM data and map them onto the surrogate

model. This approach enabled RL policy training in an accelerated environment, and the learned policies were validated through sim2real transfer to the physical robot for control tasks.

- **Model-Based Control for a Compliant, Pneumatically-Actuated System** (2019 – 2022)
  This research phase involved developing a real-time controller for a nonlinear system: a pneumatically-actuated origami manipulator. The objective was to model the system's deformations for control without using FEM, due to their computational cost. An analytical kinematic model was developed from a first-principles approach, incorporating geometric assumptions and energy-based methods to represent the system's dynamics. The model was implemented in nonlinear controller for real-time inverse kinematics. Using feedback from embedded proprioceptive sensors, this implementation enabled closed-loop position and force control on the physical hardware, providing a method for the model-based control of this type of compliant system.

- **Student Project Lead, Fully-Soft Assistive Suit** (2020 – 2023)
  As the student project lead for a government-funded (MOTIE) initiative, I spearheaded the entire lifecycle of a fully-soft wearable suit for physical assistance. I led the end-to-end system development, including the design and fabrication of novel Flat Inflatable Artificial Muscles (FIAMs) and a compact, untethered pneumatic system. The project culminated in clinical trials where I quantitatively validated the suit's effectiveness, demonstrating a significant reduction in metabolic cost for users during lifting tasks.

- **Drag Minimization of an Underwater Morphing Robot** (2022 – 2023)
  Developed a reinforcement learning environment to train a shape-morphing underwater robot. The goal was to create a policy that adapts the robot's topology in real-time to minimize hydrodynamic drag, based on mesh-based fluid dynamics simulation. My contributions included the experimental setup, reward function shaping, and topological modeling.

Publications

Google Scholar Profile: https://scholar.google.co.kr/citations?user=kzrORlsAAAAJ&hl=ko

Journal Articles

[J1] **T. Hong**, J. Yang, and Y.-L. Park, "Model-based control of proprioceptive origami actuators for pneumatic manipulation," *International Journal of Robotics Research (IJRR)*, 2025.

[J2] **T. Hong**, J. Lee, B.-H. Song, and Y.-L. Park, "Bridging High-Fidelity Simulations and Physics-Based Learning Using A Surrogate Model for Soft Robot Control," *Advanced Intelligent Systems*, (11. Oct, 2025, Accepted).

[J3] **T. Hong**, C. Lee, S. Chang, E. Choi, B. Kim, J. Ahn, and Y.-L. Park, "Design of a fully-soft lift-assist wearable suit powered by flat inflatable artificial muscles," *IEEE Robotics and Automation Letters (RA-L)*, Feb. 2025.

[J4] D. W. Kim, S. Lee, **T. Hong**, and Y.-L. Park, "Exploration-based model learning with self-attention for risk-sensitive robot control," *npj Robotics*, vol. 1, no. 1, p. 7, 2023.

[J5] F. Schwab, E. T. Lunsford, **T. Hong**, F. Wiesemuller, M. Kovac, Y.-L. Park, O. Akanyeti, J. C. Liao, and A. Jusufi, "Body caudal undulation measured by soft sensors and emulated by soft artificial muscles," *Integrative & Comparative Biology*, vol. 61, no. 5, pp. 1955-1965, 2021.

[J6] T. Kim, S. Lee, **T. Hong**, G. Shin, T. Kim, and Y.-L. Park, "Heterogeneous sensing in a multifunctional soft sensor for human-robot interfaces," *Science Robotics*, vol. 5, no. 49, p. eabc6878, 2020.

[J7] H. S. Cho, T. Kim, **T. Hong**, and Y.-L. Park, "Ratchet-integrated pneumatic actuator (RIPA): a large-stroke soft linear actuator inspired by sarcomere muscle contraction," *Bioinspiration & Biomimetics*, vol. 15, no. 3, p. 036011, 2020.

Conference Papers

[C1] **T. Hong** and Y.-L. Park, "Bidirectional Mapping between Physical Contacts and Visual Tactile Images for Physics-Based Simulation," in *Proc. IEEE-RAS International Conference on Humanoid Robots (Humanoids)*, 2025.

[C2] **T. Hong**, S. H. Park, J. H. Park, N. Park, and Y.-L. Park, "Design of pneumatic origami muscle actuators (POMAs) for a soft robotic hand orthosis for grasping assistance," in *Proc. IEEE International Conference on Soft Robotics (RoboSoft)*, 2020, pp. 627-632.

Teaching Experience

- TA, Actuation and Sensing Mechanisms for Robots. SNU Lab Sessions. (2021 & 2022)
- Guest Lecturer, High School Outreach Program on Robotics and Engineering (Aug. 2023)
- University Group Study Organizer at SNU (Convex Optimization). (Nov. 2023 – Feb. 2024)

Mentoring Experience

- **Jung-Jae Lee** (*Boston University, CS*): Mentored on physics-based simulation for soft robotics, leading to co-authorship on a journal paper submitted to *Advanced Intelligent Systems*. (Jun. 2023 – Nov. 2023)
- **Taekyung Lee** (*Caltech, ME*): Provided intensive tutoring on robot arm control using ROS2, including path planning algorithms. (Jun. 2024 - Sep. 2024)
- **Seoungwon Lee** (*Seoul National University, CS*): Supervising a project on Isaac Sim for teleoperation and RL based data acquisition. (Jun. 2025 – Dec. 2025)

Honors and Awards

- Excellence Award (Runner-up), The 2nd X-Corps Program: Real-World Problem Solving, SNU (2019)
- Academic Excellence Scholarship for Undergraduates, Seoul National University (2017)

Skills

Simulation & Modeling	FEM (SOFA, ABAQUS, COMSOL), Physics-based simulation (PyBullet, Isaac Sim, MuJoCo), Dynamics modeling, Contact mechanics, Deformable body dynamics, Model rder Reduction (MOR), System Identification
Machine Learning	Reinforcement learning agents, Physics-Informed Neural Networks (PINNs), Transformer based dynamics, Graph Neural Networks (GNNs)
Robotics & Control	ROS2, Control systems design, Sim-to-real transfer, Sensor integration (Tactile, Force, IMU, Hall-effect)
Hardware & Design	SolidWorks, Blender, Onshape, AutoCAD, Mechanical Design, Robot prototyping, Sensor calibration
Prototyping & Fabrication	3D Printing (SLA, SLS), Machining (Lathe), CO2 Laser Cutting, Pneumatic regulation, Robot prototyping
Programming	Python, C++, MATLAB