Seonwoo Kim

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Research Interests

My research focuses on **integrating model-based robotics and learning-based methods** in a complementary manner, leveraging the strengths of each to build robust and adaptive robotic systems. I aim to combine physical models, state estimation, and control with learning-based methods to handle complex dynamics, contacts, and uncertainties that are difficult to model explicitly, toward robust and adaptive robotic systems. In particular, I am interested in using physical structure to guide learning while leveraging data-driven methods to compensate for modeling limitations and unmodeled dynamics.

Education

Korea University, MS in Mechanical Engineering — Sept 2023 – Aug 2025

- Advisor: Prof. Daehie Hong | GPA: 4.0/4.0 (WES)
- **Thesis:** Adaptive Contact Force Estimation for Robotic Manipulators Using an Interacting Multiple Model-Based Disturbance Kalman Filter and Bayesian Neural Network

Korea University, BS in Mechanical Engineering — Mar 2017 – Aug 2023

- GPA: 3.34/4.0 (WES)

Work Experience

Korea Cyber University, Adjunct Professor, Dept. of Robotics Convergence — Aug 2026 – Present

Korea Institute of Science and Technology (KIST), Research Intern — Jul 2025 – Dec 2025

Republic of Korea Air Force (mandatory military service) — Feb 2019 – Dec 2020

Publications

Journal Articles

[J2] **Seonwoo Kim**, Myeongin Jin, Jihun Kim, Chanwoo Kim, Daehie Hong, "Task Space End-Effector Contact Force Estimation for Robotic Manipulators Using a Bayesian Augmented Interacting Multiple Model-Based Disturbance Kalman Filter," *IEEE Transactions on Instrumentation and Measurement*, vol. 75, Art. no. 7501213, 2026. doi:10.1109/TIM.2026.3659623

[J1] **Seonwoo Kim**, Chanwoo Kim, Yeonho Ko, Daehie Hong, "Acceleration Measurement-Free Dissipative Disturbance Observer for Robotic Manipulators," *IEEE Robotics and Automation Letters*, vol. 10, no. 6, pp. 5999–6006, 2025. doi:10.1109/LRA.2025.3564205

Conference Proceedings

[C3] **Seonwoo Kim**, Jihun Kim, Chanwoo Kim, Daehie Hong, "Soil Interaction Force Estimation via Identified Excavator Dynamics with Particle Filter," *International Conference on Precision Engineering and Sustainable Manufacturing (PRESM)*, 2024. (Poster)

[C2] **Seonwoo Kim**, Jangho Bae, Chanwoo Kim, Jihun Kim, Daehie Hong, "Estimating the Interaction Force Between Excavator Bucket and Ground Using a Simplified Dynamical Model and Hydraulic Sensors," *KSPE Spring Conference*, 2024. (Poster)

[C1] **Seonwoo Kim**, Jangho Bae, Jaemyung Huh, Chanyoung Moon, Cheolhwan Im, Jinwoo Park, Daehie Hong, "Optimal Excavator Bucket Trajectory Generation with Soil Mechanics Model Design," *KSPE Autumn Conference*, 2023. (Poster)

Teaching Experience

Korea Cyber University — Adjunct Professor, Dept. of Robotics Convergence — Aug 2026 – Present

Korea University — Teaching Assistant, MOBI208 Dynamics (Prof. Seongho Yun) — Mar 2025 – Jun 2025

Korea University — Teaching Assistant, MECH226 Dynamics (Prof. Daehie Hong) — Mar 2024 – Dec 2024

Research Experience

Korea Institute of Science and Technology (KIST), Research Intern — Jul 2025 – Dec 2025

Project: Learning-Based Humanoid Manipulation and Teleoperation

- Developed an **end-to-end VR teleoperation and demonstration-collection system** for the Unitree G1 humanoid using Meta Quest hand tracking, inverse kinematics, camera/sensor modules, and Jetson Orin-based real-time control.
- Fine-tuned **NVIDIA GR00T** with a frozen vision encoder for humanoid pick-and-place tasks across varying workspace heights and objects with diverse geometries. Collected real-world demonstrations through VR teleoperation and augmented the dataset with synthetic demonstrations generated using **NVIDIA Cosmos Transfer**.
- Designed a custom **reinforcement-learning environment in NVIDIA Isaac Sim/Lab** for a Unitree G1 equipped with an in-house dexterous hand, including the observation space, reward functions, and task formulation for learning object reorientation and upright placement of cylindrical objects.

Korea University, Student Researcher — Sep 2023 – Aug 2025

Project: Autonomous Excavation and Sensorless Contact-Force Estimation

- Contributed to the development of an **autonomous excavation system targeting expert-level operation**, using a full-scale 30-ton hydraulic excavator for field deployment and a 1/8-scale hydraulic excavator for laboratory development and validation.
- Developed a **learning-based trajectory generation framework from expert demonstrations** for autonomous excavation. Terrain geometry captured by a depth camera was projected into a 2D profile and represented using polynomial coefficients as model inputs, while the learned model sequentially generated joint trajectories. Integrated four originally task-specific policies—radial digging, trenching, slope excavation, and stockpile excavation—into a unified inference framework.
- Proposed an **acceleration-measurement-free dissipative disturbance observer (AFDDO)** using generalized momentum and (Q, S, R)–α dissipativity, with LMI-based gain and bandwidth design for robust estimation of rapidly varying disturbances without inertia-matrix inversion; experimentally validated on the 1/8-scale hydraulic excavator and published in **IEEE RA-L**.
- Extended the model-based estimator into a **Bayesian-augmented interacting multiple-model disturbance Kalman filter (BIMM-DKF)**, combining a Bayesian neural network for friction/model-discrepancy compensation and uncertainty-aware covariance adaptation with an IMM framework for switching among different contact-force dynamics. Real-world experiments reduced vertical contact-force MAE by up to **45.2%** and MSE by up to **58.0%** relative to baseline estimators; published in **IEEE TIM**.

Project: Autonomous Motor Grader Blade Control

- Developed the **kinematic model of a 6-DOF motor grader earthmoving mechanism**, consisting of a 3-DOF 3RRPS-S spatial parallel mechanism and serial blade rotation, tilt, and sideshift modules. Formulated and solved the nonlinear kinematic constraints using **CasADi-based optimization** for blade pose determination and command generation.
- Designed the **TCP/IP communication and middle-level control interface** between the blade pose controller and the low-level machine controller, and deployed the system on a full-scale motor grader for autonomous grading operations including ground leveling and specified cross-slope formation.

Awards and Scholarships

Teaching Assistantship (50% tuition, 3 semesters), Korea University — 2024 – 2025

MATLAB Korea AI Competition for University Students — Bronze Award — 2023

Developed a GRU-based imitation-learning system for autonomous excavation using expert demonstrations and depth-camera-based terrain perception. **[Demo]**

Technical Skills

Programming: C, C++, Python, MATLAB/Simulink, LabVIEW, Julia

Learning & Simulation: PyTorch, NVIDIA Isaac Sim/Lab, ROS2, Git, Docker

Modeling & Optimization: CasADi, MATLAB Robust Control Toolbox (LMI), SolidWorks

Hardware & Instrumentation: Hydraulic excavators (30-ton and 1/8-scale), motor grader, Unitree G1, Jetson Orin, Meta Quest, IMU / hydraulic pressure / depth sensors; LabVIEW-based experimental setup and data acquisition