# SOOYONG KIM

## Robotics & Autonomous Systems Engineer

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### PROFESSIONAL SUMMARY

Robotics and autonomous systems engineer with a mechanical-engineering research background in nonlinear dynamics, analytical modeling, controller design, system identification, and experimental validation. At Waterloo, conducted autonomous mobile-robot research including physical experiments, mobile MPC, localization, navigation and semantic perception. At UVic, developed vibration-based system identification and validated machining stability models experimentally. Recent independent robotics studies integrate UR5e dynamics, ROS 2 / Isaac Sim effort control, task-oriented Cartesian motion, perception, planning and bounded residual reinforcement learning. Engineering approach: establish physical assumptions, reconstruct and validate the model, evaluate competing methods, examine implementation behavior, and draw conclusions from quantitative evidence.

### EDUCATION

**University of Waterloo** | 2020–2021 · PhD Program, Mechanical & Mechatronics Engineering; voluntary withdrawal

**University of Victoria** | 2016–2019 · Master of Applied Science (MASc), Mechanical Engineering

Thesis: Predicting Regenerative Chatter in Turning Using Operational Modal Analysis

**Pusan National University** | 2005–2012 · B.Sc., Mechanical Engineering

Undergraduate thesis: Investigation of SOFC Injecting Natural Gas Directly

### SELECTED ROBOTICS & CONTROL PROJECTS

#### UR5e Heavy-Payload Transportation: Dynamics, Task Design & Nominal Control

Independent engineering study · ROS 2 Humble · Isaac Sim 6.1 · Python · C++ · MPC

- Reconstructed a six-revolute-joint UR5e model from robot-description geometry, coordinate conventions, inertia and rigid payload attachment; checked FK, Jacobian, mass terms and gravity relationships against Isaac Sim.
- Designed a 3 s two-parabola Cartesian transportation reference through extended workspace configurations; examined reach, IK continuity, Jacobian conditioning, joint velocity, dynamic torque and sampled geometry feasibility.
- Compared 25 computed-torque PD configurations against 30 constrained MPC configurations, assessing joint and Cartesian tracking, terminal motion, effort limits and solver demand.
- Selected G025 (Kp 256, Kd 41.6); achieved 1.1951 mm Cartesian Tool0 RMSE under matched 3 kg ROS 2–PhysX validation. Verified gravity preload, active return, stabilization and external effort command execution.
- Distinguished the deterministic numerical dynamics model from asynchronous ROS 2–PhysX state timing and effective actuation; documented simulation-to-hardware validation boundaries.

#### UR5e Residual Reinforcement Learning Under Payload-Mass Mismatch

G025 + PPO / SAC / TD3 · Six-joint Bounded Residual Torque · PhysX Transfer

- Defined 49-dimensional observations and six bounded corrective joint torques; developed PPO, SAC and TD3 policies using a 30,000-interaction numerical-screening protocol.
- For 3 kg assumed / 5 kg actual load, ROS 2–PhysX zero-residual Cartesian RMSE was 10.560 mm; PPO reduced it to 6.061 mm (42.6% improvement), with joint-level effort compared against analytical inverse-dynamics discrepancy.
- Verified that the same policies degraded tracking at matched 3 kg and lighter 1 kg actual loads; framed learned compensation as conditional rather than universally beneficial.

- Trained a separate reverse-mismatch PPO policy (5 kg model / 3 kg actual), reducing PhysX RMSE from 8.039 to 4.585 mm; evaluated both policy/model stacks at actual 4 kg (1.931 and 1.763 mm RMSE).

**Model-Based & Learning-Based Control of a 2-DOF Manipulator**

Computed-Torque Control · Pure SAC · Residual SAC

- Defined a Cartesian end-effector tracking task with coupled nonlinear rigid-body dynamics and a controlled 30% link-2 mass discrepancy.
- Established 0.195 mm exact-model CTC and 31.116 mm mismatched-model CTC references; evaluated Pure SAC (4.662 mm) and CTC + Residual SAC (1.290 mm) on the final task.
- Compared learned residual torque with the analytical inverse-dynamics deficit, emphasizing physical explanation rather than benchmark-only rankings.

**Robot-Aware Path Planning & Navigation**

Dijkstra · A* · RRT · RRT* · Collision & Geometry Analysis

- Evaluated deterministic search and stochastic sampling over benchmark maps, separating computational expense, path quality, and convergence behavior.
- Applied platform-specific inflation and footprint feasibility to TurtleBot3 Waffle Pi and Clearpath Ridgeback; assessed 100 shared missions and analyzed clearance and path simplification.

**Real-Time Vision Perception Pipeline**

ROS 2 · PyTorch · YOLO · OpenCV · Object Tracking

- Integrated object detection, tracking, instance segmentation and end-to-end latency measurements in ROS 2.
- Recorded 31.95 FPS over 2,136 frames, 18.26 ms average processing latency and 8.70 ms average inference latency on an RTX 5060 Laptop GPU.

**LiDAR–Camera 3D Perception & Fusion**

ROS 2 · Isaac Sim · LiDAR · RGB Camera · 3D Geometry

- Calibrated camera intrinsics and LiDAR–camera extrinsics and implemented 3D-to-2D point projection, object-level depth association and geometric consistency checks.
- Investigated alignment errors, viewpoint effects and range robustness in simulated warehouse scenes.

**ROS 2 EKF Sensor Fusion**

ROS 2 · Gazebo · Wheel Odometry · IMU

- Implemented a nonlinear state-estimation pipeline integrating wheel odometry and IMU measurements.
- Compared fused state estimates against raw odometry and ground truth to measure trajectory error and drift.

## RESEARCH EXPERIENCE

**University of Waterloo — Research Assistant, Mechanical & Mechatronics Engineering** | May 2020 – Dec 2021

Waterloo Mechanical Systems and Control Lab

- Conducted mobile-robotics research involving autonomous navigation, path planning, localization, sensing and physical-robot experimentation.
- Investigated transfer learning for robot semantic tasks and LiDAR–camera sensor fusion for semantic road segmentation using the KITTI dataset.
- Implemented MPC-based mobile-robot navigation and carried out physical path-following experiments; supported indoor planning optimization.
- Worked with Summit mobile robots, motion-capture systems and associated sensors; prepared ROS-based operation and instructional documentation.

**University of Victoria — Research Assistant, Dynamics and Digital Manufacturing Lab** | Aug 2017 – Apr 2019

- Developed an Operational Modal Analysis approach to estimate turning stability using in-process vibration measurements before chatter fully developed.
- Modeled turning dynamics with multi-DOF state-space and time-delay equations; performed modal identification, damping estimation and stability analysis.
- Designed machining experiments with accelerometers, National Instruments DAQ, acoustic measurement and EMA; compared numerical stability predictions with physical tests.
- Investigated micromilling dynamics using Laser Doppler Vibrometry, broadband excitation, output-only OMA and comparison with impact-hammer EMA.
- Applied correlation, PSD, Time Domain Poly Reference and modified Least Squares Complex Exponential methods to distinguish harmonic excitation from structural modes.

**University of Victoria — Research Assistant, Laboratory of Advanced Multi-scale Manufacturing** | Jun 2016 – Jul 2017

- Fabricated and tested fiber-optic sensors including Long Period Grating and Fiber Bragg Grating devices.
- Conducted femtosecond-laser glass processing, microfluidic channel fabrication, glass welding and nanoparticle coating experiments.

## PROFESSIONAL EXPERIENCE

**MKS Investments — Manager, Tech Research & Analysis / Business Development** | 2023–2026

- Managed technical and market research on emerging technologies, synthesizing engineering feasibility, commercial evidence, and competitive information.
- Reviewed internal and AI-assisted research, challenging unsupported assumptions, inconsistent data, incorrect benchmarks and source credibility.
- Translated technical evaluation into decision-oriented recommendations and supported business-development activities.

**Kyungdong LNG — Co-op Student** | 2010

- Monitored LNG storage-tank operating conditions, pressure-reduction equipment and routine facility status.

## TEACHING & LABORATORY DEVELOPMENT

**University of Waterloo — Teaching Assistant** | 2021

Autonomous Mobile Robotics (MTE 544 and ME 597c): ROS, Gazebo, SLAM, AMCL, navigation, RRT/RRT*, Reeds–Shepp / Dubins planning and Pure Pursuit. Developed and updated laboratory manuals, remote demos and parameter-study exercises; guided troubleshooting and evaluated technical reports.

**University of Victoria — Teaching Assistant** | 2017–2018

Introduction to Mechanical Vibrations (MECH 330); Mechanics of Solids II (MECH 320); CAD-Aided Manufacturing (MECH 460). Supported instruction, laboratory safety, CAD/CAM toolpath and G-code verification, CNC setup, reports and assessment.

## UNDERGRADUATE RESEARCH & ENGINEERING

**Solid Oxide Fuel Cell System Fueled Directly by Natural Gas** | 2011–2012 · Pusan National University

Developed and experimentally assessed a tubular SOFC system for direct natural-gas utilization; supported system setup, measurement and performance analysis. Work led to a Korean patent application and university/external awards.

## SELECTED PUBLICATION

S. Kim and K. Ahmadi, “Estimation of vibration stability in turning using operational modal analysis,” Mechanical Systems and Signal Processing (2019).

## PATENT, AWARDS & FUNDING

- Korean Patent Application No. 10-2012-0109237 (2012), “Solid Oxide Fuel Cell System Fueled By Natural Gas Directly”; inventor: Sooyong Kim et al.
- Grand Prize, Integrated Capstone Design Competition (2011); Grand Prize, Research Assessment of Industry–University Collaboration (2011); Excellence Award, Engineering Students Technology & Science Competition (2011).
- Graduate funding and scholarships: University of Waterloo CAD 40,000 (2020–2021); University of Victoria CAD 27,000 (2016–2019); Pusan National University CAD 10,000 (2008–2011).

## TEACHING CERTIFICATIONS

Certificate in University Teaching — University of Waterloo, Centre for Teaching Excellence (Sep 2020).
Certificate in TA Training — University of Victoria (Sep 2017).

## CORE TECHNOLOGIES

Robotics & Control: ROS / ROS 2, MPC, PID/LQR, computed-torque control, residual RL, URDF, IK/FK, Jacobians, dynamic modeling, SLAM/AMCL, RRT/RRT*, path planning, Pure Pursuit.

Sensing & Perception: EKF, IMU, wheel odometry, LiDAR–camera fusion, OpenCV, YOLO, object tracking, semantic / instance segmentation, camera geometry.

Simulation, Dynamics & Computing: Isaac Sim / PhysX, Gazebo, UR5e, TurtleBot, Summit, Python, C++, MATLAB, Linux, Git, numerical analysis, OMA / EMA, modal identification, PSD, system identification, FEA.