Kai Yun

Legal Name: SirkHoo Yun

Graduate Student Researcher, Robotics Institute at Carnegie Mellon University

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RESEARCH INTEREST

My research is focused on **safe and high-performance control** of autonomous robots in the wild.
My methodology encompasses **control theory**, **deep learning**, and their **intersection**.
My vision is to develop a **unified framework** for highly reactive robot controllers in complex, dynamic environments.

EDUCATION

Carnegie Mellon University, Pittsburgh, PA — Class of 2025 (Expected)
Master of Science in **Mechanical Engineering - Research** — 4.00/4.00
Advisors: Dr. Changliu Liu (Robotics Institute), Dr. John M. Dolan (Robotics Institute)

University of California, Berkeley, Berkeley, CA — Class of 2023
Bachelor of Science in **Mechanical Engineering** — 3.68/4.00
Minor in **Electrical Engineering and Computer Science (EECS)**
Military Service (Leave of Absence) — 2019 — 2020

PUBLICATIONS & PREPRINTS

* Equal Contribution

[1] **Kai S. Yun**, Rui Chen, Chase Dunaway, John M. Dolan, Changliu Liu, "Safe Control of Quadruped in Varying Dynamics via Safety Index Adaptation". *arxiv.org:2409.09882, 2024*, Submitted to 2025 IEEE International Conference on Robotics and Automation (ICRA).

[2] Simin Liu*, **Kai S. Yun***, John M. Dolan, Changliu Liu, "Synthesis and Verification of Robust-Adaptive Safe Controllers". *European Control Conference (ECC), Stockholm, Sweden, 2024*, Oral Presentation.

[3] Tianhao Wei, Luca Marzari*, **Kai S. Yun***, Hanjiang Hu*, Peizhi Niu*, Xusheng Luo, Changliu Liu, "ModelVerification.jl: a Comprehensive Toolbox for Formally Verifying Deep Neural Networks". *arxiv.org:2407.01639, 2024*.

[4] Jack C. Harms, Ethan M. Grame, **SirkHoo Yun**, Bushra Ahmed, Leah C. O'Brien, James J. O'Brien, "Mass-independent Dunham Analysis of the $[7.7]Y^2\Sigma^+ - X^2\Pi_i$ and $[16.3]A^2\Sigma^- - X^2\Pi_i$ Transitions of Copper Monoxide, CuO". *Journal of Molecular Spectroscopy*, 2019.

SKILLS

- **Area of expertise:** Humanoids, Quadrupeds, Quadrotors, Safety Index, Control Barrier Function, Control Lyapunov Function, Adversarial Training, Model Learning, Safe Reinforcement Learning, Model-based Reinforcement Learning, Optimal Control, Hybrid Control, Adaptive Control, Robust Control, System Identification, Polynomial Optimization.
- **Physical Robots/Machines:** Unitree G1, Unitree Go2, PX4 Autopilot Quadrotor, CrazyFlie, Sawyer, Kinova, Tanks.
- **Libraries:** PyTorch, TensorFlow, Isaac Lab/Sim, Gazebo, OpenAI Gym, PyBullet, Mosek, CasADi, PX4, Ray, Numpy.
- **Programming/OS/Tools:** Python, MATLAB, Julia, C++, ROS, ROS2, Linux, Git, Docker.
- **Other skills:** OpenSim, SolidWorks, LaTeX, Simulink, CAN Bus, MoTeC, Scuba Diving.
- **Languages:** Fluent in English, Korean.

RESEARCH EXPERIENCE

Intelligent Control Lab (Robotics Institue at CMU) — Pittsburgh, PA
Advisors: Dr. Changliu Liu, Dr. John M. Dolan — Jun 2023 — Present

- Research on humanoid hardware platform development for safe control, based on Unitree G1 [ongoing].
- Research on learning-based safe rapid navigation of quadrotors in forests using vision inputs [ongoing].
- Research on adaptive safe controller for varying dynamics on quadrupeds (Unitree Go2) [1].
  - Safety Index Adaptation deployment on a package-carrying quadruped for obstacle avoidance.
- Research on algorithm development for synthesizing safe controllers for robotic systems. [2]
  - Devised an optimization algorithm that generates robust-adaptive control barrier functions given uncertain systems.
- Developed *ModelVerification.jl*, a Julia library containing state-of-the-art neural network verification algorithms. [3]
- Research on developing and deploying a learning-based safe controller for quadrotor hardware.
  - Deploy a neural safe controller on quadrotor-pendulum hardware for safety and performance experiments.

Hybrid Robotics Lab (Mechanical Engineering at UC Berkeley) Berkeley, CA
Advisor: Dr. Koushil Sreenath Aug 2021 — Apr 2022

- Research on safe reinforcement learning for worst-case scenarios. [Report]
  - Devised a safe RL algorithm called *PPO-Worst-Case*, to ensure safety constraints are met in the worst-case scenarios.
  - Achieved up to 110% performance compared to state-of-the-art algorithms such as CPO and PPO-Lagrangian.

PROFESSIONAL EXPERIENCE

Tesla, Inc. Palo Alto, CA
Vehicle Dynamics / Software Engineering Intern May 2022 — Aug 2022

- Developed a correlation framework for comparing subjective vehicle evaluation and objective test data.
- Analyzed vehicle dynamics data to improve the ride, handling, and steering experiences of Models S, 3, and Semitruck.
- Instrumented Tesla vehicles and competitor vehicles with sensors and robots. Assisted vehicle tests on proving grounds.
- Developed automated ticketing, reporting, and logging systems utilizing internal software and corresponding API.

NeuroCore.ai Seoul, South Korea
Reinforcement Learning Research Intern Oct 2020 — Jul 2021

- Designed and developed RL training and deployment frameworks, which increased training efficiency by 84%.
- Developed simulators for Supply Chain Management (SCM) tasks for semiconductor manufacturers.
- These are currently deployed in South Korean semiconductor manufacturers, such as SK Hynix.

TEACHING & LEADERSHIP EXPERIENCE

Robotics Institute at Carnegie Mellon University Pittsburgh, PA
Manager/Developer — RoboticsKnowledgebase Oct 2024 — Present

Mechanical Engineering Department at CMU Pittsburgh, PA
Teaching Assistant — Dynamic Systems and Controls (24.352) Aug 2024 — Present

Robotics Institute at Carnegie Mellon University Pittsburgh, PA
Research Mentor — Robotics Institute Summer Scholars (RISS) May 2024 — Aug 2024

Mechanical Engineering Department at UC Berkeley Berkeley, CA
Teaching Assistant — Statistics and Data Science for Engineers (ENG 178) Jan 2023 — May 2023

Republic of Korea Army South Korea
K-1 Tank Mechanic, Sergeant, Squad Leader — Combat Service Support (CSS) Jan 2019 — Aug 2020

SELECTED COURSES

Carnegie Mellon University
Provably Safe Robotics *(16.883)*, Optimal Control & Reinforcement Learning *(16.745)*, Advanced Control Systems Integration *(24.774)*, Engineering Optimization *(24.785)*, Biomechanics of Human Movement *(24.663)*.

UC Berkeley
Deep Reinforcement Learning *(CS 285)*, Nonlinear Systems *(EE C222)*, Machine Learning *(CS 189)*, Robotic Manipulation & Interaction *(EECS C106B)*, Vehicle Dynamics and Control *(ME 131)*, Dynamic Systems & Feedback *(ME 132)*, Mechatronics Design *(ME 102B)*, Experimentation and Measurements *(ME 103)*.

ACADEMIC PROJECTS

- **Balancing an Inverted Pendulum on Quadrotor (16.745; 2024).** Used LQR to balance an inverted pendulum on a quadrotor in flight. The quadrotor was built with PX4 firmware. [Video]
- **Extended Kalman Filter (EKF) for Autonomous Racing (EECS C106B; 2023).** Implemented EKF system identification for tire loads and side-slip angles for a lateral stability MPC for the Indy Autonomous Challenge.
- **Model-based Reinforcement Learning (MBRL) for Trajectory Optimization (CS 285; 2022).** Developed an image-based model-learning algorithm using MBRL to locally approximate the linear dynamics and cost function for iterative LQR. [Report]
- **Dart-launching Robot (EECS C106A; 2022).** Devised a method to track dart boards with computer-vision and launch darts using spring-actuated dart-launcher with Sawyer manipulator for bullseye. [Website]