Simon (Hwanwoong) Kang

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Research Interests

simonhwk.github.io | GitHub

Modular Robotics · Multi-Agent Control and Planning · Robot Learning

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EDUCATION

- **Columbia University** — New York, NY
  M.S. in Mechanical Engineering with concentration in Robotics & Control (GPA: 3.85/4.0) — *Sept 2022 – Present*
  - **Selected Coursework**: Competitive Programming(A+), Digital Manufacturing(A+), Artificial Intelligence, Evolutionary Computation, Robot Learning, Data Science for Mechanical Engineers

- **Chung-Ang University** — Seoul, Republic of Korea
  B.S. in Mechanical Engineering (GPA: 92.69/100) — *Feb 2022*

RESEARCH EXPERIENCE

- **Robot Metabolism: Retinas** — Columbia University
  Graduate Research Assistant, Creative Machines Lab (PI: Dr. Hod Lipson) — *May 2023 - Present*
  - Developed a robust world reconstruction and robot localization system with AprilTags and 4K RGB camera
  - Achieved robot link localization with accuracy of sub 1cm, effective for 20+ robot links at a tracking speed of 25Hz
  - Coded a calibration script for the camera and designed image processing algorithm. This algorithm utilized Perspective-n-Point(PnP), and enhanced image clarity through Gaussian blur and adaptive thresholding
  - Designed the kinematics algorithm for coordinate transformation between tag frame to camera frame to world frame for pose estimation of 72+ tags
  - Customized a double-nested dictionary data structure format for efficient 6D pose data management and sharing, achieving $O(1)$ time complexity for data access

- **Robot Metabolism: Control** — Columbia University
  Graduate Research Assistant, Creative Machines Lab (PI: Dr. Hod Lipson) — *May 2023 - Present*
  - Implemented a shared, thread-safe data structure using thread `.event()` flags to control algorithm execution flow
  - Programmed 1D closed-loop control of a single robot link using Retinas for localization. Coded the `single_link` class, which includes socket programming for transmitting servo commands to the Particle Cloud server. Implemented the Bang-bang control algorithm, and integrated threading of Retinas, the server, and the controller
  - Engineered 2D closed-loop control of modular truss robots. Created the `triangle` class with socket programming for managing servo commands, designed control algorithm addressing position and orientation deviation, and utilized vector calculations for field of view and rotation angle determination
  - Developed 3D closed-loop control for modular truss robots. Implemented `crawl()` and `rotate()` function in the `tetrahedron` class, focusing on enhancing toppling mechanism, and integrating network programming for communications. A payload experiment is planned post-completion

- **Robot Metabolism: Isaac Gym** — Columbia University
  Graduate Research Assistant, Creative Machines Lab (PI: Dr. Hod Lipson) — *May 2023 - Present*
  - Co-evolving weights for DNN layers using Evolutionary Algorithm in Reinforcement Learning GPU simulations via CUDA and Isaac Gym, parallelizing across 512+ environments. This includes designing EA algorithm with operators such as population, mutation, selection, and crossover to enhance neuroevolution efficiency

ACADEMIC THESES

- **Robot Walking via Deep Deterministic Policy Gradient** — Chung-Ang University
  Implemented DDPG for RL agent training via MATLAB Simulink (Advisor: Dr. Seungtae Choi) — *Sept 2021 - Dec 2021*
  - **Algorithm Implementation**: Utilized DDPG on MATLAB's standard robot model for RL to optimize gait
  - **Reward Function Design**: Defined a multi-parameter reward function factoring in forward velocity, power consumption, and displacements (both vertical and lateral) for guiding the RL agent's actions
  - Achieved robot walking with an episode reward of 846.6369, and maintained an average of 554.65 steps per episode

- **Drowsiness Detection via Eye Movement Tracking** — Chung-Ang University
  Leveraged flex sensors and OpenCV for drowsiness detection (Advisor: Dr. Giuk Lee) — *Mar 2021 - June 2021*

- ○ **Mechatronics**: Assembled a system with flex sensors, breadboard, wires, and ATmega328P to process bend signal
- ○ **Visual Processing**: Deployed Dlib for eye detection and utilized Histogram of Oriented Gradients for brightness-based object identification. Developed a blink ratio system employing OpenCV's bilateral filter and applied thresholding for binary data conversion
- ○ **System Fusion**: Synchronized mechanical and computer vision systems with a time-based parameter, triggering an LED warning for neck bending and eyelid closure exceeding 2.5 seconds

ACADEMIC PROJECTS

Autonomous Vehicle Project (F1TENTH)　　　　　　　　　　Columbia University
Columbia University Robotics Club　　　　　　　　　　　　　　　　*Sept 2022 - Present*

- ○ **Communication**: Managed ROS inter-node communication through publish/subscribe mechanism across topics
- ○ **Global Path Planning**: Customized A* and RRT algorithms to generate waypoints for autonomous navigation
- ○ **Local Path Planning**: Implemented Dynamic Window Approach to optimize local trajectory

Digital Manufacturing　　　　　　　　　　　　　　　　　　　Columbia University
Delved into a variety of digital manufacturing methods, from 3D printing to laser cutting　　*Jan 2023 - May 2023*

- ○ **Food Printing**: Developed a tailored G-code generator script for FDM based food printing

Evolutionary Computation & Design　　　　　　　　　　　　Columbia University
Evolved mass-spring based robots using evolutionary algorithms in a custom physics engine　　*Sept 2023 - Dec 2023*

- ○ **EA**: Optimized spring dynamics (direct encoding) and mass arrangements (indirect encoding) for locomotion

Optimization of 3-DOF Humanoid Robot Leg Posture　　　　Chung-Ang University
Determined optimal joint angles to minimize torque (Advisor: Dr. Dongjun Shin)　　*Mar 2021 - June 2021*

- ○ **Kinematic Modeling**: Employed forward kinematics, Jacobian matrices, and dynamic equations for modeling
- ○ **Design & Assembly**: Designed and assembled robot components using CATIA, exporting the design as a URDF
- ○ **Control System**: Developed block diagrams in MATLAB Simulink, integrating PD controllers
- ○ Achieved a torque reduction of 11.3% at the knee joint by optimizing joint angles (j1=-32.3°, j2=87.6°, j3=-85.5°)

PROFESSIONAL EXPERIENCE

Hyundai Motor Group　　　　　　　　　　　　　　　　　　Seoul, Republic of Korea
Engineer, North America Field Analytics Engineering Team, Global HQ　　*Mar 2022 - Sep 2022*

- ○ Led the development of a machine learning safety data analytics system for HMG's automotive brands (Kia, Hyundai, and Genesis) in collaboration with Deloitte, presented at a NHTSA event in Washington DC

NAVER LABS　　　　　　　　　　　　　　　　　　　　　Seongnam, Republic of Korea
Data Assistant, AI Translation Team　　　　　　　　　　　　　　　*Dec 2016 - Mar 2017*

- ○ Engaged in a DNN initiative using TensorFlow for enhancing the capabilities of PAPAGO AI

LEADERSHIP AND SERVICES

Humanities Society Leader　　　　　　　　　　　　　　　　Chung-Ang University
Directed reading groups, curated reading lists, and facilitated literary discussions　　*Oct 2018 - Feb 2022*

- ○ Guided discussions on seminal works by authors including Orwell, Hemingway, Whitman, Sartre, and Kandinsky
- ○ Oversaw book publication featuring literary contributions from society members

Military Interpreter　　　　　　　　　　　　　　　　　　　Korea Military Academy
Served in the Office of International Affairs　　　　　　　　　　　　*Jan 2015 - Oct 2016*

- ○ Managed communications with global military academies, including West Point
- ○ Orchestrated MOU processes with diverse entities, notably the National Medical Center

TECHNICAL SKILLS

- **Programming Languages**: Python, C++, Java, MATLAB
- **Robotics & AI**: Linux, ROS(Gazebo, RViz), OpenCV, TensorFlow, PyTorch, Simulink, Colab, CMake, CUDA
- **Hardware**: PCB Design, Arduino, Raspberry Pi 4, Particle Photon(STM32), Realsense D435, Streolabs ZED Mini
- **CAD**: NX(NX Design Academic Certified), CATIA, Solidworks, Fusion 360, KiCad
- **Manufacturing**: Laser Cutting, CNC Mill/Lathing, Injection Molding, 3D Printing, Mechanical Systems Assembly
- **Version Control & Collaboration**: Git, GitHub, Docker