

Research Interests

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: 3.9/4.0) *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()`, `rotate()`, and `topple()` function in the `tetrahedron` class, and integrating network programming for communications. An autonomous payload experiment is being executed
- 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 ($j_1=-32.3^\circ$, $j_2=87.6^\circ$, $j_3=-85.5^\circ$)

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