Jason Liu

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Education

Ph.D — Robotics Sep. 2024—Present
Carnegie Mellon University
- **Research Focus:** Robot Learning, Manipulation

Engineering Science — Major in Robotics and Mechatronics Sep. 2019—May. 2024
University of Toronto | GPA: 3.98/4.0
- **Relevant Coursework:** Deep Learning, Linear Control Theory, Robot Modeling and Control, Computer Vision, Mobile Robotics, Dynamics, Algorithms and Data Structures, Computer Operating Systems

Professional Experience

University of Toronto (Robot Vision and Learning Lab) Sep. 2023—Apr. 2024
Undergraduate Thesis Research Student Toronto, Canada
- Worked on learning-based collision-free manipulator global motion generation
  - Advised by Prof. Florian Shkurti.
  - Developed Isaac Gym environments with procedurally generated obstacle environments for manipulator collision-free global motion generation.
  - Trained RL policies with Geometric Fabrics in the loop, conditioned on obstacle scene with Basis Point Sets in Isaac Gym.

Nvidia May. 2023—Aug. 2023
Robotics Simulation and Deep Learning Intern Toronto, Canada
- On-going research in reinforcement learning for robotic manipulation
  - Experimented with incorporating vectorized *Geometric Fabrics* in the loop with RL.
  - Successfully trained a RL-Fabrics policy for manipulator motion generation, exhibiting smooth motion that stayed within the velocity, acceleration, and jerk limits of the physical robot.
- Led the development of *URDF Importer* and *MJCF Importer* extensions for *Isaac Sim* Robotics Simulator
  - Overhauled the extensions that convert URDF and MJCF standard robot description formats into USD files that can be imported into Isaac Sim.
  - Open-sourced the two extensions on GitHub as the first C++ extensions released by the Isaac team.

Nvidia Jan. 2022—Aug. 2022
Robotics Simulation and Deep Learning Intern Toronto, Canada
- Co-authored *DeXtreme: Transfer of Agile In-hand Manipulation from Simulation to Reality*
  - Accepted to ICRA 2023. Advised by Dr. Ankur Hand, Prof. Dieter Fox.
  - Performed zero-shot sim-to-real transfer with vision-based RL policy for in-hand object re-orientation
  - Implemented a pipeline to generate 20 mil + synthetic images.
  - Trained and deployed real-time Mask-RCNN based object pose estimation for the RL policy.
- Co-led the development and release of a collection of 10+ RL simulation robotics environments.
  - Codebase with 450+ stars and 125+ forks on GitHub (in-hand manipulation, locomotion tasks, etc.)
- A core developer of *Isaac Sim* Robotics Simulator. Main contributions include:
  - Led the development of physics-based domain randomization APIs for RL, currently used in all Isaac Sim sim-to-real robotics experiments.
  - 30× the max number of vectorized environments in simulation (from 500 to 16000), increased RL training speed by 10×.

Vector Institute (People, AI, & Robots. Research Group) Sep. 2020—Sep. 2022
Undergraduate Robotics Research Student Toronto, Canada
- Co-led the development of low-level controllers for the Franka Panda Arm and Allegro Hand in C++

- Co-authored *ORBIT: A Unified Simulation Framework for Robot Learning and Sim-to-Real*
  - Accepted to RA-L and IROS 2023. Advised by Prof. Animesh Garg.
  - Implemented IK, MPC, OSC, RMPFlow, and various RL environments in simulation.
  - Performed sim-to-real experiments using IK, OSC, RMPFlow, and RL policies with a 7-DOF Franka Arm and 16-DOF Allegro Hand.
- Developed a vision-based robotic hand-arm teleoperation system (Video Demo). Pipeline includes:
  - A robust, real-time, RGB-based hand-pose estimator
  - Kinematic retargeting optimization
  - Reactive task-space motion controllers on the real robot
- Co-authored *Fast-Grasp'D: Dexterous Multi-finger Grasp Generation Through Differentiable Simulation*
  - Accepted to ICRA 2023. Advised by Prof. Animesh Garg.
  - Performed sim-to-real experiments using a hand-arm system to perform grasping.

Publications

1. Q. Yu*, M. Moghani*, K. Dharmarajan, V. Schorp, W. Panitch, **J. Liu**, K. Hari, H. Huang, M. Mittal, K. Goldberg, A. Garg. ORBIT-Surgical: An Open-Simulation Framework for Accelerated Learning Environments in Surgical Autonomy. *International Conference on Robotics and Automation (ICRA), 2024.*
2. S. Zhang*, Y. Qiao*, G. Zhu*, E. Heiden, D. Turpin, **J. Liu**, M. C. Lin, M. Macklin, A. Garg. HandyPriors: Physically Consistent Perception of Hand-Object Interactions with Differentiable Priors. *International Conference on Robotics and Automation (ICRA), 2024.*
3. M. Attarian, M. Asif, **J. Liu**, R. Hari, A. Garg, I. Gilitschenski, J. Tompson. Geometry Matching for Multi-Embodiment Grasping. *Conference on Robot Learning (CoRL), 2023*.
4. D. Turpin, T. Zhong, S. Zhang, G. Zhu, **J. Liu**, R. Singh, E. Heiden, M. Macklin, S. Tsogkas, S. Dickinson, A. Garg. Fast-Grasp'D: Dexterous Multi-finger Grasp Generation Through Differentiable Simulation. *International Conference on Robotics and Automation (ICRA), 2023.*
5. A. Handa*, A. Allshire*, V. Makoviychuk*, A. Petrenko*, R. Singh*, **J. Liu***, D. Makoviichuk, K. V. Wyk, A. Zhurkevich, B. Sundaralingam, Y. Narang, J. Lafleche, D. Fox, G. State. DeXtreme: Transfer of Agile In-hand Manipulation from Simulation to Reality. *International Conference on Robotics and Automation (ICRA), 2023.*
6. M. Mittal, C. Yu, Q. Yu, **J. Liu**, N. Rudin, D. Hoeller, J. L. Yuan, R. Singh, Y. Guo, H. Mazhar, A. Mandlekar, B. Babich, G. State, M. Hutter, A. Garg. Orbit: A unified simulation framework for interactive robot learning environments. *Robotics and Automation Letters (RA-L), 2023.*

Awards

2024 **Engineering Science Award of Excellence**
Awarded by the University of Toronto

2023 **Charles Edwin Trim Scholarship**
Awarded by the University of Toronto

2021 **Dharma Master Chuk Mor Memorial Scholarship**
Awarded by the University of Toronto

2020 **Sullivan Memorial Scholarship**
Awarded by the University of Toronto

2019 **Shaw Scholarship**
Awarded by the University of Toronto

2019 **C. David Naylor University Scholarship**
Awarded by the University of Toronto

Technical Knowledge Summary

Robotics: Simulation, OSC, MPC, Inverse Kinematics, Kalman Filter, Optimization, Sim-to-Real
Deep Learning: RL (PPO, etc.), Vision (Mask-RCNN, etc.), VAE, Transformers
Software: C++, C, Python (PyTorch, JAX, OpenCV, SciPy, etc.), Git, Linux
Electrical: Verilog, FPGA, ModelSim, ESP32, Arduino, Raspberry Pi
Mechanical: SOLIDWORKS (CSWP), Additive Manufacturing, ANSYS

Personal Projects

Vision-Based 2-DOF Ball Balancing Table Feb. 2023—Apr. 2023

- Developed a 2-DOF servo-actuated platform that can regulate a ball to any desired position or track a given reference trajectory (Project Link) (Video Demo).
- CAD model designed using SOLIDWORKS.
- Interfaced with two servos and a camera module using a Raspberry Pi 4.
- Ball position estimation using a series of image processing with OpenCV.
  - Gaussian blur, HSV masking, erosion, and dilation to reveal potential regions.
  - Computation of maximum contour followed with centroid computation to locate the ball center.
- Tuned PID controllers for servos and achieved critical damping validated through step-response analysis.

Low-Cost Mobile Manipulator Platform May. 2022—Aug. 2022

- Designed and built a custom holonomic mobile manipulator base aimed to be a low-cost open-sourced alternative to existing industrial solutions (Project Link).
- The manipulator base can support a Franka Panda arm or two UFactory Lite 6 arms.
- Frame constructed with 2020 aluminum extrusions.
- A Lithium ion car battery powers four brushed DC motors and an inverter used to convert DC to AC for powering the robot arms.
- Intel RealSense RGB-D camera used in localization and mapping via ORB-SLAM.

Remote Controlled Quadruped Spider Robot May. 2021—Jul. 2021

- Designed, built, and controlled a sprawling-type 12-DOF quadruped that can be remotely operated to walk and turn via SSH (Project Link) (Simulation Demo) (Real Robot Demo).
- Designed the quadruped using SOLIDWORKS and rapidly iterated via 3D printing.
- Robot is imported and simulated in Drake via the SOLIDWORKS URDF Exporter.
- The robot walks via a creeping gait to ensure passive stability at all times.
- A high-level state machine specifies desired cartesian feet placement locations for each step, which are sent to a linear trajectory interpolator that generates a list of desired feet locations at each time step.
- Custom inverse kinematics solver is then used to convert desired feet locations to desired joint positions.
- Joint commands are then sent to a servo velocity controller, regulating the speed of the servos.

Kinematic Tree Inverse Kinematics Solver May. 2021—Jul. 2021

- Developed an inverse kinematics solver in Python that can solve for any number of desired end-effector poses while respecting the joint limit constraints (Project Link).
- Pinocchio used to process the URDF of the robot and compute forward kinematics.
- SciPy's SLSQP optimizer is used to solve for the joint positions once the EE poses are given.
- Across 1000 tests for the Franka arm, the average time to solve is 0.0129s with zero failures.

3D-Printable DSLR Camera Gimbal Jun. 2020—Aug. 2020

- Developed a low-cost, 3D-printable 2-DOF gimbal for DSLR cameras (Project Link).
- CAD model designed in SOLIDWORKS, with frame to be easily assembled/disassembled using PVC pipes and 3D-printed connection joints.
- Interfaced with MPU6050 IMU module and retrieved data using the I2C protocol.
- Implemented a Kalman filter on the IMU sensor data to estimate the row and pitch angle states.
- Tuned PID controllers to stabilize the camera such that it remains parallel to the ground.