Kartik Virmani

4525 Walnut St., Apt. 213, Philadelphia, PA 19139 | (215) 452-8308 | kartik8virmani@gmail.com
LinkedIn | GitHub | ResearchGate

Technical Skills

Programming: C++, Python (JAX, PyTorch, TensorFlow), Bash, Git
Simulation & AI: Gazebo, Unity, PyBullet, Model and Policy Based RL (PPO), Imitation Learning/Behaviour Cloning
Robotics Frameworks: NVIDIA Isaac Sim / Omniverse, ROS / ROS 2 (Humble, Jazzy), RViz, micro-ROS (ESP32)
Control & Planning: PID, Model Predictive Control, Trajectory Optimization, RRT*, A*, PRM
Computer Vision: OpenCV, Grounding DINO, SAM, Kalman Filter tracking, auto-annotation pipelines
Hardware & Sensors: Intel RealSense D435i/D455, SICK PicoScan LiDAR, BNO085 IMU, CAN bus Integration

Education

University of Pennsylvania, Philadelphia, PA — ***May 2026***
M.S.E. in Mechanical Engineering & Applied Mechanics — Mechatronics & Robotics **(GPA 3.75/4.0)**

Vellore Institute of Technology, Vellore, India — ***May 2022***
B.Tech. in Mechanical Engineering **(GPA 9.73/10.00)**

Research Experience

Modular Robotics Lab (MODLAB), University of Pennsylvania — Research Assistant ***May 2025 – Present***

- Modeled holonomic robot kinematics and dynamics to support simulation-driven controller and planner development.
- Developed Jacobian-based velocity control enabling precise multi-axis motion and constraint-aware control.
- Built sensor-fusion EKF models to analyze estimation accuracy and latency tradeoffs in closed-loop operation.
- Integrated RealSense-based elevation mapping to generate traversability cost models for planning evaluation.
- Conducted hardware-in-the-loop experiments to validate simulation assumptions and controller performance.

Technical Projects

Bimanual Manipulation through Imitation Learning ***Jan 2025 – Present***

- Developing behavior cloning pipelines to learn joint-space and Cartesian trajectories from 6-DOF Franka arm.
- Built multi-arm kinematic models in NVIDIA Omniverse for coordinated end-effector trajectory generation.
- Developed behavior cloning pipelines learning joint-space and Cartesian trajectories from expert demonstrations.
- Modeled continuous-time velocity fields using flow matching for smooth, constraint-aware motion synthesis.
- Integrated impedance control to analyze stability under contact uncertainty and varying object dynamics.

Reinforcement Learning–Based Quadrotor Control (PPO) ***Oct 2025 – Present***

- Trained PPO-based flight policies in Isaac Sim (Isaac Lab) for aggressive quadrotor control under disturbances.
- Designed reward functions capturing attitude stability, velocity tracking, and control smoothness for real flight transfer.
- Performed extensive domain randomization (mass, inertia, drag, wind) to improve sim-to-real robustness.
- Deployed trained policies to a physical quadrotor via offline inference, validating sim-to-real consistency.

SICK LiDAR Challenge — Autonomous Library Robot ***Oct 2025 – Present***

- Designed a mobile library robot for book retrieval using AMR/AGV base and adding multi-sensor fusion for navigation.
- Developed book-counting and placement validation via onboard OCR algorithms for automated shelf organization.
- Architected a mobile robot system using CANopen motor drivers, LiDAR, and localization on an i.MX7 controller.
- Implemented particle-filter localization fusing LiDAR mapping with DataMatrix tag–based global pose initialization.
- Bridged low-level control and high-level autonomy via UDP over Ethernet between i.MX7 and Jetson platforms.

Real-to-Sim 3D Reconstruction and Neural Scene Modeling ***Sept 2025 – Oct 2025***

- Built a two-view 3D reconstruction pipeline from calibrated camera data using classical multi-view geometry.
- Compared SIFT and LoFTR feature matching for robustness under viewpoint change and low-texture conditions.
- Implemented bundle adjustment to refine camera poses and structure, benchmarking reconstruction against COLMAP.

Trajectory Optimization & Reinforcement Learning with MuJoCo ***Apr 2025 – May 2025***

- Implemented sampling-based MPC and iLQR to analyze nonlinear system behavior under control constraints.
- Designed cost functions balancing tracking accuracy, control effort, and smoothness across simulated tasks.
- Compared trajectory optimization and policy learning in terms of sample efficiency and execution robustness.

Dynamic Object Filtering in ORB-SLAM3 using GroundingDINO + SAM ***Apr 2025 – May 2025***

- Integrated GroundingDINO, SAM, and Kalman Filters for dynamic object detection and filtering in ORB-SLAM3.
- Achieved 29.5% ATE and 25% RPE reduction, improving localization stability and map density by over 80%.
- Built dual-container ROS system connecting C++ SLAM and Python vision stack for modular real-time perception.

F1/10th Autonomous Vehicle Racing ***Jan 2025 – May 2025***

- Built ROS 2-based navigation stack integrating perception, planning, and control for autonomous high-speed racing.
- Implemented RRT*, Pure Pursuit, and MPC algorithms for dynamic trajectory optimization and generation.
- Leveraged NVIDIA Jetson's CUDA cores for real-time LiDAR and camera-based decision-making on the vehicle.

Model Predictive Control for Quadrupeds ***Oct 2024 – Dec 2024***

- Designed an MPC framework in Python for quadruped locomotion, improving trajectory tracking and stability.
- Coded Zero Momentum Control and impedance control in Python for dynamically stable legged motion.
- Simulated contact-rich dynamics in PyDrake and MuJoCo to validate gait phases improving Sim2Real.