

Pranay Katyal

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SUMMARY

Robotics Engineering graduate student specializing in navigation, planning, and control software for multi-robot systems. Skilled in C++, Python, and ROS2 with hands-on experience in SLAM, state estimation (UKF/EKF), and distributed coordination protocols. Demonstrated success designing and simulating robust communication frameworks. Seeking full-time Robotics Software Engineer roles. F-1 visa; eligible for OPT (EAD expected June 2026); will require H-1B sponsorship for long-term employment.

EDUCATION

Master of Science, Robotics Engineering | Worcester Polytechnic Institute | Worcester, MA | Aug 2024 - May 2026

GPA: 3.77/4.0

Completed Coursework: Foundation of Robotics (A), Robot Dynamics (A), Robot Control (B), Motion Planning (A), Multi Robot Systems (A), Machine Learning for Robotics (A), Deep Learning (A), Hands-On Autonomous Aerial Vehicles (A), Directed Research (A), Capstone Project (A), Leadership (B)
Currently Pursuing: Computer Vision, Formal Safety Guarantees in Autonomous Robots

Bachelor of Science, Mechatronics Engineering | Chandigarh University | PB, India | Jul 2019 - Jun 2023

GPA: 3.4/4.0

SKILLS

Programming and Core Tools: Python, C++, MATLAB, ROS2 (Humble, Jazzy, Foxy), Docker, Git, CMake, Bash/Shell Scripting, NumPy, SciPy, OpenCV, PLC (Ladder)

Autonomy and Control: Control Barrier Functions (CBF/GCBF), Cascaded PID/LQR Control, State Estimation (UKF, EKF), RRT* Planning, Kinodynamic Planning, Minimum Snap Trajectory Optimization, Quadratic Programming (QP/OSQP), Consensus Algorithms, Visual Servoing, SLAM, Motion Planning, Quaternion Kinematics

Machine Learning and Vision: PyTorch, TensorFlow, RAFT Optical Flow, U-Net Semantic Segmentation, ResNet Transfer Learning, LSTM/RNN, Depth Estimation, Motion Parallax, PnP Pose Estimation, Object Detection, Synthetic Data Generation, Sensor Fusion, Perception and Computer Vision

Robotics Concepts: Multi-Agent Systems, Distributed Control, Safety-Critical Control, Formation Control, Event-Triggered Control, Collision Avoidance, Kinematic and Dynamic Modeling, Forward and Inverse Kinematics, Recursive Newton-Euler Dynamics

Robotics Platforms: CrazyFlie 2.0 Quadcopter, AWS DeepRacer, OpenManipulatorX (4-DOF), Kinova Gen3 (6-DOF), Event-based Cameras (GenX320, Prophesee EVK4), Dynamixel Motors, IMU Sensors, Tello Quadcopter

Simulation and Development: VizFlyt, Gazebo, MuJoCo, OMPL, Blender (Synthetic Datasets), Simulink, Fusion 360, ANSYS, Jupyter Notebook, UiPath Studio

Computing Infrastructure: WPI Turing HPC Cluster (NVIDIA A30 GPU), NVIDIA RTX 4080, Distributed Training Pipelines

PROFESSIONAL EXPERIENCE

Research Assistant - Multi-Robot Communication and Simulation | Worcester Polytechnic Institute (Automata Lab) | Worcester, MA | Jan 2025 - Present

- Contributed to a research paper under submission on an optical communication system using Prophesee EVK4 event cameras and high-frequency LED signaling, achieving 95%+ decoding accuracy during motion and 7x faster processing over prior EKF-based methods.
- Led hardware setup and integration of event camera sensors with ROS2; developed simulation frameworks, visualizations, and performance plots to validate system behavior across motion and lighting conditions.
- Implemented tracking pipeline bug fixes and supported real-world testing of the transmitter-receiver system, contributing to reliability ahead of multi-agent deployment.
- Integrated AWS DeepRacer with ROS2 Teleop and Nav2 packages for autonomous control and SLAM; employed GenX320 event-camera sensors for real-time perception, resulting in smoother navigation and faster data exchange.

Grading Assistant - Multi-Robot Systems RBE510 | Worcester Polytechnic Institute | Worcester, MA | Aug 2025 - Present

- Graded the Multi-Robot Systems RBE510 course using Python scripts; applied knowledge of IMU sensors and state estimation techniques to evaluate assignments and help graduate students master complex multi-robot concepts.
- Provided one-on-one tutoring on IMU sensor integration, UKF/EKF state estimation, and depth estimation using computer vision, enabling students to complete project milestones successfully.

Graduate Assistant - Control Systems 3011 | Worcester Polytechnic Institute | Worcester, MA | Sep 2024 - Mar 2025

- Supported 60 students in mastering complex control systems concepts, conducting weekly MATLAB lab sessions covering signal processing and motion planning.
- Delivered personalized guidance to approximately 15 students weekly, contributing to a class average increase from 75% to 90% on assessments.

UNIVERSITY PROJECTS

Async vs Sync Consensus for Multi-Agent Formation Control with GCBFs | Worcester Polytechnic Institute | Aug 2025 - Dec 2025

- Developed a distributed multi-agent control system comparing synchronous and asynchronous consensus protocols ($\alpha=0.3, 0.7$) for a 5-drone pentagon formation tracking moving targets through obstacles with realistic constraints (8m visual range, 6m communication range, 0.02s timestep).
- Implemented Graph-Based Control Barrier Functions (GCBFs) for distributed collision avoidance with local QP optimization (OSQP solver), achieving $O(n*k)$ complexity versus $O(n^2)$ centralized approaches, maintaining 2.0m safety distance with zero CBF violations across all test scenarios.
- Demonstrated asynchronous protocol superiority at $\alpha=0.7$ with better stability, faster tracking, and 50% lower control effort (0.024 vs 0.048 m/s²) compared to synchronous, validating event camera-based non-RF communication for interference-free multi-robot coordination.

Autonomous Navigation through Windows and Gaps using Optical Flow | Worcester Polytechnic Institute | Nov 2025 - Dec 2025

- Developed a modular three-phase navigation architecture combining RAFT optical flow with the TS2P (Temporally Stacked Spatial Parallax) algorithm for bidirectional course traversal through rectangular windows and irregular gaps.
- Implemented skill-based navigation (Scan, Recenter, Align, Explore) with separate forward/return modules handling textured and featureless window faces.
- Achieved 3rd place in class with complete bidirectional navigation in 264.6 seconds simulation time and 0.729s inference time, demonstrating robust gap detection without depth data using pure RGB optical flow.

Monocular Depth Estimation with Transfer Learning | Worcester Polytechnic Institute | Nov 2025 - Dec 2025

- Reproduced the M4Depth temporal depth estimation framework fusing sequential camera images with GPS/IMU data, training on the synthetic MidAir dataset (550 images) and transferring to the real-world UseGeo dataset (828 images).
- Achieved 2.65m RMSE and 98.6% accuracy (delta less than 1.25) on synthetic data after 71 epochs using a pretrained checkpoint; identified a critical pose format incompatibility preventing direct transfer learning.

Optical Flow-Based Gap Detection and Navigation | Worcester Polytechnic Institute | Oct 2025 - Nov 2025

- Implemented RAFT optical flow neural network for texture-invariant gap detection using motion parallax, achieving 89-95% IoU segmentation accuracy regardless of foreground/background texture similarity.
- Developed a visual servoing controller using optical flow magnitude thresholding and connected component analysis to identify the largest enclosed gap and compute pixel-displacement control commands.
- Validated approach on Blender-generated test data and VizFlyt simulation, completing navigation in 35 seconds with 40ms inference rate (25Hz) and 10px goal-reaching accuracy.

LSTM-Based 3D Dubins Trajectory Prediction | Worcester Polytechnic Institute | Oct 2025 - Nov 2025

- Developed a rotation-invariant LSTM architecture for 3D Dubins airplane path prediction using body-frame representation, trained on 1,053,091 synthetic trajectories with variable-length sequences.
- Implemented a 3-layer LSTM (256 hidden units) with sequence-to-sequence design generating complete trajectories from 4D input (goal position + climb angle) using masked MSE loss.
- Achieved 5.52m average error (approximately 2%), 14.59m maximum error (approximately 6%), and 16.70m endpoint error across 100 diverse test cases with various headings and climb angles.

Deep Learning-Based Window Detection for Drone Navigation | Worcester Polytechnic Institute | Sep 2025 - Oct 2025

- Developed a U-Net semantic segmentation model trained on 10,000 Blender-generated synthetic images with extensive augmentation for robust window frame detection.
- Achieved 1cm goal-reaching accuracy and 21ms inference time through a visual servoing pipeline combining semantic segmentation, PnP pose estimation, and depth-based control scaling.
- Deployed the perception stack on VizFlyt simulator on the Turing HPC cluster, completing a 3-window navigation course in 35 seconds with real-time RGB-D processing.

Quadrotor Path Planning and Trajectory Optimization | Worcester Polytechnic Institute | Sep 2025 - Oct 2025

- Implemented RRT* path planning with 79% waypoint reduction (48 to 10 nodes) and 94.7% path efficiency, coupled with 7th-order polynomial minimum-snap trajectory generation for smooth quadrotor flight.
- Achieved 5mm final positioning accuracy and 1.5cm average tracking error using cascaded PID control (position/velocity/angular rate) based on PX4 architecture.
- Integrated the navigation stack with VizFlyt photorealistic simulator on the WPI Turing HPC Cluster (NVIDIA A30 GPU), completing missions in 15.3 seconds with zero collisions.

Vehicle Classification via ResNet18 Transfer Learning | Worcester Polytechnic Institute | Sep 2025 - Oct 2025

- Applied two-phase transfer learning with pretrained ResNet18 for 10-class vehicle classification: 20 epochs with frozen backbone followed by 30 epochs of full fine-tuning with 10x reduced learning rate.
- Achieved 96.0% validation accuracy on a dataset of 1,400 training images through data augmentation (random flips, color jitter, rotation, crops) and weight decay regularization; completed training in 22 minutes on NVIDIA RTX 4080.

Unscented Kalman Filter for Attitude Estimation | Worcester Polytechnic Institute | Aug 2025 - Sep 2025

- Implemented an Unscented Kalman Filter (UKF) for nonlinear attitude estimation using quaternion representation, sigma point generation, and iterative quaternion mean computation via gradient descent.
- Achieved superior performance over Complementary and Madgwick filters through probabilistic fusion of gyroscope and accelerometer measurements with process/measurement noise tuning.

Neural Network Control Allocator for Ship Thrusters | Worcester Polytechnic Institute | Aug 2025 - Sep 2025

- Implemented an LSTM encoder-decoder architecture replacing computationally expensive Sequential Quadratic Programming with fast neural network inference for ship thruster control allocation.
- Trained on 1 million synthetic samples with a composite loss function enforcing physics consistency, actuator limits, rate constraints, energy minimization, and forbidden sector penalties; achieved less than 6% error for sway, yaw, and mixed force commands.

Benchmarking Advanced IK Algorithms | Worcester Polytechnic Institute | Mar 2025 - May 2025

- Implemented Product of Exponentials method for forward kinematics and multiple IK algorithms (Newton-Raphson, Damped Least Squares, Gradient Descent) in MATLAB; modeled velocity kinematics, quintic trajectory generation, and inverse/forward dynamics using the Recursive Newton-Euler algorithm.
- Conducted a benchmark study of modern IK algorithms (SVDDLs, IDLS, PSO) on a 6-DOF Kinova Gen3 arm with real-time VR headset control; led the SVDDLs implementation translating research into deployable code.

Chance-Constrained RRT Motion Planning with OMPL Integration | Worcester Polytechnic Institute | Mar 2025 - May 2025

- Integrated a Chance-Constrained RRT (CCRRT) algorithm with the Open Motion Planning Library (OMPL) in C++ for robust path planning; achieved less than 1-second planning times under varying probabilistic safety constraints.
- Utilized Docker for reproducible development and led core algorithm development; introduced OMPL integration into the CCRRT framework.

Control of 4-DOF OpenManipulatorX Robotic Arm | Worcester Polytechnic Institute | Nov 2024 - Dec 2024

- Led a team of 3, developing and implementing position and velocity kinematics for the 4-DOF robotic arm using ROS2; integrated Dynamixel motors with a PD controller in effort control mode.
- Achieved 97.5% control accuracy with repeatable, high-precision motions, significantly improving arm performance in complex tasks.

Quadrotor Controller Implementation - CrazyFlie 2.0 | Worcester Polytechnic Institute | Nov 2024 - Dec 2024

- Designed and tuned PD and LQR controllers for the CrazyFlie 2.0 quadcopter using MATLAB; demonstrated 10-second path tracking for both controller designs.
- Leveraged LQR control strategy to achieve up to 17.28% faster performance compared to PD controllers, improving flight efficiency and precision.

Design and Testing of Robotic Dog (SPOT) | Worcester Polytechnic Institute | Jan 2024 - Mar 2024

- Engineered and tested a robotic dog (SPOT) using Fusion 360 for design and ANSYS for load analysis; validated structural performance under static loads of up to 1000g across real-world scenarios.

LEADERSHIP

Secretary | IEEE-RAS WPI Chapter | Worcester, MA | Jan 2025 - Present

- Coordinated events, workshops, and technical talks to promote robotics research and student engagement.
- Managed communications between faculty, industry speakers, and 50+ student members, ensuring smooth event execution.