Vineet Pasumarti

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Research Interests

Aerodynamics and Autonomous Systems, Perception, Planning, and Control in Extreme Real-world Environments, Aerial Autonomy, Multi-Agent Systems, Game-theoretic Solutions, Dynamic Games and Optimal Control, Guidance Navigation and Control, Reinforcement Learning, Deep Learning.

Education

University of Pennsylvania — *Aug 2024 – May 2026*
Master of Science in Engineering (MSE) in Robotics advised by Antonio Loquercio
- GPA: 4.0/4.0
- **Thesis:** Vision-Based Multi-Agent Drone Racing using Deep Reinforcement Learning
- **Teaching:**
  - TA for ESE 650 Learning in Robotics *(State Estimation, Control, and Reinforcement Learning)*
  - TA for ESE 651 Physical Intelligence *(Deep RL, Imitation Learning, Behavior Models)*
- **Coursework:** Advanced Robotics, Real-World Robot Learning, Learning in Robotics, Machine Learning, Artificial Intelligence, Control and Optimization, Advanced Machine Perception
- **Extracurricular:** I host the Robot Learning Reading Group alongside my advisor to read and discuss state-of-the-art robot learning literature.

University of Wisconsin- Madison — *Sep 2019 – May 2023*
Bachelor of Science (BS) with Honors in Mechanical Engineering
- GPA: 3.7/4.0
- **Teaching:** TA for ME 120 Intro to Mechanical Engineering
- **Coursework:** Aerodynamics, Compressible Gas Dynamics, Control Theory

Publications

Vineet Pasumarti, Mukul Dave, Jennifer Franck, ”Simulation of two cross-flow turbines under confinement”, *American Institute of Aeronautics and Astronautics (AIAA) AVIATION Forum 2022* — Jun 2022
DOI: 10.2514/6.2022-4103

Vineet Pasumarti, Mukul Dave, Jennifer Franck, ”Simulation of dual cross-flow turbines under confinement”, *American Physical Society Division of Fluid Dynamics (APSDFD) 2022* — Nov 2022
V67.N19.J15.00008

Experience

Janus Intelligent Robots Lab - GRASP Lab, University of Pennsylvania — *Philadelphia, PA*
Graduate Student Researcher advised by Dr. Antonio Loquercio — *Aug 2024 – Present*
- Designed and trained multi-agent drone racing policies using reinforcement learning to discover both purely competitive and adversarial strategies grounded in game-theoretic behavior.
- Developed recurrent RL methods that overcome the assumption of stationary transition dynamics in Markov Decision Processes, enabling real-time decision-making for competitive multi-agent systems.
- Led the architectural design and ablation study of hybrid recurrent–feedforward policy networks with Feature-wise Linear Modulation layers for external conditioning.
- Designed shared critic architecture in PyTorch with separate value heads for competitive multi-agent PPO training to enable agent-specific value estimates.

- Bridged sim2real gap for agile quadrotor policies by enhancing simulation accuracy in Isaac Lab with physics-based motor dynamics, aerodynamic drag modeling, collective thrust and body rate control (CTBR), and standard domain randomization techniques, then implementing a custom low-level controller in C within the brushless CrazyFlie 2.1 firmware for deployment.

Boeing Research and Technology *Huntington Beach, CA*
Research Engineer II - Loads and Dynamics *July 2023 – Jan 2025*

- Primary researcher on an Independent Research and Development (IRAD) to best represent the constituent material properties of carbon-matrix-ceramics (CMCs) for hypersonics using reinforcement learning.
- Responsible for loads envelope during flight-testing of the T7 Red Hawk trainer fighter jet at Edwards Air Force Base.
- Wrote code base for internal tools that allow structural analysts to parametrically build composite wing stringer co-bond configurations with wrinkles for Boeing 777X commercial airliner, reducing design+analysis iteration time by 60%.
- Designed components for a hypersonic vehicle test bed and validated via load analysis.
- Performed loads analysis on a composite tank for satellite propulsion.
- Redesigned mechanisms for a composite Mars habitat for reduced mass.

Computational Flow Physics Modeling Lab, University of Wisconsin-Madison *Madison, WI*
Jan 2020 – May 2023
Undergraduate Student Researcher advised by Dr. Jennifer Franck

- Led Computational Fluid Dynamics (CFD) investigations of cross-flow turbine arrays for ARPA-E funded project on renewable energy capture where I discovered wake-recovery phenomenon in confined turbine arrays and collaborated with Dr. Brian Polagye's experimental team at the University of Washington.
- Developed automated simulation tools including custom OpenFOAM airfoil morphing library and 2D-to-3D blockage modeling techniques that reduce computational time while maintaining accuracy.
- Published and presented at APS Division of Fluid Dynamics 2022 and AIAA Aviation 2022 on turbine interaction dynamics and confinement exploitation for hydrokinetic power generation.
- Awarded Faustin Prinz Undergraduate Research Fellowship due to research contributions and academic merit.

INNIO Waukesha Natural Gas Engines *Waukesha, WI*
Simulation Engineer (Worked half-time as a full-time college student) *Nov 2021 – Dec 2022*

- Reduced exhaust valve temperature by 30 Kelvin in a V-12 natural gas engine by calculating heat transfer capabilities of various materials and valve designs according to isentropic relationships then conducted thermal analysis via CFD simulations to validate.
- Successfully led an investigation to determine optimal mesh resolution and temporal resolution of CFD simulations to match experimental data, allowing for accurate and time-effective solutions.
- Successfully determined solutions to bypass motion-related numerical errors in thermal simulations.
- Performed mesh preparation and thermo-fluid simulations using CONVERGE software.

NASA Langley Research Center *Hampton, VA*
Vehicle Engineering Intern - Entry, Descent, and Landing *June 2021 – Aug 2021*

- Designed collapsible drag systems for heat shields that deploy upon re-entry of the atmosphere to support sample-return missions.
- Validated performance of various drag systems via comprehensive simulations of loads experienced on heat shield capsules at varying Mach numbers.
- Worked extensively with Solidworks and Autodesk Inventor for design, assembly, modification, and animation of drag system designs.

NASA Langley Research Center *Hampton, VA*
Vehicle Engineering Intern - Mechanisms *June 2020 – Aug 2020*

- Collaborated in a team of 4 to develop a collapsible mobile lunar crane concept for the manipulation and offloading of large payloads to establish an outpost and permanent human presence on the lunar surface.
- Personally designed a highly-integrated hinge-rail hybrid structure to enable collapsible functionality without

restricting motion of the crane trolley under load.

- Led design and analysis of crane trolley to produce a structure of minimal mass and volume capable of withstanding load requirements.

Projects

Learning to Overtake in Drone Racing via Recurrent RL *Project PDF*

- Designed a two-stage PPO-based training pipeline for overtaking in head-to-head drone racing on a life-size 3D Figure-8 track in simulation.
- Demonstrated that feedforward MLP policies with full opponent state fail due to lack of temporal reasoning, even with increased network capacity.
- Proposed a recurrent policy architecture (2-layer LSTM + 4-layer MLP) that encodes opponent dynamics over time, improving strategic overtaking behavior.
- Augmented the observation space with full opponent state and evaluated policies under dense and sparse competition rewards to promote tactical behavior.
- Achieved 85.7% gate success and 50% sustained overtake rate using the recurrent policy, outperforming all MLP baselines across metrics including crash rate and lap completion.
- Provided empirical evidence that temporal memory is critical for non-stationary multi-agent settings.

Autonomous VIO-Based Quadrotor Navigation and Control *Project PDF*

- Developed complete classical autonomy stack for quadrotor navigation using Visual-Inertial Odometry (VIO) with an Error State Extended Kalman Filter (ES-EKF) for onboard state estimation.
- Implemented stereo vision fusion with IMU data to achieve optimal state estimation by strategically tuning process noise covariance to weight visual measurements over inertial predictions and prevent drift-induced hover errors.
- Designed geometric nonlinear PD controller with fine-tuned gains (K_p, K_d, K_R, K_ω) achieving 2s settling time and 2% steady-state error on the CrazyFlie 2.0 platform.
- Integrated A* path planning with Ramer-Douglas-Peucker sparsification and minimum-jerk trajectory generation, as well as optimized voxel resolution and safety margins for obstacle avoidance.
- Extended framework with an online replanning pipeline using a limited 5m sensor range and 7.5m planning horizon by implementing collision detection and dynamic replanning every 20 time steps for unknown environment exploration.

'Beat-the-Expert': An IL-RL Framework to Outperform Expert Racing Policies *Project PDF*

- Developed an imitation learning-reinforcement learning (IL-RL) framework combining HG-DAGGER and PPO to surpass expert racing performance on the F1TENTH platform
- Implemented Human-Gated DAGGER imitation learning bootstrap using 54-dimensional LiDAR observations and multi-layer perceptron policy networks to achieve 3x faster convergence than end-to-end RL
- Fine-tuned pre-trained IL policies with Proximal Policy Optimization, achieving 28.2% lap time improvement over easy expert demonstrations while maintaining sample efficiency
- Demonstrated policy generalization across multiple real-world F1TENTH tracks (Spielberg, Nürburgring, Spa-Francorchamps) with up to 100% lap completion rates
- Conducted comprehensive performance analysis comparing bootstrapped RL, end-to-end RL, and expert policies, contributing insights to autonomous racing control strategies

Img2GPS: GPS Coordinate Prediction from Single Images via ResNet *Project PDF*

- Framed geolocation as a supervised learning task to regress 2D GPS coordinates from RGB input using deep residual networks.
- Collected a dataset of 741 images across diverse lighting, weather, and viewpoints in the Penn Engineering Quad, then extracted GPS labels from EXIF metadata and normalized coordinates for regression.
- Tuned batch size and learning rate through ablation: identified batch size 16 and learning rate 0.001 with learning rate scheduler (step size 5, $\gamma = 0.1$) as optimal.
- Conducted in-depth analysis of learning rate–batch size interactions and architecture bias-variance behavior.