Justin M. Lidard

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My research focuses on enhancing the generalization, safety, and adaptability of robotic systems in ambiguous or uncertain contexts. Specifically, my interests include uncertainty quantification for neural network-based policies, rapid and flexible decision-making around uncertain human actors, and the safe deployment of foundational models (LLMs/VLMs) in robotic systems. To achieve these aims, I use tools from theoretical machine learning (conformal prediction), generative AI (diffusion policies), and game theory (Hamilton-Jacobi-Isaacs analysis) to equip robots with the ability to make confident decisions in light of their complex surroundings.

Education

Ph.D. in Mechanical and Aerospace Engineering, ***Princeton University*** 2020 – Present

Bachelor of Science in Aerospace Engineering, ***University of Maryland, College Park*** 2016–2020
Minor in Computer Science. GPA: 3.99/4.00

Experiences

Graduate Researcher, ***Princeton University*** 2020 – Present

I work in the Intelligent Robot Motion (IRoM) Lab advised by Prof. Anirudha Majumdar and Prof. Naomi Leonard. My work centers on enabling robot policies, particularly those that leverage large-scale imitation learning, to be aware of their own uncertainty when presented with ambiguous or potentially confusing contexts. Additionally, I focus on making these policies more robust by ensuring that they are able to plan safe fallback strategies or directly work with people to resolve their uncertainty.

Research Scientist Intern, ***Toyota Research Institute (TRI)*** 2022 Summer

Worked on improving coverage of rare events for large-scale trajectory prediction models for autonomous vehicles using techniques from game theory and stochastic optimal control. My work allowed these models to better capture the distribution of multi-agent interactions by ensuring that the predictions are safe, smooth, and semantically varied.

Machine Learning Intern, ***Aurora Flight Sciences*** 2020 Summer

Worked on developing neural network models to predict the outcome of multi-agent games.

Undergraduate Researcher, ***University of Maryland*** 2018 – 2020

I worked in the Collective Dynamics and Control Lab advised by Prof. Derek Paley. My research involved developing a nonlinear dynamics model for an actuated pitching airfoil, optimizing its periodic solution for enhanced lift using techniques from bifurcation theory.

Ongoing Projects

Enabling Human-Guided Robotic Construction with Large Vision-Language Models 2024–Present

This project seeks to enable rapid design iteration for on-site robotic construction guided by a human. Our system allows a robot to leverage in-context learning, wherein a large vision-language model queries examples of real construction scenarios, from initial design to finished product. The robot interacts with the human to finalize the design. We provide a guarantee on the human's satisfaction with the final design with Conformal Prediction.

Diffusion Policy Policy Optimization 2024–Present

Diffusion Policies have become state-of-the-art for learning complex robot trajectories from diverse data sources. However, since they are learned from imperfect demonstrations, they may be unreliable, and the datasets they are trained on may fail to cover the optimal behavior for the task. In this project, we show that Diffusion Policies can be fine-tuned using reinforcement learning (RL). Our method, which includes

a set of best practices, is able to stably and reliably train long-horizon and sparse-reward manipulation tasks to a high success rate.

Fast, Flexible, and Transparent Strategy Alignment for AI-Assisted Racing 2024–Present

While AI agents can reach superhuman prowess in fully autonomous racing in just a few days of training time, humans take much longer to build their proficiency. In this project (a collaboration with TRI), we seek to enable AI agents to reliably "coach" human drivers to reach a higher level of performance. We construct a two-layer safety filter to ensure safety during the learning process: an outer layer "nudges" the human towards optimal strategies, and an inner layer maintains the strict physical safety of the vehicle.

Publications

[9] Safety with Agency: Human-Centered Safety Filter with Application to AI-Assisted Motorsports
D. D. Oh*, J. Lidard*, H. Hu, H. Sinhmar, E. Lazarski, D. Gopinath, E. Sumner, J. DeCastro, G. Rosman, N. E. Leonard, J. F. Fisac. *Submitted, 2025*.

[8] A survey on uncertainty quantification of large language models: Taxonomy, open research challenges, and future directions.
O. Shorinwa, Z. Mei, J. Lidard, A. Z. Ren, and A. Majumdar. *Submitted, 2024*.

[7] Diffusion Policy Policy Optimization
A. Z. Ren, J. Lidard, L. L. Ankile, A. Simeonov, P. Agrawal, A. Majumdar, B. Burchfiel, H. Dai, M. Simchowitz. *ICLR (to appear), 2025*.

[6] Risk-Calibrated Human-Robot Interaction via Set-Valued Intent Prediction
J. Lidard, H. Pham, A. Bachman, B. Boateng, A. Majumdar. *Robotics: Science and Systems (RSS), 2024*.

[5] Blending Data-Driven Priors in Dynamic Games
J. Lidard*, H. Hu*, A. Hancock, Z. Zhang, A. G. Contreras, V. Modi, J. DeCastro, D. Gopinath, G. Rosman, N. E. Leonard, M. Santos, J. F. Fisac. *Robotics: Science and Systems (RSS), 2024*.

[4] NashFormer: Leveraging Local Nash Equilibria for Semantically Diverse Trajectory Prediction
J. Lidard, O. So, Y. Zhang, J. DeCastro, X. Cui, X. Huang, Y. L. Kuo, J. Leonard, A. Balachandran, N. E. Leonard, G. Rosman. *ArXiv, 2023*.

[3] Provably Efficient Multi-Agent Reinforcement Learning with Fully Decentralized Communication
J. Lidard, U. Madhushani, N. E. Leonard. *American Control Conference, 2022*.

[2] Feedback Control and Parameter Estimation for Lift Maximization of a Pitching Airfoil
J. Lidard, D. Goswami, D. Snyder, G. Sedky, A. R. Jones, D. A. Paley. *Journal of Guidance, Control, and Dynamics*, 2021.

[1] Output Feedback Control for Lift Maximization of a Pitching Airfoil
J. Lidard, D. Goswami, D. Snyder, G. Sedky, A. R. Jones, D. A. Paley. *AIAA SciTech Forum*, 2020.

* denotes equal contibution.

Workshops

[W3] Risk-Calibrated Human-Robot Interaction via Set-Valued Intent Prediction
J. Lidard, H. Pham, A. Bachman, B. Boateng, A. Majumdar. *Back to the Future: Robot Learning Going Probabilistic (**Best Paper Award**), IEEE International Conference on Robotics and Automation (ICRA), 2024.*

[W2] Blending Data-Driven Priors in Dynamic Games
J. Lidard*, H. Hu*, A. Hancock, Z. Zhang, A. G. Contreras, V. Modi, J. DeCastro, D. Gopinath, G. Rosman, N. E. Leonard, M. Santos, F. Fisac. *Northeast Systems and Control Workshop (**Oral**), 2024.*

[W1] Provably Efficient Multi-Agent Reinforcement Learning with Fully Decentralized Communication
J. Lidard, U. Madhushani, N. E. Leonard. *Workshop on Reinforcement Learning in Games (**Oral**), AIAA, 2022*.

* denotes equal contibution.

Awards and Honors

- **NSF Graduate Research Fellowship,** ***National Science Foundation*** 2022
  The GRFP provides three years of funding for graduate research.
- **Summerfield Fellowship,** ***Princeton University*** 2021
  One year funding award for performance in the second year.
- **NDSEG Fellowship,** ***Air Force Office of Scientific Research*** 2020
  The NDSEG provides up to three years of funding for graduate research.
- **Space Technology Graduate Research Fellowship (declined),** ***NASA*** 2020
  The NSRF provides up to four years of funding for graduate research in space technology.
- **Francis Robbins Upton Fellowship,** ***Princeton University*** 2020
  Granted to incoming students based on research and academic achievement.

Co-Authored Proposals for Research Funding

Submitted

[G2] Eric and Wendy Schmidt Transformative Technology Fund, "Revolutionizing Construction and Maintenance of Civil Infrastructure through Embodied A" (PIs: Anirudha Majumdar (MAE) and Arash Adel (Architecture); Amount (requested): $870,000; Proposed period: 04/01/2025-04/01/2026)

Current

[G1] Toyota Research Institute University Research Program, "Towards Aligned and Transparent Human-AI Shared Autonomy" (PIs: Naomi Ehrich Leonard (MAE) and Jaime Fernández Fisac (ECE); Amount: $750,000; Period: 04/01/2024 – 04/01/2026)

Teaching Experience

Teaching Assistant

- Fall 2023, MAE 577 Multi-robot Systems, Princeton MAE department.
- Fall 2022, MAE 545 Collective Intelligence, Princeton MAE department.
- Spring 2022, MAE 434 Modern Control, Princeton MAE department.
- Spring 2019, ENAE380: Flight Software, UMCP Aero department.

Academic Service

Undergraduate research mentoring

- Christina Zhang (COS), Princeton 2023 - Present
- Hang Pham (COS), Princeton 2023 - Present
- Bryan Boateng (MAE), Princeton 2023 - Present
- William Li (MAE), Princeton Summer 2024
- Ariel Bachman (MAE), Princeton 2023 - 2024
- Christine Ohenzuwa (MAE), Princeton 2022 - 2023

Reviewing

- Learning for Decision and Control (L4DC) Conference 2025 - Present
- IEEE Robotics and Automation Letters (RA-L) 2024 - Present
- IEEE International Conference on Robotics and Automation (ICRA) 2024 - Present

Miscellaneous

- Co-organizer, Symposium on Safe Deployment of Foundation Models in Robotics Nov 2024

Key Skills

Topics: Robotics (Kinematics, Dynamics, Motion Planning, Feedback Control, Grasping), Machine Learning (Regression, Classification, SVM), Deep Learning (Neural Networks, CNNs, RNNs, Transformers), Reinforcement Learning, Imitation Learning (Diffusion Policies, Boltzmann Models, Inverse Reinforcement Learning), Large (Vision-)Language Models, Dynamic Game Theory (Nash/Stackelberg Equilibria, Potential Games, Mixed Strategies, Hamilton-Jacobi-Isaacs).

Software: Python, C/C++, MATLAB, HTML, Unix scripting, PyTorch, Robot Operating System (ROS), Open3D, MeshLab, COLMAP, PyBullet, Mujoco, High-performance computing (HPC).

References

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