

AKASH HARAPANAHALLI

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SUMMARY

Graduate Research Assistant in the Formal Methods & Autonomous Control of Transportation Systems ([FACTS](#)) Lab at Georgia Tech, under the supervision of Dr. Samuel Coogan, currently pursuing a PhD in Machine Learning. Research is centered around safety verification of nonlinear AI-based control systems, mainly through reachability, invariance, and contraction analysis. Developer of [immrax](#), a JAX toolbox used to scalably certify safe performance of neural networks in safety-critical control systems and to train neural networks with robust safety guarantees outright.

CURRENT POSITION

Georgia Institute of Technology — Atlanta, GA
Machine Learning PhD Candidate, Department of Electrical and Computer Engineering Aug 2022 - Present

EDUCATION

Georgia Institute of Technology — Atlanta, GA

- **PhD Machine Learning** — GPA: 4.00 Aug 2022 - 2027
- **MS Mathematics** — GPA: 4.00 Aug 2022 - Aug 2025
- **BS Computer Engineering, with Highest Honor** — GPA: 4.00 Aug 2019 - May 2022

TECHNICAL SKILLS

ML & Scientific Computing: JAX, PyTorch, Tensorflow, NumPy, SciPy, SymPy, DRAKE, immrax (author)

Math, Control & Robotics: Neural network verification, Reachability analysis, Contraction theory, Lie groups, Differential geometry, Model predictive control

Programming Languages: Python, C/C++, MATLAB, SystemVerilog, Embedded C / RTOS

Tools & Platforms: Linux, Claude Code, Git, ROS2, Arduino, Raspberry Pi, Onshape, Solidworks, Eagle PCB

RESEARCH EXPERIENCE

Graduate Research Assistant — [FACTS Lab, Georgia Tech](#) Aug 2022 - Present

Research is centered around safety verification in AI-based control of nonlinear dynamical systems.

Research Philosophy: Develop rich mathematical theory alongside useful computational tools.

- AI models have little robustness guarantees; this is dangerous when applied in safety-critical domains.
- Developed a mathematical framework and efficient, GPU-scalable, differentiable toolbox called [immrax](#) for parametric reachability analysis of nonlinear systems with neural network controllers.
- Trained neural network controllers for dynamical systems with formal guarantees of safe operation.
- Developed algorithm for efficient reachable set computation in systems evolving on Lie group state spaces.
- Studied contracting dynamical systems evolving on homogeneous manifolds with Riemannian metrics.
- Mentoring a PhD student and an undergraduate student, building technical communication skills.

Athena Controls Lead — [LIDAR Lab, Georgia Tech](#) Jan 2020 - May 2022

- Led and mentored a subteam of 8 undergraduates to design manipulator planning and control solutions for a humanoid robot using position, velocity, and force approaches.
- Guided peers through a ramping process to understand complex math and background theory.
- Used the DRAKE C++ toolbox to simulate dynamic physical conditions and validate control methods.
- Designed impedance controller for robust, compliant task-space position and force robot manipulation.

PUBLICATIONS [[GOOGLE SCHOLAR](#)]

* indicates equal contribution

Preprints

- [P1] V. Madabushi, **A. Harapanahalli**, S. Coogan, M. Tucker, "[Differentiable Invariant Sets for Hybrid Limit Cycles with Application to Legged Robots.](#)" To appear in IEEE Conference on Decision and Control (CDC), 2026. [[pdf](#)]

Journal Articles

- [J6] **A. Harapanahalli**, S. Coogan, A. Davydov, "[Learning Certified Neural Network Controllers Using Contraction and Interval Analysis.](#)" IEEE Control Systems Letters (L-CSS), 2026. [[pdf](#)]
- [J5] **A. Harapanahalli**, S. Coogan, "[A Linear Differential Inclusion for Contraction Analysis to Known Trajectories.](#)" IEEE Transactions on Automatic Control (TAC), 2025. [[pdf](#)] [[slides](#)]
- [J4] B. Gould, **A. Harapanahalli**, S. Coogan, "[Automatic and Scalable Safety Verification Using Interval Reachability With Subspace Sampling.](#)" IEEE Control Systems Letters (L-CSS), 2025. [[pdf](#)]
- [J3] S. Jafarpour*, **A. Harapanahalli***, S. Coogan, "[Efficient Interaction-Aware Interval Analysis of Neural Network Feedback Loops.](#)" IEEE Transactions on Automatic Control (TAC), 2024. [[pdf](#)]
- [J2] **A. Harapanahalli**, S. Jafarpour, S. Coogan, "[Forward Invariance in Neural Network Controlled Systems.](#)" IEEE Control Systems Letters (L-CSS), 2023. [[pdf](#)] [[slides](#)]
- [J1] L. Baird, **A. Harapanahalli**, S. Coogan, "[Interval Signal Temporal Logic From Natural Inclusion Functions.](#)" IEEE Control Systems Letters (L-CSS), 2023. [[pdf](#)]

Conference Papers and Abstracts

- [C10] **A. Harapanahalli**, S. Coogan, "[Efficient Norm-Based Reachable Sets via Iterative Dynamic Programming.](#)" American Control Conference (ACC), 2026. [[pdf](#)]
- [C9] **A. Harapanahalli**, S. Coogan, "[Certified Robust Invariant Polytope Training in Neural Controlled ODEs.](#)" Learning for Dynamics and Control Conference (L4DC), 2026. [[pdf](#)] [[code](#)] [[slides](#)]
- [C8] **A. Harapanahalli**, S. Coogan, "[Parametric Reachable Sets Via Controlled Dynamical Embeddings.](#)" IEEE Conference on Decision and Control (CDC), 2025. [[pdf](#)]
- [C7] **A. Harapanahalli**, S. Coogan, "[A Global Coordinate-Free Approach to Invariant Contraction on Homogeneous Manifolds.](#)" American Control Conference (ACC), 2025. [[pdf](#)] [[slides](#)]
- [C6] **A. Harapanahalli**, S. Coogan, "[Efficient Reachable Sets on Lie Groups Using Lie Algebra Monotonicity and Tangent Intervals.](#)" IEEE Conference on Decision and Control (CDC), 2024. **Runner-Up for the Hybrid Systems Technical Committee Outstanding Student Paper Prize** [[pdf](#)] [[slides](#)]
- [C5] **A. Harapanahalli**, S. Jafarpour, S. Coogan, "[Immrx: A Parallelizable and Differentiable Toolbox for Interval Analysis and Mixed Monotone Reachability in JAX.](#)" IFAC Conference on Analysis and Design of Hybrid Systems (ADHS), 2024. [[pdf](#)] [[github](#)] [[slides](#)]
- [C4] **A. Harapanahalli**, S. Jafarpour, S. Coogan, "[Contraction-Guided Adaptive Partitioning for Reachability Analysis of Neural Network Controlled Systems.](#)" IEEE Conference on Decision and Control (CDC), 2023. [[pdf](#)] [[slides](#)]
- [C3] **A. Harapanahalli**, S. Jafarpour, S. Coogan, "[A Toolbox for Fast Interval Arithmetic in numpy with an Application to Formal Verification of Neural Network Controlled Systems.](#)" Workshop on Formal Verification of Machine Learning, ICML (WFMV), 2023. [[pdf](#)] [[github](#)] [[poster](#)]
- [C2] S. Jafarpour*, **A. Harapanahalli***, S. Coogan, "[Interval Reachability of Nonlinear Dynamical Systems with Neural Network Controllers.](#)" Learning for Dynamics and Control Conference (L4DC), 2023. [[pdf](#)] [[poster](#)]
- [C1] **A. Harapanahalli***, E. Muly*, H. Welch*, T. Brumfiel*, Z. Weng*, M. Akhtar, A. R. Abouelnasr, A. Newland, J. Bunting, K. McGorrey, J. S. Lee, G. Wang, L. Drnach, D. J. Lee, Y. Zhao, "Towards a Biomimetic and Dexterous Robot Avatar: Design, Control, and Kinematics Considerations." IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM), 2020. **Best Latest Breaking Results Poster; First Place in the Hardware, Devices & Robotics Track of the 2021 GaTech VIP Innovation Competition** [[pdf](#)] [[abstract](#)] [[poster](#)] [[video](#)]

HONORS AND AWARDS

2025-2026 Herbert P. Haley Fellowship — ML PhD Program, Georgia Tech	Dec 2025
Georgia Tech President's Fellowship	2022 - 2026
Runner Up for Outstanding Student Paper Prize — IEEE CSS Hybrid Systems TC	2024
ECE Senior Scholar Award (4.00 GPA) — School of ECE, Georgia Tech	Apr 2022
Faculty Honors (every semester) — Georgia Tech	Fall 2019 - Spring 2022
Best Overall Hack — HackGT Horizons 2022	Mar 2022
Best Hardware Hack — HackGT 8	Oct 2021
First Place — 2021 Georgia Tech VIP Innovation Competition (Hardware, Devices & Robotics)	Apr 2021
Best Latest Breaking Results Poster — 2020 IEEE/ASME Intl. Conf. on Adv. Int. Mechatronics	Jul 2020

Best in Show — HackGT Horizons 2020	Feb 2020
Second Place, Best TI Integration — The Invention Studio's Hack-A-Thing 2020	Jan 2020
State Tournament Champion — 2019 California VEX Robotics High School State Championship	Mar 2019

ACADEMIC SERVICE

Student Activities Lead of IEEE CSS Hybrid Systems TC [link]	May 2026 - Present
General Chair of the Decision and Control Laboratory Student Committee [link]	Aug 2025 - Present
Organizer of IEEE CSS Hybrid Systems TC Seminar Series [link]	Jul 2025 - Dec 2025
Chair of 2025 Decision and Control Symposium Organizing Committee [link]	2025
Reviewer for the following venues:	
• Automatica	2024 - 2025
• IEEE Control Systems Letters (L-CSS)	2023 - 2026
• IEEE Control Systems Magazine	2026
• IEEE Conference on Decision and Control (CDC)	2023 - 2025
• American Control Conference (ACC)	2023 - 2025
• IEEE Int'l Conference on Intelligent Transportation Systems (ITSC)	2024

TEACHING AND PROFESSIONAL EXPERIENCE

Graduate Teaching Assistant — School of ECE, Georgia Tech	Aug 2022 - Dec 2022
• ECE 3803 — Optimization for Information Systems • ECE 3084 — Signals and Systems	
Applications Engineering Intern — Texas Instruments	Jun 2021 - Aug 2021
• Designed modern Over-The-Air update process for Wi-Fi network processors using embedded C with RTOS. • Analyzed customer feedback to optimize the design for utility, functionality, and practicality. • Developed interpersonal professional skills while learning about product lifecycle and post-market strategy.	

OTHER EXPERIENCES AND PROJECTS [\[PORTFOLIO\]](#)

Data Acquisition Technician — GT Off-Road (BAJA SAE) [github]	Jan 2020 - May 2022
• GT Off-Road designs and manufactures a car to compete in the BAJA SAE competition cycle. • Rebuilt embedded software infrastructure with a custom dynamic communications protocol using C++ to streamline data transfer in a mesh network of microcontrollers communicating over wired and wireless regimes. • Designed and programmed a dashboard for a driver to read critical measurements using Solidworks and Eagle. • Built a closed-loop control algorithm for an Electronic Continuous Variable Transmission (eCVT) in C++.	
Voxel — ECE Senior Capstone [expo] [report]	Aug 2021 - May 2022
• Created world's first fully volumetric high-density holographic persistence of vision display (3D hologram). • Designed an algorithm to convert arbitrary mesh files to a custom cylindrical 3D display video format. • Wrote embedded software in C++ and SystemVerilog to encode/decode 3D video over HDMI.	
StepDance — HackGT Horizons 2022 — Best Overall Hack [devpost] [github]	Mar 2022 - Mar 2022
• An interactable piano using stepper motor vibrations to generate music with computer vision features. • Personally wrote all embedded C++ code to take inputs, schedule, and control stepper motors.	
Zen — HackGT 8 — Best Hardware Hack [devpost] [github]	Oct 2021 - Oct 2021
• Repurposed an old 3D printer as a data visualization tool and art piece under strict time constraints. • Personally designed the system and mounts in Onshape and wrote embedded C++ to control stepper motors.	
OxySpool — Tikkum Olam Makers (TOM) at GT Makeathon 2021 — Second Place [project] [github]	May 2021 - May 2021
• TOM is a service organization sponsoring open source solutions to the challenges of underserved people. • Created a low-force oxygen cord reel designed for patients with COPD to avoid tripping hazards. • Personally helped design/manufacture using Onshape, and wrote embedded C++ to control the device.	
TrashTalker — HackGT Horizons 2020 — Best in Show [devpost] [github]	Feb 2020 - Feb 2020

- Integrated art and technology by engineering a music instrument out of trashed beer bottles.
- Modeled mounts and connections in Solidworks, wrote embedded Arduino software using MATLAB.

Industrial Screw Sorter — Hack-a-Thing — Second Place, Best TI Integration [\[github\]](#) Sep 2019 - Jan 2020

- Competed in a five-month-long competition to create an industrial screw sorting apparatus.
- Personally worked on its design and on reusable embedded C++ for its TI MSP-432 using Energia.