AKASH HARAPANAHALLI

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CURRENT POSITION

Georgia Institute of Technology - Atlanta, GA
Machine Learning PhD Student, 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 Eng. with Highest Honor** - GPA: 4.00   Aug 2019 - May 2022

RESEARCH EXPERIENCE

Graduate Research Assistant - FACTS Lab, Georgia Tech   Aug 2022 - Present

My research is centered around safety verification in AI-based control of modern nonlinear dynamical systems.
Research Philosophy: Develop rich mathematical theory alongside useful computational tools.

- AI models have little robustness guarantees, which is dangerous when applied in safety-critical domains.
- Developed a mathematical framework and efficient, GPU scalable toolbox called `immrax` for parametric reachable set computation and invariant set analysis of nonlinear systems with neural network controllers.
- Trained neural network controllers for dynamical systems with formal guarantees of safe operation.
- Developed an algorithm for efficient reachable set computation in systems evolving on Lie group state spaces.
- Studied contracting dynamical systems evolving on homogeneous manifolds equipped with invariant metrics.
- Mentoring first-year PhD 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

* indicates equal contribution

Preprints

[P3] A. Harapanahalli, S. Coogan, "Parametric Reachable Sets Via Controlled Dynamical Embeddings." *Accepted for presentation at IEEE Conference on Decision and Control (CDC)*, 2025. [pdf]

[P2] A. Harapanahalli, S. Coogan, "A Linear Differential Inclusion for Contraction Analysis to Known Trajectories." *In submission*, 2024. [pdf]

[P1] A. Harapanahalli, S. Coogan, "Certified Robust Invariant Polytope Training in Neural Controlled ODEs." *In submission*, 2024. [pdf] [code]

Journal Articles

[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.

[J3] S. Jafarpour*, A. Harapanahalli*, S. Coogan, "Efficient Interaction-Aware Interval Analysis of Neural Network Feedback Loops," *IEEE Transactions on Automatic Control (TAC)*, 2023. [pdf]

[J2] A. Harapanahalli, S. Jafarpour, S. Coogan, "Forward Invariance in Neural Network Controlled Systems," *IEEE Control Systems Letters (L-CSS)*, 2023. [pdf]

[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

[C7] A. Harapanahalli, S. Coogan, "A Global Coordinate-Free Approach to Invariant Contraction on Homogeneous Manifolds." *American Control Conference (ACC)*, 2025. [pdf]

[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, "`immrax`: A Parallelizable and Differentiable Toolbox for Interval Analysis and Mixed Monotone Reachability in JAX." *The 8th IFAC Conference on Analysis and Design of Hybrid Systems (ADHS)*, 2024. [pdf] [github] [slides]

[C4] 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," *2nd Workshop on Formal Verification of Machine Learning, ICML (WFVML)*, 2023. [pdf] [github]

[C3] 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]

[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]

[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, and Y. Zhao, "Towards a Biomimetic and Dexterous Robot Avatar: Design, Control, and Kinematics Considerations," *IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)*, 2020. (poster) **Award: Best Latest Breaking Results Poster**. [abstract] [poster] [video]

HONORS AND AWARDS

Runner Up for Outstanding Student Paper Prize - IEEE CSS Hybrid Systems TC	2024
ECE Senior Scholar Award (4.00 Cumulative 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 VRC High School State Championship	Mar 2019

ACADEMIC SERVICE

Chair of Hybrid Systems TC Seminar Series Organizing Committee	Jul 2025 - Present
Lead Organizer of the 2025 Georgia Tech Decision and Control Symposium [article]	2025

Reviewer for the following venues:

• IEEE Control Systems Letters (L-CSS)	2023 - 2025
• IEEE Conference on Decision and Control (CDC)	2023 - 2025
• American Control Conference (ACC)	2023 - 2024
• Automatica	2024
• IEEE International Conference on Intelligent Transportation Systems (ITSC)	2024

TEACHING AND PROFESSIONAL EXPREIENCE

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 a 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 strategies.

OTHER EXPERIENCES AND PROJECTS

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 the 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

- 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

- 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

- 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

- 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.