

# 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 [[GOOGLE SCHOLAR](#)]

\* indicates equal contribution

### Preprints

- [P2] A. Harapanahalli, S. Coogan, “Parametric Reachable Sets Via Controlled Dynamical Embeddings.” *Accepted for presentation at IEEE Conference on Decision and Control (CDC), 2025.* [\[pdf\]](#)
- [P1] A. Harapanahalli, S. Coogan, “Certified Robust Invariant Polytope Training in Neural Controlled ODEs.” *In submission, 2024.* [\[pdf\]](#) [\[code\]](#)

### Journal Articles

- [J5] A. Harapanahalli, S. Coogan, “A Linear Differential Inclusion for Contraction Analysis to Known Trajectories.” *IEEE Transactions on Automatic Control (TAC), 2025.* [\[pdf\]](#)
- [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, "`imrrax`: 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**

<b>Runner Up for Outstanding Student Paper Prize - IEEE CSS Hybrid Systems TC</b>	2024
<b>ECE Senior Scholar Award (4.00 Cumulative GPA)</b> - School of ECE, Georgia Tech	Apr 2022
<b>Faculty Honors (every semester)</b> - Georgia Tech	Fall 2019 - Spring 2022
<b>Best Overall Hack</b> - HackGT Horizons 2022	Mar 2022
<b>Best Hardware Hack</b> - HackGT 8	Oct 2021
<b>First Place</b> - 2021 Georgia Tech VIP Innovation Competition (Hardware, Devices & Robotics)	Apr 2021
<b>Best Latest Breaking Results Poster</b> - 2020 IEEE/ASME Intl. Conf. on Adv. Int. Mechatronics	Jul 2020
<b>Best in Show</b> - HackGT Horizons 2020	Feb 2020
<b>Second Place, Best TI Integration</b> - The Invention Studio's Hack-A-Thing 2020	Jan 2020
<b>State Tournament Champion</b> - 2019 California VEX VRC High School State Championship	Mar 2019

### **ACADEMIC SERVICE**

<b>General Chair of the Decision and Control Laboratory Student Committee</b> [ <a href="#">link</a> ]	Aug 2025 - Present
<b>Organizer of IEEE CSS Hybrid Systems TC Seminar Series</b> [ <a href="#">link</a> ]	Jul 2025 - Present
<b>Chair of 2025 Decision and Control Symposium Organizing Committee</b> [ <a href="#">article</a> ]	2025

Reviewer for the following venues:

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

## TEACHING AND PROFESSIONAL EXPREIENCE

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<b>Graduate Teaching Assistant</b> - School of ECE, Georgia Tech	Aug 2022 - Dec 2022
<ul style="list-style-type: none"><li>• ECE 3803 - Optimization for Information Systems</li><li>• ECE 3084 - Signals and Systems</li></ul>	
<b>Applications Engineering Intern</b> - Texas Instruments	Jun 2021 - Aug 2021
<ul style="list-style-type: none"><li>• Designed a modern Over-The-Air update process for Wi-Fi network processors using embedded C with RTOS.</li><li>• Analyzed customer feedback to optimize the design for utility, functionality, and practicality.</li><li>• Developed interpersonal professional skills while learning about product lifecycle and post-market strategies.</li></ul>	

## OTHER EXPERIENCES AND PROJECTS [PORTFOLIO]

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<b>Data Acquisition Technician</b> - GT Off-Road (BAJA SAE) <a href="#">[github]</a>	Jan 2020 - May 2022
<ul style="list-style-type: none"><li>• GT Off-Road designs and manufactures a car to compete in the BAJA SAE competition cycle.</li><li>• 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.</li><li>• Designed and programmed a dashboard for a driver to read critical measurements using Solidworks and Eagle.</li><li>• Built a closed-loop control algorithm for an Electronic Continuous Variable Transmission (eCVT) in C++.</li></ul>	
<b>Voxel</b> - ECE Senior Capstone <a href="#">[expo]</a> <a href="#">[report]</a>	Aug 2021 - May 2022
<ul style="list-style-type: none"><li>• Created the world's first fully volumetric high-density holographic persistence of vision display (3D hologram).</li><li>• Designed an algorithm to convert arbitrary mesh files to a custom cylindrical 3D display video format.</li><li>• Wrote embedded software in C++ and SystemVerilog to encode/decode 3D video over HDMI.</li></ul>	
<b>StepDance</b> - HackGT Horizons 2022 - Best Overall Hack <a href="#">[devpost]</a> <a href="#">[github]</a>	Mar 2022
<ul style="list-style-type: none"><li>• An interactable piano using stepper motor vibrations to generate music with computer vision features.</li><li>• Personally wrote all embedded C++ code to take inputs, schedule, and control stepper motors.</li></ul>	
<b>Zen</b> - HackGT 8 - Best Hardware Hack <a href="#">[devpost]</a> <a href="#">[github]</a>	Oct 2021
<ul style="list-style-type: none"><li>• Repurposed an old 3D printer as a data visualization tool and art piece under strict time constraints.</li><li>• Personally designed the system and mounts in Onshape and wrote embedded C++ to control stepper motors.</li></ul>	
<b>OxySpool</b> - Tikkum Olam Makers (TOM) at GT Makeathon 2021 - Second Place <a href="#">[project]</a> <a href="#">[github]</a>	May 2021
<ul style="list-style-type: none"><li>• TOM is a service organization sponsoring open source solutions to the challenges of underserved people.</li><li>• Created a low force oxygen cord reel designed for patients with COPD to avoid tripping hazards.</li><li>• Personally helped design/manufacture using Onshape, and wrote embedded C++ to control the device.</li></ul>	
<b>TrashTalker</b> - HackGT Horizons 2020 - Best in Show <a href="#">[devpost]</a> <a href="#">[github]</a>	Feb 2020
<ul style="list-style-type: none"><li>• Integrated art and technology by engineering a music instrument out of trashed beer bottles.</li><li>• Modeled mounts and connections in Solidworks, wrote embedded Arduino software using MATLAB.</li></ul>	
<b>Industrial Screw Sorter</b> - Hack-a-Thing - Second Place, Best TI Integration <a href="#">[github]</a>	Sep 2019 - Jan 2020
<ul style="list-style-type: none"><li>• Competed in a five-month-long competition to create an industrial screw sorting apparatus.</li><li>• Personally worked on its design and on reusable embedded C++ for its TI MSP-432 using Energia.</li></ul>	