

# AKASH HARAPANAHALLI

408-515-9157 ◊ Atlanta, GA ◊ San Ramon, CA ◊ US Citizen ◊ [akash.harapanahalli@gmail.com](mailto:akash.harapanahalli@gmail.com) ◊ [akashhara.com](http://akashhara.com)

## SUMMARY

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Third-year PhD student with interests in automatic control, machine learning, and robotics. Strong educational background in mathematics, controls, learning, and signals. Demonstrated research experience through (i) ongoing work in safety verification of modern AI-enabled control systems through reachability, invariance, and contraction; (ii) award-winning undergraduate results for a dual-arm manipulator robot. Demonstrated professional experience through an industry internship. Won several awards in competitive settings through collaboration and innovative designs. Seeking an internship for Summer 2025 to tackle real-world challenges and build critical applied skills.

## EDUCATION

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Georgia Institute of Technology - Atlanta, GA

- **Ph.D. Machine Learning** - GPA: 4.00 Aug 2022 - 2027
- **M.S. Mathematics** - GPA: 4.00 Aug 2022 - May 2025
- **B.S. Computer Eng. with Highest Honor** - GPA: 4.00 Aug 2019 - May 2022

## RESEARCH EXPERIENCE

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

My research is centered around safety verification in learning-based control of modern nonlinear dynamical systems. *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 interval reachable set and polytope invariant set analysis of nonlinear systems with neural network controllers using JAX.
- 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

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\* indicates equal contribution

### Journal Articles

- [J5] A. Harapanahalli, S. Coogan, “A Linear Differential Inclusion for Contraction Analysis to Known Trajectories.” *In submission*, 2024. [\[pdf\]](#)
- [J4] A. Harapanahalli, S. Coogan, “Certified Robust Invariant Polytope Training in Neural Controlled ODEs.” *In submission*, 2024. [\[pdf\]](#) [\[code\]](#)
- [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. [\[pdf\]](#)
- [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

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|---|-------------------------|
| <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                |

### TEACHING AND PROFESSIONAL EXPREIENCE

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**Graduate Teaching Assistant** - School of ECE, Georgia Tech Aug 2022 - Dec 2022

- Graded assignments and tutored students in undergraduate optimization and signals courses.
- Developed teaching and vocational skills while sharpening technical abilities in related fields.

**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

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**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.
- 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.