Karan Muvvala

Formal Methods >_ Game Theory >_ Neural Network Verification >_ Control Synthesis
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Research Summary

My research centers around correct-by-construction algorithms that utilize rigorous mathematical reasoning to synthesize controllers that enable assured and intelligent autonomy. Currently, I am working on

1. Verifying the safety of complex autonomous systems modeled as neural networks and guaranteeing their safety using Barrier Methods for safe autonomy
2. Synthesizing high-level strategies for a robotic manipulator operating in the presence of a human using game-theoretic approaches to enable more human-like behavior for robots.

My current research interests are formal methods, task and motion planning, verification of neural networks, and safe controller synthesis. My goal eventually is to build safe autonomous systems to operate efficiently in collaborative and unstructured environments.

Education

Ph.D. in Aerospace Engineering Sciences - Autonomous Systems *3.95/4.0*
University of Colorado Boulder - Ann and H.J. Smead Aerospace Engineering Sciences 05/21 - Present

Research Advisor Dr. Morteza Lahijanian

M.S. in Mechanical Engineering - Robotics and Systems Design *3.94/4.0*
University of Colorado Boulder - Paul M. Rady Mechanical Engineering Conferred 05/21

Research Advisor Dr. Morteza Lahijanian
Research Topic Human-aware Strategy Synthesis for Robotic Manipulators using Regret Games (Link)

B.E in Mechanical Engineering *8.36/10.0*
University of Mumbai Conferred 06/18

Research Experience

Graduate Research Assistant - Ph.D. *Boulder, CO*
Assured Reliable Interative Autonomous Systems Group at CU Boulder (ARIASystems) 05/21 - Present

- Developing an efficient symbolic regret-minimizing strategy synthesis framework to mitigate formal methods induced state explosion and help scale up the explicit game-theoretic based regret synthesis approach.
- Designed a framework to certify safety of an autonomous system modelled as neural network using Control Barrier Functions and synthesized a minimally invasive controller to guarantee user-defined safety threshold - **Submitted NeurIPS 2022**.

M.S. Thesis *Boulder, CO*

Assured Reliable Interative Autonomous Systems Group at CU Boulder (ARIASystems) 08/19 - 05/21

- Developed a novel and general regret based reactive synthesis framework to synthesize a regret-minimizing strategy for robots operating in dynamic environments.(Video)
- Synthesized an optimal strategy for the robot that explores possible cooperation with other agents while guaranteeing task completion and spending no more than the user-defined energy budget.
- Demonstrate our framework's efficacy on a robotic manipulator operating in presence of a human, completing complex tasks with temporal constraints in the face of external interventions.

Summer Research Intern - Fast Behaviors Project *Pensacola, FL*

Florida Institute for Human and Machine Cognition (IHMC) 05/19 - 08/19

- Developed and implemented high-level complex behaviors for the Atlas robot in Java that combined perception, planning, and controls.
- Built a new and improved event-triggered sequential behavior framework that includes a cleaner pipeline with quicker compile times, and easy to manipulate Interface class in Java.
- Performed a literature review and implemented an efficient human-like kicking motion controller for the Atlas robot.

Publications

2022

M. Karan, A. Peter, M. Lahijanian., "Let's Collaborate: Regret-based Reactive Synthesis for Robotic Manipulation", IEEE ICRA, 2022

M. Jay, M. Lahijanian, A Nisar, **M. Karan**, et al., "Expert-Informed Autonomous Science Planning for In-situ Observations and Discoveries", IEEE Aerospace Conference, 2022

2018

M. Karan, M. Amol, N. Ashwin, et al., "Condition based monitoring system of Induction Motor using IoT", International Journal of Applied Engineering Research (IJAER), Vol 13, No. 12 (2018) pp. 10186-10190

Scholarships

2022	Inclusion@RSS Fellowship
2022	ICRA 22 Travel Grant by IEEE RAS
2021	Aerospace Eng. Sciences Departmental Fellowship
2021	CU Financial Aid
2020	Diversity & Inclusion Scholarship - Mechanical Eng.

Skills

Languages	Python, Java, MATLAB, C++, LaTeX
Software	ROS, moveit!, Solidworks
Frameworks	Slugs, SPOT, PRISM, TensorFlow, OMPL, PyTorch

Professional Membership

2021 - current	American Institute of Aeronautics and Astronautics (AIAA)
2020 - current	IEEE Computer Society (CS)
2019 - current	IEEE & IEEE-Robotics and Automation Society (RAS)
2016 - 2019	American Society of Mechanical Engineers (ASME)
2017 - 2018	Indian Society of Heating, Refrigeration, and Air Conditioning Engineers (ISHRAE)

Honors & Awards

Core Organizing Committee - Robotics Networking event — *Boulder, CO*
Spearheaded the very first annual collaborative robotics networking event at CU Boulder attended by industry professionals working at the local robotics companies. — 2019

ASME engineer's conclave — *Mumbai, India*
Recognition by ASME India team for organizing the very first ASME early career engineer's conclave for professionals in India. — 2018

Outreach

Sitting with BIPOC - Event at CU GEARRS Fall 20 Mechanical Symposium — *Boulder, CO*
Q & A session with potential graduate students on various communities at CU Boulder and clarify diversity & equity related queries. — 11/20

Teach Robotics - St. Vrain Valley School District — *Boulder, CO*
Initiated talks with local district school teachers to nurture skills related to robotics and STEM for K-12 students. — 10/20 - 05/21

Graduate Peer Mentoring — *Boulder, CO*
Providing academic guidance to graduate students during their first year at CU Boulder. — 06/20 - Present

Leadership and Services

Chapter Secretary — *Boulder, CO*
IEEE Denver Computer, Information Theory, and Robotics Society (CIR) — 2020 - Present

Committee Member — *Boulder, CO*
Committee for Equity in Mechanical Engineering (CEME) - CU Boulder — 2020 - 2021

Technical Secretary — *Mumbai, India*
American Society of Mechanical Engineers (ASME) - RGIT — 2017 - 2018