

Karan Muvvala

Formal Methods >_ Game Theory >_ Neural Network Verification >_ Robotics

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Research Summary

My research centers around developing algorithms with performance and safety assurances to enable assured and intelligent autonomy. My interests include Formal Methods, task planning, neural network verification, and safe controller synthesis. I aim to build safe autonomous systems to operate efficiently in dynamic 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

Grant NASA COLDTech - Developing provably safe and robust planning algo. for autonomous landers for efficient exploration of ocean worlds like Europa ([Link](#))

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 Iterative Autonomous Systems Group at CU Boulder ([ARIASystems](#))

05/21 - Present

- Developing an efficient symbolic regret-minimizing strategy synthesis framework for scalable reactive synthesis applied to human-robot collaboration scenario.
- Formulated a novel verification framework to certify behavior of autonomous systems represented as neural networks using Stochastic Barrier Functions.
- Synthesizing a minimally-invasive controller that induces provable probabilistic guarantees on violating the user-defined safety constraints.

M.S. Thesis

Boulder, CO

Assured Reliable Iterative Autonomous Systems Group at CU Boulder ([ARIASystems](#))

08/19 - 05/21

- Developed a novel and general regret based reactive synthesis framework 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.

Research Internships

Research Intern - Proactive and Robust Planning under Uncertainty

Detroit, MI

Planning and Decision Making R & D - General Motors

05/23 - 08/23

- Developed & validated algorithms to augment learning-based (RL) planners to be robust to perceptual uncertainties for Autonomous Vehicles.

Summer Research Intern - Fast Behaviors Project

Pensacola, FL

Florida Institute for Human and Machine Cognition ([IHMC](#))

05/19 - 08/19

- Developed high-level complex behaviors for Humanoid Robots in Java that combined perception, planning, and controls.
- Implemented an efficient human-like kicking motion controller for the Atlas robot.

Publications

2023

K. Muvvala, A. Wells, M. Lahijanian, L. Kavraki, M. Vardi, “Stochastic Games for Interactive Manipulation Domains”, IEEE International Conference on Robotics and Automation (**ICRA**) (submitted), 2024

K. Muvvala, M. Lahijanian, “Efficient Symbolic Approaches for Quantitative Reactive Synthesis with Finite Tasks”, IEEE International Conference on Intelligent Robots and Systems (**IROS**) (to appear), 2023

J. McMahon, M. Lahijanian, N. Ahmed, **K. Muvvala**, et al., “REASON-RECOURSE Software for Science Operations of Autonomous Robotic Landers”, **IEEE Aerospace Conference**, 2023

2022

R. Mazouz*, **K. Muvvala***, A. Babu, et al., “Safety Guarantees for Neural Network Dynamic Systems via Stochastic Barrier Functions”, Advances in Neural Information Processing Systems (**NeurIPS**), 2022. - *Equal Contribution

K. Muvvala, P. Amorese, and M. Lahijanian, “Let’s Collaborate: Regret-based Reactive Synthesis for Robotic Manipulation”, IEEE International Conference on Robotics and Automation (**ICRA**), 2022

J. McMahon, M. Lahijanian, N. Ahmed, **K. Muvvala**, et al., “Expert-Informed Autonomous Science Planning for In-situ Observations and Discoveries”, **IEEE Aerospace Conference**, 2022

K. Muvvala, M. Lahijanian, “Near-Optimal Regret-Minimizing Strategies For Human-Aware Robotic Manipulation”, **RSS Workshop** on Risk Aware Decision Making: From Optimal Control to Reinforcement Learning, 2022

2021

K. Muvvala, M. Lahijanian, “Reactive Synthesis for Human-aware Robotic Manipulation using Regret Games”, **RSS Workshop** on Robotics for People: Perspectives on Interaction, Learning and Safety, 2021

Skills

Languages

Python, Java, MATLAB, C++, \LaTeX

Software

ROS, moveit!, Solidworks

Frameworks

PRISM, PRISM-games, TensorFlow, PyTorch, CVXPY

Scholarships

2023	IROS 23 IEEE/RAS Member Support Program
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.

Open Source Tools

Let's Collaborate - Reactive synthesis without Regret

Python, C++, Cython, Binary & Algebraic Decision Diagrams, LTLf, LTL

- First Symbolic framework for efficient quantitative reactive synthesis. ([Github](#))
- First correct-by-construction Regret-Minimizing Reactive Synthesis tool. ([Github](#))

NeuralNetControlBarrier

Julia, Python, Matlab, Docker

- Safety certification and control for Neural Network Dynamic Models via Stochastic Barrier Functions. ([Github](#))

Correct-by-Synthesis Reinforcement Learning

General Reactivity (1), Slugs, Python

- Correct-by-synthesis maximally permissive strategy synthesis for RL agent with temporal constraints. ([Github](#))

Professional Membership

2019 - Present	IEEE & IEEE-Robotics and Automation Society (RAS)
2020 - Present	IEEE Computer Society (CS)
2021 - 2022	American Institute of Aeronautics and Astronautics (AIAA)
2016 - 2019	American Society of Mechanical Engineers (ASME)
2017 - 2018	Indian Society of Heating, Refrigeration, and Air Conditioning Engineers (ISHRAE)

Outreach

IEEE Volunteer Leadership Training Program Fellow	2022
Graduate Peer Mentoring	2020 - Present
Sitting with BIPOC - Event at CU GEARRS Fall 20 Mechanical Symposium	2020
Teach Robotics - St. Vrain Valley School District	2020
Core Organizing Committee - Robotics Networking event	2019