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 robots operating in presence of humans using game-theoretic approaches to enable safe human-like behavior for robots in collaborative settings.

My current research interests are formal methods, task and motion planning, verification of neural networks, and safe controller synthesis. My goal is 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 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.
- Formulating 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 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.

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

2023

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

2022

R. Mazouz*, **K. Muvvala***, A. Ratheesh Babu, L. Laurenti, and M. Lahijanian„ "Safety Guarantees for Neural Network Dynamic Systems via Stochastic Barrier Functions ", Advances in Neural Information Processing Systems **(NeurIPS)**, 2022. (accepted) - *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

2018

K. Muvvala, A. Mangrulkar, A. Nair, 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	TensorFlow, OMPL, PyTorch, PRISM

Open Source Tools

Let's Collaborate - Reactive synthesis without Regret

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

- The first correct-by-construction Regret-Minimizing Reactive Synthesis tool. (Github)
- Developing the first Symbolic quantitative framework for efficient Reactive Synthesis. (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 Services

Conference Paper Reviewer

Int. Conference on Robotics and Automation (ICRA) 2022, 2023

Teaching Expereince

Graduate	MCEN 5228 Inverse Methods (S21)
Graduate	MCEN 5127 Biomedical Ultrasound (F20)
Undergraduate	MCEN 3030 Computational Methods (S20, F19, S19)

Outreach

IEEE Volunteer Leadership Training Program Fellow *2022*

Graduate Peer Mentoring *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*