

Parv Kapoor

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Education

Carnegie Mellon University

Pittsburgh, U.S.A.

Ph.D. in Software Engineering, Advisors: Dr. Eunsuk Kang and Dr. Sebastian Scherer

August 2021 - August 2025 (expected)

GPA: 4.03/4.00 | Selected Courses: Deep Learning Systems, Artificial Intelligence for Social Good, Advanced Formal Methods, Provably Safe Robotics, Human-Robot Interaction

Manipal Institute of Technology

Manipal, India

B.Tech. in Computer Science Engineering

August 2016 - August 2020

GPA: 8.59/10 | Minor: Intelligent Systems

Academic Research

Software Design and Analysis Lab, Carnegie Mellon University

Pittsburgh, U.S.A.

Graduate Research Assistant | PI: Eunsuk Kang

August 2021 - Ongoing

- Defined a new notion of robustness for reinforcement learning policies to meet system requirements in the presence of deviations
- Constructed a logical falsification problem and a novel simulation-based analysis framework for finding small robustness violations
- Implemented 8 real-world robustness benchmark environments using MATLAB Simulink, PyBullet, and OpenAI Gym
- Devised an Signal Temporal Logic decomposition theory for incremental Task and Motion Planning and Safe Reinforcement Learning
- Achieved a 65% reduction in solving time and a 51% performance improvement over state-of-the-art optimization-based planners

AirLab, Carnegie Mellon University

Pittsburgh, U.S.A.

Graduate Research Assistant | PI: Sebastian Scherer

August 2021 - Ongoing

- Enhanced Learning from Demonstration (LfD) policy STL specification satisfaction via Monte Carlo Tree Search refinement
- Attained a 60% improvement in real-world trajectory planning leveraging human demonstration data over baseline LfD methods
- Designed an angular rate-based control barrier function for autonomous aircraft collision avoidance using only vision-based sensing
- Analyzed the enforcing reactive controller in a digital twin environment within Nvidia Isaac Sim and conducted over 70 hours of in-field testing on Aurelia X6 drones
- Achieved a 71% improvement over baseline system with high-speed closure rates (92 mph)

Research Experience

Verimag, Université Grenoble Alpes

Grenoble, France (Remote)

Research Engineer | PI: Thao Dang

January 2021 - August 2021

- Developed a theory for uniform random stimulus generation using timed automata for autonomous system validation
- Evaluated these techniques within the SUMO simulation environment for applications in autonomous vehicles

Cyber Physical Systems Lab, University of Southern California

Los Angeles, U.S.A.

Research Intern | PI: Jyotirmoy Vinay Deshmukh

January 2020 - January 2021

- Developed novel model-based reinforcement learning algorithms for safe policy training from signal temporal logic specifications
- Implemented efficient model-free algorithms (TRPO, A3C, PPO) in PyTorch with unique STL-based reward design
- Achieved 82 percent higher specification satisfaction compared to baseline RL policies
- Engineered in-house simulation environments for algorithm benchmarking employing CARLA, AirSim, and Gazebo

Visual Computing Group, Cardiff University

Cardiff, U.K.

Research Intern | PI: David Marshall

May 2019 - July 2019

- Constructed a safe trajectory prediction system for visually impaired individuals using ZED stereo camera
- Implemented and trained a 2-stream CNN in TensorFlow on human walking data for forecasting ego agent camera movement
- Improved CNN accuracy in low-data regimes through neuro-inspired data augmentation

RapidQube Digital solutions Pvt. Ltd.

Mumbai, India

Research Intern

May 2018 - July 2018

- Created an accident prediction system leveraging convolutional neural networks and object tracking algorithms (YOLOv3)
- Implemented depth prediction Residual CNNs alongside YOLO v3 in Tensorflow to classify nearby drivers' speed profiles with 300 ms latency

Skills

Programming Python, C/C++, JAVA, MATLAB, Alloy, TLA+, MySQL, CUDA programming, OpenCL

Tools and Libs PyTorch, TensorFlow, ROS, Isaac sim, AirSim, CARLA

Projects

Safeguards for Large Language Models (with Microsoft Research NYC)

Collaborators: Hosein Hasanbeig, Siddhartha Sen

- Working with AI for Systems Group to develop iterative, feedback-guided in context learning
- Building deep learning pipelines for integration of safety specifications in Large Language Models (LLMs).
- Analysing Embedding Spaces to improve alignment of LLMs.

Differential Programming in Needle

Course Project

Fall 2023

- Built a comprehensive deep learning library from scratch, enabling GPU acceleration, automatic differentiation, and customizable layers, loss functions, and optimizers.
- Deployed Implicit Layers, convolutional networks, recurrent networks, self-attention models, and generative models using the library.

Predicting Food Insecurity in Somalia using Machine Learning

Collaborators: Michael Feffer, Sebastian Dodt and Fei Fang

Spring 2022

- Collaborated with United Nations OCHA for food insecurity predictions in Somalia.
- Employed random forests, gradient-boosted trees, and gaussian processes for accurate real-time forecasting of hunger levels.

Trust elicitation and restoration in assistive robots

Collaborators: Angela Chen, Simon Chu, Henny Admoni

Fall 2022

- Investigated the impact of customization and perspective on perceived trust in dexterous manipulation of assistive robotics.
- Conducted a pilot user study that showed higher trust and comfort measures with increased customization.

Selected Publications

Specification-Based Robustness Analysis of CPS in the face of System Deviations

C. Zhang*, **P. Kapoor***, R.M. Goes, D. Garlan, E. Kang, A. Ganlath, S. Mishra, N. Ammar

- **International Conference on Cyber Physical Systems (ICCPs) 2024** [arxiv] (Submitted)

Safe Planning through Incremental Decomposition of Signal Temporal Logic

P. Kapoor, R.M. Goes and E. Kang

- **Nasa Formal Methods (NFM) 2024** (Submitted)

ViSafe: Vision-enabled Safety for High-speed Detection and Avoidance

P. Kapoor, I. Higgins, N. V. Keetha, J. Patrikar I. Cisneros, Z. Ye, Y. He, Y. Hu, S. Scherer

- Under Submission

FoundLoc: Vision-based Onboard Aerial Localization in the Wild

Y. He, I. Cisneros, N. V. Keetha, J. Patrikar, Z. Ye, I. Higgins, Y. Hu, **P. Kapoor**, S. Scherer

- **Computer Vision and Pattern Recognition (CVPR) 2024** [arxiv] (Submitted)

Follow The Rules: Online Signal Temporal Logic Tree Search for Guided Imitation Learning in Stochastic Domains

J. Patrikar, J. Aloor, **P. Kapoor**, S. Scherer and J. Oh

- **IEEE International Conference on Robotics and Automation (ICRA) 2023** [arxiv]

Challenges in Close-Proximity Safe and Seamless Operation of Manned and Unmanned Aircraft in Shared Airspace

J. Patrikar, J. Dantas, S. Ghosh, **P. Kapoor** et al

- **IEEE International Conference on Robotics and Automation (ICRA) 2022** [arxiv]

Model-based Reinforcement Learning from Signal Temporal Logic Specifications

P. Kapoor, A. Balakrishnan, J. V. Deshmukh

- [arxiv]

Predicting Time to Contact Across the Visual Image

D. Marshall, S.K. Rushton, J. Redfern, **P. Kapoor**, R.J. Moran

- In PERCEPTION (Vol. 49, No. 6, pp. 714-714) SAGE PUBLICATIONS LTD.

Achievements & Volunteer Work

- 2022 Selected for 11th Summer school on Formal Techniques organized by SRI International
- 2020 Member of the Organising Committee for the 20th International Conference on Runtime Verification held in Los Angeles.
- 2020 Remotely mentored UW-Madison students on applications of deep reinforcement learning for stock trading and analysis.
- 2019 Presented a Poster at Bristol Vision Colloquium at University of Exeter.