Parv **Kapoor**

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Education

Carnegie Mellon University *Pittsburgh, U.S.A.*

Ph.D. in Computer Science, Advisors: Dr. Eunsuk Kang and Dr. Sebastian Scherer *August 2021 - August 2025 (expected)*

CQPA: 4.06/4.00 | Research Areas: Reinforcement Learning, Software Engineering for AI, Safe Control, Formal Verification

Manipal Institute of Technology *Manipal, India*

B.Tech. in Computer Science Engineering *August 2016 - August 2020*

CGPA: 8.59/10 | Minor: Intelligent Systems

Graduate Coursework: Deep Learning Systems, Provably Safe Robotics, Human-Robot Interaction, Artificial Intelligence for Social Good, Advanced Formal Methods

Skills

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

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

Research Experience

Software Design and Analysis Lab, *Carnegie Mellon University* *Pittsburgh, U.S.A.*

Graduate Research Assistant| PI: Eunsuk Kang *August 2021 - December 2023*

- Defined a new notion of robustness for autonomous control agents 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 eight real-world robustness benchmark environments using MATLAB Simulink, PyBullet, and OpenAI Gym.
- Devised a requirement decomposition theory for incremental Task and Motion Planning and Safe Reinforcement Learning.
- Achieved a 65% reduction in solving time and a 51% performance improvement compared to state-of-the-art planners.

Airlab, *Carnegie Mellon University* *Pittsburgh, U.S.A.*

Graduate Research Assistant| PI: Sebastian Scherer *August 2021 - December 2023*

- Designed an angular rate-based control barrier function for autonomous aircraft collision avoidance using only vision-based sensing.
- Analyzed the technique in a digital twin environment within Isaac Gym and conducted over 70 hours of in-field testing.
- Achieved a 71 % improvement over baseline system with high speeds closure rate (92 mph).
- Enhanced Learning from Demonstration (LfD) policy constraint satisfaction via Monte Carlo Tree Search refinement.
- Attained a 60 % improvement in real-world aviation trajectory planning leveraging human demonstration data over baseline LfD methods.

Verimag, *Université Grenoble Alpes* *Grenoble, France (Remote)*

Research Engineer | PI: Thao Dang *January 2021 - August 2021*

- Formalized concepts 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 Assistant | 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.
- Engineered in-house simulation environments for algorithm benchmarking employing CARLA, AirSim, and Gazebo.

Visual Computing Group, *Cardiff University* *Cardiff, U.K.*

Undergraduate Researcher | 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.

Other Projects

Needle (NEcessary Elements of Deep LEarning)

Course Project

- Built a comprehensive deep learning library from scratch, enabling GPU acceleration, automatic differentiation, and customizable layers, loss functions, and optimizers.
- Deployed 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

- 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

- Investigated the impact of customization and perspective on perceived trust in an assistive robotics context.
- 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 *2023*

- International Conference on Cyber Physical Systems (ICCPS) 2024 (Submitted)

Safe Planning through Incremental Decomposition of Signal Temporal Logic

P. Kapoor, R.M. Goes and E. Kang *2023*

- Under Submission

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 *2023*

- 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 *2023*

- 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 *2022*

- 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 *2022*

- 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 *2020*

- [arxiv]

Predicting Time to Contact Across the Visual Image

D. Marshall, S.K. Rushton, J. Redfern, **P. Kapoor**, R.J. Moran *2020*

- 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 Exetor.