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)*
TA: Designing Large Scale Software Systems (S3D S24)

Carnegie Mellon University   *Pittsburgh, U.S.A.*
Masters in Software Engineering   *August 2021 - August 2024 (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

Research Experience

Scaled Foundations   *Seattle, WA*
Research Intern | PIs: Dr. Sai Vemprala and Dr. Ashish Kapoor   *May 2024 - Ongoing*
- Developing a foundation model deployment pipeline for domain adaption to diverse physical form factors
- Building novel alignment strategies for robotics foundation models using constrained decoding in transformers

Verimag, *Université Grenoble Alpes*   *Grenoble, France (Remote)*
Research Engineer | PI: Dr. Thao Dang   *January 2021 - August 2021*
- Developed input stimulus generation theory 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: Dr. 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: Dr. 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

Academic Research

AirLab, *Carnegie Mellon University*   *Pittsburgh, U.S.A.*
Graduate Research Assistant | PI: Sebastian Scherer   *August 2021 - Ongoing*
- Enhanced Learning from Demonstration (LfD) policy constraint 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)

Software Design and Analysis Lab, *Carnegie Mellon University*   *Pittsburgh, U.S.A.*
Graduate Research Assistant | PI: Eunsuk Kang   *August 2021 - Ongoing*
- Defined a new tolerance notion for safe reinforcement learning policies and created a simulation-based framework to identify unsafe operating conditions.
- Proposed a novel inverse learning problem leveraging positive and negative behavior traces, through translation into maximal satisfiability (MaxSAT) problems.
- 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 over state-of-the-art optimization-based planners

Skills

Programming   Python, C/C++, JAVA, MATLAB, Alloy, TLA+, MySQL, CUDA programming, OpenCL
Tools and Libs   PyTorch, TensorFlow, ROS, Issac sim, AirSim, CARLA

Projects

Safeguards for Large Language Models (with Microsoft Research NYC)
Collaborators: Hosein Hasanbeig, Siddhartha Sen
- Worked with AI for Systems Group to develop iterative, feedback-guided in context learning
- Analysed Embedding Spaces to improve alignment of LLMs.

Differential Programming in custom Deep Learning libraries
Deep Learning Systems 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 assitive robotics.
- Conducted a pilot user study that showed higher trust and comfort measures with increased customization.

Preprints and Publications

Logically Constrained Robotics Transformers for Enhanced Perception Action Planning
P. Kapoor, Sai Vemprala, Ashish Kapoor
- Under Review

Analyzing Tolerance of Reinforcement Learning Controllers against Deviations in Cyber Physical Systems
C. Zhang*, **P. Kapoor***, R.M. Goes, D. Garlan, E. Kang, A. Ganlath, S. Mishra, N. Ammar
- **Formal Methods (FM)** 2024 [arxiv]

Safe Planning through Incremental Decomposition of Signal Temporal Logic
P. Kapoor, R.M. Goes and E. Kang
- **Nasa Formal Methods (NFM)** 2024 [arxiv]

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 Review

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
- Under Review [arxiv]

Example-based Constrained LTL specification learning using MaxSAT
C. Zhang*, **P. Kapoor***, I. Dardik, A. Cui, R.M. Goes, D. Garlan, E. Kang
- Under Review

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
- 2020 [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. 2020