

Dvij Kalaria

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Research Interests

Robotics & AI: Agile robots, Embodied AI, Reinforcement Learning, Adaptive control, Computer Vision

Academics

Masters in Robotics (MSR)
Robotics Institute, Carnegie Mellon University (CMU)

Aug 2022 - July 2024
GPA: 4.08/4

B. Tech in Computer Science and Engineering
Indian Institute of Technology, Kharagpur

July 2018 - June 2022
GPA: 9.16/10

Publications Under Review

1. **Dvij Kalaria**, Qin Lin, and John M. Dolan. Towards optimal head-to-head autonomous racing with curriculum reinforcement learning. Presented at MADGames workshop, IROS 2023 and Under review, IROS 2024 [\[Website\]](#)

Publications

1. **Dvij Kalaria**, Qin Lin, and John M. Dolan. Adaptive planning and control with time-varying tire models for autonomous racing using extreme learning machine. ICRA 2024 [\[Website\]](#) [\[Code\]](#) [\[PDF\]](#)
2. **Dvij Kalaria**, Qin Lin, and John Dolan. Delay-aware robust control for safe autonomous driving and racing. T-ITS journal [\[PDF\]](#) [\[Code\]](#)
3. **Dvij Kalaria**, Qin Lin, and John Dolan. Delay-aware robust control for safe autonomous driving. [Oral, 10% of accepted] IEEE-IV 2022 [\[PDF\]](#) [\[Code\]](#)
4. **Dvij Kalaria**, Qin Lin, and John Dolan. Towards safety assured end-to-end vision based control for safe autonomous racing. IFAC Congress 2023 [\[PDF\]](#) [\[Code\]](#)
5. Emanuel Munoz, **Dvij Kalaria**, Qin Lin, and John M. Dolan. Online adaptive compensation for model uncertainty using extreme learning machine-based control barrier functions. IROS 2022 [\[PDF\]](#)

Peer-Reviewed Workshop Papers

1. **Dvij Kalaria** et al. Local NMPC on Global Optimised Path for Autonomous Racing. In *OCAR Workshop*, ICRA 2021 [\[PDF\]](#)
2. **Dvij Kalaria**, Aritra Hazra, and Partha Pratim Chakrabarti. Detecting Adversaries, yet Faltering to Noise? Leveraging Conditional Variational AutoEncoders for Adversary Detection in the Presence of Noisy Images . In *AdvML workshop*, AAAI 2022 [\[PDF\]](#)
3. **Dvij Kalaria**, A. Hazra, and P. Chakrabarti. Towards Adversarial Purification using Denoising AutoEncoders. MLSW, NeurIPS 2022 [\[PDF\]](#)

Technical Skills

Languages: Python | C | C++ | MATLAB | JAVA | SQL | LaTeX

Libraries & Tools: ROS | PyTorch | OpenCV | Gazebo | Casadi | Blender | VRXPERIENCE | Unity

Relevant Coursework: F1Tenth | Learning for 3D Vision ([3 class choice awards](#)) | Computer Vision | Safe robotics | Deep Learning | Robot Learning | SLAM | Reinforcement Learning | Machine Learning | Algorithms-1 & 2 | Operating Systems | SDM | Probability and Statistics | SDE | Game development

Research Experience

CMU AV Center lab, Robotics Institute, CMU Advisor: Dr. John M. Dolan, Dr. Qin Lin June '21 - Present

- **Robotics Institute Summer Scholar (RISS)** [\[PDF\]](#) [\[poster\]](#) [\[video\]](#)[\[Code\]](#) : Implemented a delay aware Tube-MPC which compensates for delays observed in autonomous vehicles due to computation, actuator command processing and actuator dynamics for autonomous driving and racing scenarios
- Formulated a control plan to compensate for delays in deploying a blackbox learning enabled controller
- Used **Control Barrier Functions (CBFs)** in Frenet frame for obstacle avoidance and lane keeping
- **Vision based End-to-end safety assured control for autonomous racing** [\[Code\]](#) : Proposed a novel framework to learn both a policy and a CBF to guarantee safety with only camera image sensor being used. Improved safety and training efficiency by atleast 50%. Tested on carla and real RC car
- **APACRace** [\[Website\]](#) [\[Code\]](#) : Proposed an online learning framework that can both learn and quickly adapt the vehicle model as well as reference racing line online under various changing environmental conditions like friction and aerodynamic parameters. Tested on carla, numeric sim and real RC car
- **Hierarchical RL for head-to-head racing** [\[Website\]](#) : Proposed an automated curricula based on transitioning vehicle model friction parameters from easier to harder. Also, proposed curriculum-CBF approach to effectively inculcate safety while not compromising optimality. Tested for head-to-head racing and safety-gym benchmark to improve performance by atleast **15%** on all environments

- **Offroad driving on uneven terrain [Simulator]** : Open sourced simulator environment in Unity capable of procedurally generating random trail environment. Trained automated imitation learning, CBF guided RL with just depth image and IMU as input on it. Ongoing deployments on real buggy car

AI Racing Tech team, Indy Autonomous Challenge [Website] [Code]

July'23 - Present

- Implemented Model Predictive Control (MPC) control with a more complex vehicle model suitable at high speeds to consider objectives for overtaking, optimal racing line keeping and use of drafting. 🌀
- Implemented **Adaptive LQG** control followed by a CBF layer that considers lateral tire dynamics
- Implemented **online parameter estimator** that can adapt controllers to friction, aerodynamic params
- Implemented **CBF** for track boundary violations and safe distance keeping from opponent
- Various engineering tasks like offline torque map generation, implementing ABS, developing numeric simulator, parallel processing, bank angle estimation, sensor data filtering and bias corrections etc
- AI Racing Tech team finished 3rd on the Indy Autonomous Challenge, **CES 2023** at Las Vegas

Autonomous Ground Vehicles, IIT Kharagpur Advisor : Dr. Debashish Chakravarty

Apr'19 - Dec'20

- **Eklavya 7.0 for IGVC 2019 (Finished 2nd), May'19-July'19**
 - Incorporated Localization module on ROS using EKF (Extended Kalman Filter) and UKF (Uncentred Kalman Filter) techniques taking as input from odometry, IMU and GPS sensors.
 - Worked under Path Planning module, costmap generation, waypoint generation, ramp detection, pothole detection, sensor integration.
- **Hybrid A* Motion Planner [Code]**: Implemented the conventional path planner on ROS C++ with added voronoi field into heuristic cost to plan safer path while not compromising admissibility. Tested on Gazebo simulation, Husky industrial prototype, Mahindra e2o on dynamic obstacle course
- **Deep Learning based trajectory prediction [Code]**: Used Graph convolution layers over GRIP++ SOTA architecture and outperformed the SOTA on Apolloscape and NGSIM dataset by 10% on WSADE loss

Adversary Detection and Purification, BTech Thesis [Code]

Mar'21 - Present

Advisor: Dr. Partha Chakravarty, Dr. Aritra Hazra

- Implemented a novel Conditional-VAE network for detecting white box **adversarial attacks**
- Implemented proposed adaptive **Denosing AutoEncoders (DAE)** for purification of adversaries
- Improved results on ImageNet, Cifar10, MNIST dataset with the state of the art methods with added advantage of not detecting an image with random noise as an adversary

Industrial Experience

Pratt Miller Research intern

May'23-July'23

- Proposed **ML** models for opponents to predict their pit strategy, driver and vehicle limit parameters
- Developed an **optimization** framework to get an optimal pit stop choice given the opponent ML models
- Used **RL** to optimize ego agent race strategy against other trained racing agents based off previous races
- Deployed the model on **flask** as a demo during a live **IMSA race**

PreImage DL Research intern

Dec'20-Feb'21, Aug'21-Jun'22

- Incorporated a **generative DL model** to generate different 3D shapes of a particular class
- Worked on **DL based auto-calibration** of raw images to correct barrel and pincushion distortion
- Worked on **DL based image matching and clustering** to get image clusters capturing common scene

Oracle Cloud Infrastructure (OCI) DL Research intern

Apr'21-Jun'21

- Simulated an **uncertainty aware active learning** workflow to assist manual labelers on image detection task. Used a modified YOLOv5 network to consider epistemic uncertainty in the confidence score
- Implemented **image clustering** to present images in clusters with common features to reduce fatigue
- Touched upon extending the active learning workflow to NLP **Named Entity Recognition (NER)** task

Teaching Positions

- **F1Tenth course head TA, CMU** : Involved significantly high efforts as was introduced for first time in CMU. Tutored **2 lectures** based on my research, **8 tutorials** including hardware as part of the course. Mentored course projects of **4 teams**, organized **3 races**. Also organized demo presentation in **Safety21**
- **IEEE Winter Workshop, IIT Kharagpur** : Mentored a week long IEEE certified IP Workshop attended by more than 100 first years on topics related to image processing
- **Kharagpur Winter of Codes (KWOC), IIT Kharagpur** : Mentored for a pygame project with 5 first year mentees involved, conducted by KOSS, IIT Kharagpur
- **Oracle coding workshop** : Tutored a 3-day workshop conducted to teach high school students from various social backgrounds the basics of programming

Other Relevant Projects

EasyDataLabeler Android App [\[Code\]](#) Advisor: Prof. Debasis Samanta

Apr'20-May'20

- Developed fully functional android app developed for easily adding bounding box and polygon labels, free line semantic segmentation on a dataset.
- Employed industrial software development techniques like preparing SRS, DFD, Class diagrams.

Achievements

- **JEE Advanced, All India Rank 245 (Top 0.1%), Indian Institute of Technology (IITs), 2018**
- **JEE Mains, All India Rank 393 (Top 0.01%) Central Board For Secondary Education (CBSE), 2018**
- **Bosch MidPrep InterIIT tech 2022** : Head of the solo gold winning team
- **JOSAA 2021** : Was part of the committee responsible for for the largest pan India entrance exam with 1.2 million candidates. Prepared automated scorecard and ranklist creation scripts taking into consideration complicated reservation rules