Rahul Kashyap Swayampakula

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Education

University of Michigan, Ann Arbor — Aug 2022 - May 2024 *(expected)*
Masters in Robotics — *GPA: 4.0/4.0*

International Institute of Information Technology, Hyderabad, India — June 2018 - June 2022
B.Tech (Hons.) in Electronics and Communication Engineering — *GPA: 9.17/10.0*

Experience

Research Assistant @ Ford Center for Autonomous Vehicles Lab *Ann Arbor, MI* — Jun 2023 - Present

- Working on **Reachability-based Motion Planning Algorithms** in a Gaussian Splatting Environment for Enhanced Safety Guarantees in Robotic Arms and Mobile Manipulators
- Worked on utilizing implicit representations for robotic applications, including proposing a **SLAM** pipeline based on **Gaussian Splatting**. Conducted research on **Decoder-only NeRF** representations for object detection
- Created a real-time interactive rendering package in Nerfstudio for **LiDAR-Only Neural Representations SLAM.**

Research Assistant @ Robotics Research Center, IIIT Hyderabad *Hyderabad, Telangana* — Jul 2020 - May 2022

- Worked on building novel non-linear control algorithms for payload carrying drones with variable mass and inertia.
- Formulated **Adaptive Sliding Mode** and nonlinear **Model Predictive Controller** through dynamic modeling for payload carrying drones and aerial manipulators, optimizing performance in constrained environments.
- Developed simulation environments in ROS-Gazebo and implemented controllers on PX4 flight controller.
- Published Our work at **IEEE Robotics and Automation Letters** and **European Control Conference (ECC)**

Robotics Intern @ DreamVu Inc. *Hyderabad, Telangana* — May 2021 - Jul 2021

- Implemented **Frame2Map** based **Visual Odometry** module using ORB features for **360° single sensor stereo** *PAL camera* using a piecewise perspective camera model.
- Produced **Scene maps** and refined the tracking pose using **Bundle Adjustment**. Evaluated the Visual Odometry module on real-world indoor and outdoor datasets, and achieved best tracking performance of **14 cms RMSE** in a 7.5mx12m map

Projects

Gaussian Splatting SLAM | *Pytorch, Python, SLAM, C++*

- Proposed a novel SLAM algorithm for Gaussian Splatting by jointly optimizing the Gaussian Splats and camera poses .
- Improved the performance of Gaussian Splatting based SLAM by integrating **RAFT** (Recurrent All-pairs Field Transforms for optical flow) based tracking pipeline and **SuperPoint** based Visual **Place Recognition** Modules.
- Evaluated and Finetuned the method across Replica and TUM datasets and achieved high PSNR and low tracking errors.

Autonomous Cleaning Robot | *Software, ROS, C++, Python*

- **Runner-ups** of ARTPARK Robotics Challenge 2021-22 (out of 133 teams), in developing an autonomous cleaning robot.
- Developed **ROS based Autonomy software stack** for detection of doors, markers and trash and countertops using Image and Pointcloud Processing. Integrated with RTAB-MAP SLAM and move-base planner for autonomous **mapping, navigation and obstacle avoidance** of robot.

MBot ROS Development | *C++, Python, ROS, Robotics*

- Developed a **Autonomy Software package** for UMich Educational robot platform (MBot) , using **ROS2-microROS**
- Deployed the package on **Jetson-Raspberry Pi Pico**, incorporating various modules, including a differential drive motion controller with PID tuning, LIDAR-based Occupancy Mapping utilizing Particle Filter Localization, A* Path Planning.

Rapid Motor Adaptation on Unitree Go1 | *Robotics, Reinforcement Learning, Pytorch, Python*

- Fine-tuned the PPO-based RL locomotion policy (**Rapid Motor Adaptation Policy**) for the Unitree Go-1 robot by optimizing both the base and adaptation modules. Analyzed robot behavior across range of terrains and robot parameters.
- Integrated a vision-based **Cross Modal Supervision** algorithm to enhance the robot's locomotion performance in challenging terrains.
- Deployed and tested the policy on a real robot in diverse terrains such as steps, sand, and rocky surfaces, achieving superior performance compared to baseline models.

Pytorch Implemntation of Context Encoders | *Computer vision, Pytorch, Python*

- Implemented **Context Encoders**: Feature Learning by Inpainting in **Pytorch** to reconstruct the missing part of the image through unsupervised feature learning by image Inpainting using GANs.
- Reproduced the author's results by tuning hyperparameter and loss functions, extended method to random patches.

Block stacking robot | *Robotics, ROS, Python*

- Developed autonomy software for the 5-DoF ReactorX 200 Robot Arm, integrating **Inverse Kinematics, PID control, and a state machine** for precise block detection and stacking.
- Calibrated the Real Sense camera and employed **HSV color segmentation**, depth analysis for effective object recognition.

Course Projects | *Vision, Robotics*

- **Object detection and pose estimation** - Implemented Faster R-CNN and PoseCNN architectures from scratch.
- **Grabcut for image segmentation** - Implemented the GMM, energy model and minimization algorithms from scratch.
- **Viola Jones for face detection** - Implemented the Haar features, integral image and adaboost algorithm from scratch.

Technical Skills

Programming: Python, C, C++, Matlab, Bash, C#, HTML, CSS, Javascript
AI/ML: PyTorch, Pandas, Keras, NumPy, OpenCV, PIL, Sklearn, Matplotlib, Plotly
Frameworks and Hardware: ROS, ROS2, microROS, PX4, Linux, Unity, Hololens, Jetson

Coursework

Robotics: Mobile Robotics, Adv in Control, Planning and Navigation, Robotic Systems Laboratory
Deep Learning: Deep Learning for Robot Perception, Action Perception, Statistical Methods in AI, Computer Vision.
Computer Science: Data Structures and Algorithms, Operating Systems, Processor Architecture
Mathematics: Applied Optimization, Probability and Random Processes, Linear Algebra, Real Analysis

Publications

1. Published *Robustifying Payload Carrying Operations for Quadrotors Under Time-Varying State Constraints and Uncertainty*, in **IEEE Robotics and Automation Letters - 2022**.
2. Published *Predictive Barrier Lyapunov Function Based Control for Safe Trajectory Tracking of an Aerial Manipulator*, in **European Control Conference (ECC) - 2023**.

Achievements and Positions

- **Runner-ups** of ARTPARK Robotics Challenge 2021-22 (out of 133 teams), in developing an autonomous cleaning robot.
- Invited as reviewer for **European Control Conference (ECC 23')**.
- **Dean's List** Awardee for Academic Excellence for 6 out of 8 semesters.
- Semi-finalist of **Flipkart Grid 2.0 challenge** (out of 500 teams), in building an **Autonomous Stair Climbing Robot**.
- Represented IIIT-H at **Smart India Hackathon**, contributing to a **LoRaWAN-based Smart Streetlight System**.
- Represented IIIT-H at **CANSAT 2021** by designing maple seed payload.
- **Coordinator** for the **IIITH Robotics Club** during the academic year 2020-2021.
- **Teaching Assistant** for VLSI Design, Electronic Workshop, System Thinking during Spring 21', Spring 22', Monsoon 20'. at **IIIT Hyderabad**
- **Teaching Assistant** for SLAM & Navigation during Fall 23' and Winter 24' at **University of Michigan, Ann Arbor**.