# SANDEEP SAM ZACHARIAH

Master of Science in Robotics (MSR)
Carnegie Mellon University
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## RESEARCH AREAS

Vision Language Action Models, Robot Localization and Mapping, Perception, Robot Learning, Generative AI, Task and Motion Planning, Image Processing.

## EDUCATION

**Master of Science in Robotics (MSR)** August 2024 - Present
*Carnegie Mellon University* GPA: 4.11/4.0
**Courses**: Robot Localization and Mapping, Machine Learning, Robot Learning.

**Bachelor of Technology (B. Tech)** July 2018 - May 2022
*National Institute of Technology Calicut, India (NIT Calicut)* GPA: 9.75/10, Institute Rank 1
Department of Electronics and Communication Engineering
**Courses**: Robotics, Artificial Intelligence, Computer Vision, Embedded Systems, Signal Processing.

**High School ($12^{th}$ Grade)** August 2017 - March 2018
*St Thomas Residential School, India* Grade: 98.5%, Rank 2

## EXPERIENCE

**Graduate Research Assistant** September 2024 - Present
*Carnegie Mellon University*
Topic: Simultaneous Localization and Mapping in Forest Environments

- Design and Integration of sensor suite for drone-based data collection.
- Co-registration of under-canopy and above-canopy maps for comprehensive forest environment reconstruction.
- Detection of invasive tree species and semantic 3D forest maps.

**Project Scientist** July 2022 - July 2024
*Indian Institute of Technology Delhi, India (IIT Delhi)*
Topic: Language-guided mobile manipulation.

- Developed the autonomy stack for the mobile manipulator.
- Task planning in incomplete world knowledge.
- Foundation model based planning and perception for zero-shot generalization to novel scenes.

**Project Intern** April 2021 - August 2021
*Indian Institute of Space Science and Technology, India (IIST)*
Topic: Modeling, Control and Simulation of Quadruped robots.

- Closed Loop Inverse Kinematic (CLIK) algorithm for the resolved acceleration control of torso and foot frames.
- Mathematical modeling of quadruped dynamics using Composite rigid body and Recursive Newton-Euler algorithms.
- Joint space and Task space inverse dynamics control with holonomic constraints. Video1, Video2

**Summer Intern** May 2019 - July 2019

*Indian Institute of Technology Delhi, India (IIT Delhi)*

Topic: Modeling, Control and Simulation of Planar Robotic Manipulator.

- Modeling of manipulator dynamics based on the Euler-Lagrange equations of motion.
- CAD design and structural analysis of the manipulator.
- Joint space and Task space control.

## MAJOR PROJECTS

**Dense Forest Under-Canopy and Above-Canopy Map Merging** May 2025 - Present

*Carnegie Mellon University*

Foliage occlusions hinder complete 3D reconstruction of dense forest environments from any single viewpoint. In this work, I align under-canopy and above-canopy maps by maximizing mutual information in a shared latent space of tree-likelihood fields inferred from each map.

**Open-World Scene Graphs for Human-instructed Manipulation Tasks Using Foundation Models** November 2023 - May 2023

*Indian Institute of Technology Delhi*

Effective sequential robot instruction following requires a scene representation that is simultaneously structured and open-set. We present a representation that admits local updates as the scene evolves. Even without any hand-crafted priors, the approach achieves superior performance on open-world object detection and relation extraction compared to previous methods.Paper

**Leveraging Foundation Models for Generalization in Robust Task Planning for Field Robots** May 2023 - July 2024

*Indian Institute of Technology Delhi*

This work focuses on implementing vision language and large language models for perception and planning tasks in a language-guided mobile manipulator designed for outdoor environments. As these models are trained on internet-scale data, this approach equips these systems with the capability to handle novel scenes.

**Task Planning in Incomplete World Knowledge** July 2022 - July 2023

*Indian Institute of Technology Delhi*

Mobile robots deployed on the field are often faced with incomplete knowledge about their surroundings. This project focussed on the development of a language-guided mobile manipulation system that contextually spawns exploration goals based on the information extracted from the natural language instructions. The proposed system achieved a Goal Reaching Rate(GRR) of 90%. Draft Paper, Video

**Underwater Image Enhancement** June 2021 - April 2022

*National Institute of Technology Calicut*

Autonomous exploration systems capture vast image data to study marine life but these images frequently exhibit distortion and clutter. To enhance these images, a novel technique based on wavelet fusion of Multiscale Retinex and Dark Channel Prior algorithm was developed. The proposed model outperformed naive approaches and learning based methods (UNET, CycleGAN) on both quantitative metrics and qualitative metrics. Thesis

## COURSE PROJECTS

**Video conditioned Vision Language Action Models** January 2026 - Present
*Carnegie Mellon University*
Proposed a video-conditioned VLA framework that aligns diffusion model intermediate features with semantic DINO representations to enhance action prediction and generalization in long-horizon manipulation tasks.

**Diffusion and Flow Matching for Long-Horizon Manipulation** August 2025 - December 2025
*Carnegie Mellon University*
Implemented and benchmarked diffusion policy and flow-matching methods on multi-step, multi-robot manipulation tasks (e.g., object transfer, tool hanging) from the RoboMimic dataset.

**Coordinated Dual Arm Manipulation** August 2025 - December 2025
*Carnegie Mellon University*
Implemented a disturbance-rejecting coordinated control framework for a dual-arm robotic setup in PyBullet. Demonstrated successful peg-in-hole insertion and bottle-cap fastening tasks.

**Semantic Simultaneous Localization and Mapping** January 2025 - April 2025
*Carnegie Mellon University*
Collected a semantic SLAM benchmark on the CMU campus using a custom LiDAR–camera–IMU-GNSS sensor suite and evaluated state-of-the-art systems (Kimera, SegMap, SlideSLAM) on it.

## PUBLICATIONS

**MapForest: A Modular Field Robotics System for Forest Mapping and Invasive Species Localization**
**Sandeep S. Zachariah**, Francisco Yandun, Sachet Korada, Abhisesh Silwal
arXiv, Website

**G2TR: Generalized Grounded Temporal Reasoning for Robot Instruction Following by Combining Large Pre-trained Models**
Riya Arora, Niveditha Narendranath, Aman Tambi, **Sandeep S. Zachariah**, Souvik Chakraborty, Rohan Paul
arXiv

**Generating Open-World & Multi-Hierarchy Scene Graphs for Human-instructed Manipulation Tasks via Foundation Models**
**Sandeep S. Zachariah**, Aman Tambi, Moksh Malhotra, P. V. M. Rao and Rohan Paul
ICRA 2024: 2nd Workshop on Mobile Manipulation and Embodied Intelligence
Paper, Website

**Generalized Grounded Temporal Reasoning with Foundation Models for Language-guided Robot Manipulation**
Riya Arora, Niveditha Narendranath, **Sandeep S. Zachariah**, Aman Tambi, Souvik Chakraborty and Rohan Paul
ICRA 2024: Physical Human-Robot Interaction Workshop
Paper, Website

**Incorporating Foundation Model Priors in Modeling Novel Objects for Robot Instruction Following in Unstructured Environments**
Moksh Malhotra, Aman Tambi, **Sandeep S. Zachariah**, P. V. M. Rao and Rohan Paul

ICRA 2024: 3D Visual Representations for Robot Manipulation
Paper, Website

## AWARDS AND HONORS

**Vikram Sarabhai Ever Rolling Trophy** September 2022
*National Institute of Technology Calicut*
Institute level: Awarded for the Best Outgoing student of the year 2022.

**Prof. Allesu Kanjirathinkal Memorial Award** September 2022
*National Institute of Technology Calicut*
Institute level: For having scored the highest CGPA(Rank 1) among all undergraduate programs.

**Er M L Bapna Gold Medal** September 2022
*National Institute of Technology Calicut*
Institute level: For having scored the highest CGPA(Rank 1) among all undergraduate programs.

**Gold Medal** September 2022
*National Institute of Technology Calicut*
Department level: Outstanding scholastic performance in Electronics and Communication Engineering department(Rank 1) with a CGPA of 9.75/10.

**Certificate of Merit** February 2019
*National Institute of Technology Calicut*
For securing the first position among 1050 students in the first-semester exam of the undergraduate program.

**Merit Award** January 2019
*St Thomas Residential School*
School $2^{nd}$ rank among 235 students in the ISC Board exam.

**Merit Award** August 2018
*Vikram Sarabhai Space Centre, Indian Space Research Organization (ISRO)*
For procuring 98% in the ISC Board exam.

## PROFESSIONAL AND ACADEMIC SERVICES

**Academic Service** August 2025
Reviewed papers and workshop proposals for the IEEE Transactions on Automation Science and Engineering (T-ASE-2025, 2026) and IEEE International Conference on Robotics and Automation (ICRA 2024).

**Robot Fabrication and Integration** March 2022 - May 2024
Worked in an interdisciplinary team with IIT Delhi and Nex Robotics Pvt. Ltd. Mumbai, India, to develop an indigenous mobile manipulator designed for outdoor environments.

- Software stack design for the indigenous robotic platform.
- Sensor suite selection - 3D and 2D Lidars, RGBD cameras, microphones, force-torque sensors.

**Demonstration and Academic Interaction with Project Sponsors** July 2022 - May 2024
*Defence Research and Development Organisation, India (DRDO)*

- Technology and Know-How Transfer.
- Led robot field experiments for the research agency.

**Teaching Assistantship** August 2023 - November 2023
*Indian Institute of Technology Delhi*
Participated in the evaluation and development of assignments based on Reinforcement Learning in collaboration with a Ph.D. student for the COL864 Embodied AI course offered at IIT Delhi.

**Involvement in Student Projects** July 2023 - June 2024
*Indian Institute of Technology Delhi*
Worked with seven undergraduate students and one doctoral student as part of their course projects to develop language and robot skill modules for the mobile manipulator.

## PROFESSIONAL SKILLS

**Robotics System Experience**
Clearpath Husky, UR5e manipulator, Franka Emika Panda Manipulator, Robotiq 3f-gripper, Force-Torque Sensor, Velodyne VLP-16, Hokuyo LiDAR, Intel Realsense and OAK-D cameras, Nvidia Orin.

**Programming Languages and Frameworks**
Python, C++, PyTorch, Matlab, ROS, Proteus, LTSpice, Solidworks, LaTex, Github, Docker, Microsoft Office.

**System skills**
Linux, System management for GPU clusters, Fine-tuning of Large Language Models, Network setup.

**Languages**
English, Malayalam, Hindi.

## EXTRACURRICULARS AND HOBBIES

**Music Band Performance at Ragam, Cultural Fest** March 2020
*National Institute of Technology Calicut*
Won the third prize as a part of a music band in Ragam, south India's biggest intercollegiate cultural fest.

**House Captain** August 2016 - March 2018
*St Thomas Residential School*
As the captain of the Red house consisting of over 700 students, I was responsible for organizing different cultural and sports competitions each year.

**Playing Musical Instruments (Keyboard and Guitar)**
**Photography**

## REFEREES

**Prof. Abhisesh Silwal**
Assistant Professor, Robotics Institute

Carnegie Mellon University
Email: asilwal@andrew.cmu.edu

**Prof. Rohan Paul**
Assistant Professor, Department of Computer Science and Engineering
Joint Faculty, Yardi School of Artificial Intelligence
Indian Institute of Technology Delhi
Email: rohan@cse.iitd.ac.in

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