

Damanpreet Singh



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EDUCATION

Carnegie Mellon University (CMU)

Master of Science in Mechanical Engineering – Research (Concentration: Robotics)

Pittsburgh, PA

May 2023

Relevant Coursework: Simultaneous Localization & Mapping (SLAM), Computer Vision, Geometry-based Methods in Vision, Learning for 3D Vision, Convex Optimization, Deep Learning, Machine Learning

Thapar Institute of Engineering and Technology

Bachelor of Engineering in Mechanical Engineering

Patiala, India

June 2021

SKILLS

Languages and Tools: Modern C++, Python, Git, ROS, CMake, Bash, Docker, MATLAB, SolidWorks, COLMAP, Linux

Packages: Eigen, Ceres, Point Cloud Library, OpenCV, GTSAM, C++ STL, Boost, PyTorch, NumPy, SciPy, Matplotlib, Pandas

Hardware: Jetson Xavier, Orin, Velodyne Lidar, Eposon IMU, Leopard Imaging RGB, FLIR Boson, Pixhawk, Traxxas, ARDUINO

Mathematical Concepts: Advanced Linear Algebra, Vector Calculus, Probabilistic Methods, Kalman Filters, Factor Graphs

EXPERIENCE

The Airlab & Biorobotics Lab, CMU

Graduate Research Assistant (Prof. Sebastian Scherer, Dr. Mathew Travers)

Pittsburgh, PA

Sep 2021 – May 2023

Project: Heterogeneous multi-robot system for exploration in unstructured subterranean environments (**MMPUG, DARPA-SubT**)

SLAM Implementation and Dataset Management (ICCV '23 workshop)

- Implemented and evaluated **4** SOTA SLAM algorithms - **LIO-SAM, LOAM, FAST-LIO, CLINS** on **SubT-MRS** dataset
- Integrated real-time point cloud colorization in **SuperOdometry** by field-of-view analysis between RGB camera and LIDAR
- Co-led team of **5** in acquiring a **2 TB SubT-MRS** SLAM dataset, comprising **4** robots, **5** sensors, and **5** locations
- Designed Python scripts for dataset cleaning, statistics generation, PyTorch DataLoader, and dataset pip package integration

Open-Set Vocabulary Inter-Object (O2O) 3D Affordance Prediction in Point Clouds

- Enabled natural language query-driven affordance prediction in point clouds, reaching **90%** performance relative to **SOTA**
- Performed ablation study for point cloud architectures: **PointNet, PointTransformer**, and LLM architectures: **CLIP, CG3D**
- Currently advancing **O2O-Afford** to open-set vocabulary-based inter-object prediction, utilizing sim-in-the-loop training

Systems Engineering

- Developed C++ algorithm for generating SNR graph for radios in multi-robot setup, employing Websockets and ROS-DDS
- Innovated planning constraints using spanning trees in SNR graph, increasing exploration distances by **90%** against SOTA
- Devised **2** behavior trees for switching between **8** autonomy modes in a multi-robot system with 3 UGVs and 2 Spots
- Integrated and calibrated **FLIR-Boson** thermal camera into sensor stack with **<25 ms** time sync delay and **60 Hz** frequency

ACADEMIC PROJECTS

3D Rendering using Neural Radiance Fields (NeRF)

Spring 2023

- Implemented 3D volume and surface reconstruction pipelines in Pytorch3D, using Neural Radiance Fields
- Extended baseline with Phong relighting and hierarchical point sampling

Learning-based Single View to 3D Reconstruction

Spring 2023

- Designed image to 3D reconstruction using convolutional and MLP networks, for **voxels, meshes, and point clouds**
- Achieved object reconstructions with **0.88 F1** score and extended the network for occupancy queries

Absolute Conic-based Single view to 3D Reconstruction

Fall 2022

- Designed **2** single image-based camera intrinsics calibration routine using Image of Absolute Conic and vanishing points
- Designed image-based 3D reconstruction using plane annotations and camera intrinsics, with Shapely in Python3

MNIST Diffusion

Spring 2023

- Designed denoising diffusion probabilistic model (**DDPM**) for **MNIST** number dataset, using Pytorch in Python3
- Produced **80%** generation, for 36 sample sets of MNIST numbers, using 10,000 diffusion timesteps

Multi-view Reconstruction

Fall 2022

- Built structure-from-motion (SfM) employing perspective-n-point and triangulation, using Numpy and OpenCV in Python3
- Extended baseline to improve camera extrinsics computation, leveraging Bundle Adjustment

Feature Extractor Voting for Visual Inertial Odometry

Spring 2022

- Incorporated **SuperPoint** feature extractor into frontend of **VINS-MONO**
- Created feature voting and fusion algorithm for SuperPoint and classical features, reducing odometry failure cases by **~40%**

PUBLICATIONS

- Shibo Zhao, **Damanpreet Singh**, Sebastian Scherer et. al. "SubT-MRS: A Subterranean, Multi-Robot, Multi-Spectral and Multi-Degraded Dataset for Robust SLAM", Submitted to ICCV 2023
- Namya Bagree, Charles Noren, **Damanpreet Singh**, Matthew Travers, and Bhaskar Vundurthy. "High Speed Convoy in Unstructured Indoor Environments" IFAC World Congress, 2023