Damanpreet Singh

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EDUCATION

Carnegie Mellon University (CMU) *Pittsburgh, PA*
Master of Science in Mechanical Engineering – Research (Concentration: Robotics) *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 *Patiala, India*
Bachelor of Engineering in Mechanical Engineering *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, Epson 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 *Pittsburgh, PA*
Graduate Research Assistant (Prof. Sebastian Scherer, Dr. Mathew Travers) *Sep 2021 – May 2023*
<u>*Project*</u>: *Heterogeneous multi-robot system for exploration in unstructured subterranean environments (<u>**MMPUG, DARPA-SubT**</u>)* 🌐

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*