Athrva Pandhare

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EDUCATION

Master of Sciences in Robotics, *(3.72/4)* **University of Pennsylvania** 2021 – 2023

Bachelor of Technology in Aerospace Engineering, *(9.54/10)* **SRM Institute of Science and Technology** 2016 – 2020

EXPERIENCE

Research Assistant **Kumar Robotics, PERCH Lab, UPenn** September 2021 – Present

- Working on a novel algorithms and Learning based frameworks for Autonomous Exploration in cluttered indoor environments.
- Developed algorithms including classical Frontier based exploration strategies and Direction primitive based Reinforcement Learning strategies.
- Working on a Novel hierarchical RANSAC for online clutter removal from egocentric point cloud scans for stable Map building.
- The tools used for this include ROS gazebo, Nvidia Isaac Gym, C++, tensorflow and pytorch, along with openCV.

Teaching Assistant **Aerial Robotics, Mobility - UPenn** September 2021 - January 2022

- Handled TA responsibilities for three courses (Aerial Robotics, Mobility and Capstone Project).
- Responsibilities include using MATLAB to develop small angle quadrotor control on MATLAB. Occasionally, required to develop localization and mapping codes on MATLAB and Python and cross-translate code between C++ and MATLAB.

Research Intern **Welspun Corporation ltd.** April 2020 – June 2021

- Worked on the development of three Machine vision based Metrology systems and a surface defect detection system.
- Developed systems allowed for a high precision measurement of Diameter (error < 0.5mm) for a 314-3127mm range, Length (error < 5mm) for a 8 to 10m range, Ovality (error < 0.5mm) for a 324-768mm range.
- The surface defect detection system was based on Gabor filter banks and FFT to isolate low frequency signals. An accuracy of $> 95.3\%$ was obtained on unseen real world samples.

RELEVANT PROJECTS

- **Point2Point: An Efficient Generative Architecture for Direct Point Cloud to Point Cloud translation**
  1. A Novel Neural Architecture was created for Generative tasks on Point Clouds without the need for conversion to intermediate representations like 3D voxel grids, range images etc.
  2. Hilbert curves were used to induce a locality consistent ordering on Point clouds which allows for subsequent learning.
  3. The resulting Neural Architecture was used to make 3D occupancy and drivable space predictions from Point cloud sequences coming from an autonomous vehicle. The proposed architecture produces 13% less error in a Chamfer distance sense than the State-of-Art baselines.
  4. First Author Paper on the aforementioned research is pending submission to CVPR.
- **Autonomous Exploration in Unknown Indoor environments using Frontier based Exploration (Kumar Robotics)**
  1. This Project was aimed at developing efficient Frontier based Exploration algorithms for small autonomous quadrotors.
  2. The developed framework was integrated into the quadrotor navigation stack and was tested in a physical indoor environment.
  3. A Time-of-flight (ToF) based depth camera was used to construct a 3D map, which was then converted to a 2D occupancy grid. For navigation, a configuration space representation was built by adding inflation to the 2D occupancy grid.
  4. A Frontier based strategy was then used for exploration. The developed system was successful and produced $> 95\%$ coverage of unknown indoor environments.
- **Learned Reinforcement Learning based direction primitives for Autonomous Exploration of Indoor Environments(Kumar Robotics)**
  1. This Project was aimed at developing light weight Reinforcement Learning (RL) based strategies for Autonomous Exploration.
  2. Direction primitives were used as learned control commands by the PPO algorithm. The input the the RL algorithm was the partially explored 2D occupancy grid and the output was a probability distribution over the defined direction primitives.
  3. The developed framework was integrated in a realistic simulation environment (Gazebo). The full navigation stack was designed for small quadrotors consisting of a Time-of-Flight (ToF) based depth sensor for map building.
  4. The Exploration algorithm showed promising results with a $> 85\%$ coverage of unknown indoor environments.
- **Monocular Multi-view Structure From Motion (SFM) with Bundle Adjustment**
  1. A Monocular SFM pipeline was implemented for 3D reconstruction. The hardware used was a calibrated smartphone camera. Calibration was carried out using OpenCV's implementation of the Zhang's method.
  2. The SFM pipeline was divided into two parts, initial pose estimation and pose refinement using Bundle Adjustment (BA). The Initial Pose Estimation module consisted of solving the Epipolar geometry based pose estimation (first frame pair), followed by PnP for subsequent frame pairs.
  3. These initial estimates of the Pose and landmarks were serialized and a Full Bundle Adjustment was run in an offline fashion. The Ceres library was used for Optimization. The Bundle Adjustment reduced the reprojection errors from the Initial Pose Estimation module significantly.
- **Convolutional LSTM based Predictive Mapping for Manhattan World Environments**
  1. This Project was aimed at developing a Map Predictor for Manhattan indoor environments. The premise in this project was that most commercial indoor spaces have a similar "Manhattan" structure.
  2. A dataset was constructed containing > 200000 synthetic images of egocentric indoor occupancy grid sequences, and a Convolutional LSTM was trained to predict future occupancy given past sequences.
  3. The developed Map Predictor (Convolutional LSTM) was then tested in a realistic simulation environment (Gazebo) for fast exploration tasks. It was seen that Map Prediction resulted in a 25% reduction in exploration time when compared to system without Map Prediction.

RELEVANT SKILLS AND COURSEWORK

- **Coursework :** Computer Vision, Machine Perception, Deep Learning, State Estimation, Mobile Robotics (SLAM), Robot Operating Systems, Machine Learning, Sensor Fusion, Convex Optimization.
- **Deep Learning Frameworks :** Pytorch, Tensorflow, Tensorflow-lite
- **Programming Languages :** C++, Python, C
- **Simulators :** Gazebo, Carla, MORSE, Nvida Isaac Sim & Gym
- **Software tools :** Git, CMake, Docker
- **Misc : ROS** 1, **ROS** 2, MATLAB, CUDA