NALIN BENDAPUDI

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EDUCATION

University of Michigan - Ann Arbor Sep 2019 - May 2021
Master of Sciences in Robotics, GPA: 4.0/4.0 Ann Arbor, MI
Coursework: Robotic Systems Lab, Mobile Robotics (SLAM), ROS, Self-driving Cars, Motion Planning

Indian Institute of Technology - Delhi Jul 2013 - May 2017
Bachelor of Technology in Mechanical Engineering (Minor in Computer Science), GPA: 8.9/10.0 New Delhi, India
Coursework: Algorithms, Data Structures, Control Theory, Embedded Systems, Robotics

WORK EXPERIENCE

Ford Motor Company Jun 2021 - Present
Localization Engineer - ADAS Ann Arbor, MI, USA

- Implemented third-party-map-based visual localization algorithm using pose-graph optimization technique to integrate IMU, radar,and GNSS measurements with a distance-transform image based map-matching constraint
- Developed a real-time application to project map information on camera image to monitor calibration and localization accuracy, and aid the object-detection network by providing an initial bounding-box estimate of traffic signs
- Implemented and bench-marked a lane assignment algorithm to determine the accurate lane-id of ego and traffic vehicles by fusing nearest lane candidates from map and the planned-path lanes in a Hidden Markov Model approach
- Evaluated third-party localization systems and developed metrics for benchmarking accuracy, availability and stability

Mapping and Localization Engineer - Autonomous Shuttle

- Designed a grid-map library to load semantic map layers in real-time and provide functions to query map information
- Surveyed various Visual-Laser-Inertial fusion algorithms and presented a new design for vehicle's localization system
- Assisted in various stages of HD-Map creation: collected data, built pose-graph, constructed lane-level RoadRunner map
- Configured and calibrated GNSS and IMU sensors; modified their ROS drivers according to vehicle's software architecture
- Developed metrics and visualization tools to test and analyze performance of individual sensors and the whole sub-system

APRIL Lab, University of Michigan Jan 2021 - May 2021
Graduate Student Research Assistant Ann Arbor, MI, USA

- Developed novel simple policies and integrated them in the Decentralized Multi-Policy Decision Making (D-MPDM) framework to plan efficient paths for a robot cluster executing an adversary search task under uncertain communications
- Implemented adversary-state estimator and a decentralized data fusion technique to integrate communicated measurements
- Enhanced the quality of existing D-MPDM code-base by refining the modularity and updating the documentation

Robert Bosch GmbH Aug 2017 - May 2019
Machine Learning Software Engineer Bangalore, India

- Analyzed trend and seasonality of time series data, and developed applications for anomaly detection and forecasting of automobile metrics. The applications were deployed on Mercedes-Benz servers and evaluated to have an accuracy of 92%
- Utilized deep-NLP on unstructured error logs to develop a recommendation engine to identify potential high-impact issues
- Applied unsupervised learning to find associations in error data that reduced time for resolution & root-cause analysis

TEACHING AND MENTORSHIP EXPERIENCE

- Student Mentor - Robotics Institute, University of Michigan Jul 2020 - May 2021
- Student Mentor - College of Engineering, University of Michigan Jul 2020 - Dec 2020
- Grader (Math for Robotics) - Robotics Institute, University of Michigan Sep 2020 - Dec 2020
- Grader (Robot Modelling and Control) - Robotics Institute, University of Michigan Jan 2020 - May 2020
- Teaching Assistant (Material Sc & Engg) - Mechanical Engineering, Indian Institute of Technology Jul 2016 - May 2017
- Technical Mentor - Robotics Club, Indian Institute of Technology Jul 2015 - May 2017

TECHNICAL SKILLS

Languages C++ (Eigen, Ceres, OpenCv, STL), Python (gtsam, open3d, numpy, pandas, pytorch)
Tools ROS, Git, JIRA, RoadRunner, MATLAB

PUBLICATIONS

Shenbagaraj Kannapiran, **Nalin Bendapudi**, Ming-Yuan Yu, Devarth Parikh, Spring Berman, Ankit Vora, Gaurav Pandey "*Stereo Visual Odometry with Deep Learning-Based Point and Line Feature Matching using an Attention Graph Neural Network*", IEEE International Conference on Intelligent Robots and Systems (**IROS-2023**), Detroit, November 1-5, 2023

Vaibhav Gupta, **Nalin Bendapudi**, I.N.Kar, S.K.Saha "*Three-Stage Computed-Torque Controller for Trajectory Tracking in Non-Holonomic Wheeled Mobile Robot*", 15th IEEE International Workshop on Advanced Motion Control (**AMC-2018**), Tokyo, 9-11 March 2018

PATENTS

- Shenbagaraj Kannapiran, **Nalin Bendapudi**, Devarth Parikh, Ankit Vora, "*Stereo Visual Odometry using point and line features*" (2023) · Application No: US 18/324398
- Ankit Vora, **Nalin Bendapudi**, Devarth Parikh, Siddharth Agarwal, "*Birds-Eye-View Image based Robot Localization*" (2022) · Application No: US 18/066299
- Subodh Mishra, **Nalin Bendapudi**, Ankit Vora, Gaurav Pandey, Kevin Chen, Sharnam Shah, Alexander Carr, Jacob Skwirsk, Nahid Pervez, "*Vision Based Vehicle Localization in Prior Maps using Distance Transforms*" (2023) · Filing in Progress
- Sharnam Shah, **Nalin Bendapudi**, Ankit Vora, Ganesh Kumar, Nahid Pervez, "*Route Planning, Navigation and Operation Domain Decision using predicted look ahead GNSS error data*" (2023) · Filing in Progress
- Sharnam Shah, **Nalin Bendapudi**, Ankit Vora, Ganesh Kumar, Nahid Pervez, "*Large Scale GNSS Failure and Operation Zones Map Layer*" (2023) · Filing in Progress

ACADEMIC PROJECTS

Occupancy-Grid SLAM for Autonomous Ground Robot

- Constructed a 40,000 cell occupancy grid map using Breshenham's algorithm for differential mobile robot navigating a maze
- Implemented Monte-Carlo localization using a particle filter with an odometry action model and LiDAR-based sensor model
- Incorporated an exploration strategy to search for new frontiers in the SLAM map and reach them using A$\star$ path planning

Visual Inertial Navigation SLAM using SuperPoint features

- Improved OpenVINS method by substituting the ORB feature extractor with deep-learning based SuperPoint visual descriptor
- Evaluated our approach on EuRoC MAV datasets of varying difficulties and recorded 22.6% reduction in error on average

Visual Odometry using Point Cloud and Stero Images

- Computed the vehicle trajectory from relative motion between consecutive point-clouds using Iterative Closest Point algorithm
- Detected 3D points using SIFT feature matching on stero image pairs and used RANSAC to estimate the transformations

Filter Comparison for State Estimation

- Calculated the filtered pose trajectory of a robot using odometry data and range & bearing measurements from six landmarks
- Compared the mean deviation from ground-truth of Extended Kalman Filter, Unscented Kalman Filter and Particle Filter

Smoothing and Mapping using Factor Graphs

- Constructed a 2D map of Intel Research Lab and a 3D map of a parking garage using pose-graph optimization tool GTSAM

Continuous Semantic and Occupancy-Grid Mapping

- Utilized a continuous counting sensor model to generate smooth occupancy-grid and semantic maps using 2D Intel dataset

Object Detection using FasterR-CNN and YOLO

- Implemented YOLO to detect and classify objects in Pascal VOC dataset to obtain a mAP of 12.5% in half-hour of training
- Developed Faster RCNN based vehicle classification model with an accuracy of 62% on a dataset generated from GTA5