

PRITHWIRAJ PAUL

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EDUCATION

University of California - San Diego

September 2022 - Ongoing

Master's of Science, Electrical and Computer Engineering (Intelligent Robotics)

GPA: 3.855

Relevant Courses: Sensing and Estimation in Robotics, Planning and Learning - Robotics, Robot Manipulation and Control, Deep Learning - Computer Vision, Safety for Autonomous Systems, Software Foundations, Linear Systems, Data Analysis

Indian Institute of Technology Kharagpur (IIT-KGP)

August 2015 - June 2020

Dual Degree (Master's + Bachelor's), Mechanical Engineering

GPA: 9.24

Relevant Courses: Programming and Data Structures (C, C++), Soft Computing, Robot Dynamics and Kinematics, Dynamics and Control, Non-linear Control, Mechatronics Laboratory (LabVIEW), Systems Reliability

PROFESSIONAL EXPERIENCE

Jacobs School of Engineering, UC San Diego

San Diego, USA

Graduate Teaching Assistant – Sensing and Estimation in Robotics

Jan 2024 – present

Skills – **SLAM, Kalman Filter, Computer Vision (CV), Python, Leadership, Public Speaking, University Teaching**

- Facilitating student learning in Bayesian filtering, SLAM, Convex Optimization – taught skills in probability, linear algebra
- Guiding ~140 graduate students in projects and homework focusing on **SLAM**, Sensor Fusion, Sensor Calibration, and CV

Symbiotic

Wilmington, MA, USA

Bot Controls Software Engineering Intern

June 2023 – Dec 2023

Project - **Developing Real-time Safe Trajectory Planning and Control for SymBot - Line Follower Warehouse Automation Robot**

Skills - **Motion Planning, Optimal Control, Bot Testing, Software Development, Jira, Git, Version Control, C++, Python, Gazebo**

- Utilized SimbaSim **Gazebo** for visualization and analysis of offline turn profiles, gaining insights into bot driving behavior
- Implemented **Model Predictive Control** with **CasADi** for online trajectory generation, achieving planning time on the scale of **seconds** and reducing to **milliseconds** with a **Control Barrier Function - Control Lyapunov Function QP** framework
- Validated generated trajectories, yielding a **46% improvement** in optimization time and a **10% reduction** in turn time versus the baseline method, conducted extensive **unit testing** and integrated into Symbot's **production** codebase in **C++** as an online **API**

Indian Space Research Organization

Bengaluru, Karnataka, India

Scientist/Engineer SC

September 2020 - August 2022

Project - **Alleviating water impact loads on Crew Module through active control during parachute descent phase**

Skills - **Human Spaceflight, Non-linear Control design, Spacecraft Dynamics, Mathematical Modelling, MATLAB, Simulink**

- Developed a **6-DOF** trajectory simulator in Simulink for a 5-tonne crewed spacecraft, simulating atmospheric re-entry dynamics
- Successfully executed a **Bang-Bang controller** with **Proportional-Derivative action** at **100%** duty cycle, minimizing propellant usage to **22 kg** for a **450 N** control force, and ensuring **targeted** orientation at touchdown within +/- 3° dead band

TECHNICAL SKILLS

Programming Languages: Python, C++, MATLAB

Technologies/Frameworks: PyTorch, OpenCV, ROS, Gazebo, Linux, Git, GitLab, Jira, Simulink, LATEX, NumPy, JAX, Docker

ACADEMIC PROJECTS

Vision-guided Autonomous Navigation using Reinforcement Learning

October 2023 - Present

Skills – **Robot Perception, Deep Neural Network, Transformer, CNN, ROS, PyBullet, Hardware-Testing and Deployment, OpenCV**

- Developed a Neural Network model for learning autonomous navigation in Ackermann drive vehicles, achieving over **95%** accuracy with a reinforcement learning agent trained in a **PyBullet** and **Stable-Baselines3** simulated environment
- Executing **Sim2Real** pipeline for autonomous navigation - Deployed trained RL model using custom **C++ ROS node** in **Nvidia TX2**, and benchmarked neural network architectures such as CNN, Transformer, Vision Transformer for image feature analysis

Stochastic Optimal Control for Trajectory Tracking of Differential Drive Robot ([GitHub](#))

April 2023 - June 2023

Skills - **Model Predictive Control (MPC), Global Policy Iteration (GPI), Non-linear Control, Python, CasADi**

- Formulated a **Markov Decision Process** for trajectory tracking performance evaluation, using **MPC** and **GPI** algorithms, with MPC optimized through **CasADi** and GPI applied via discretized **Value Iteration**
- Showcased MPC's **real-time robustness** and GPI's **reduced noise sensitivity** on Differential-drive robot model, balancing speed and discretization dependence through tracking performance analysis

Motion Planning in 3D obstacle environments ([GitHub](#))

April 2023 - June 2023

Skills - **3D Motion Planning, A*, RRT*, Heuristic Function, 3D Graph-search, Data Structures and Algorithms**

- Implemented collision-checking for safe robot navigation in 3D mazes, evaluating custom-designed **weighted-A*** and **RRT**, **RRT*** algorithms; RRT outperformed by **30%** in speed and memory efficiency, whereas A* excelled in **path quality**
- Analyzed algorithms based on expanded nodes, **heuristic methods (Euclidean, Manhattan)**, highlighting trade-offs in complexity and efficiency, and graph creation efficiency in sampling-based approaches

Routing Engine development using Open Street Maps

November 2023 – December 2023

Skills – **Motion Planning, A*, Data Structures and Algorithms, C++, Unit Testing, Software Development, CMake**

- Crafted and deployed a **C++ navigation API** using OpenStreetMap data, significantly enhancing real-time route planning
- Enhanced navigation accuracy and performance by implementing the **A* algorithm** through effective API integration
- Conducted extensive **unit testing** with **Google Test** for high-precision vehicle positioning using **RTK GPS system** integration

ROS-Based Indoor SLAM and Mapping on Nvidia Xavier Autonomous Racecar

December 2022 - May 2023

Skills - **ROS, Hardware Integration and Testing, Sensor Fusion, SLAM, Point Cloud, OctoMap, Voxel Mapping, C++, Gazebo**

- Used ROS, Intel RealSense, and Hokuyo 2D Lidar: Conducted hardware calibration and testing; verified functionality in **Rviz**
- Utilized **Hector mapping** with lidar data and generated real-time **2D occupancy grids**; created octomaps using **Octomap ROS package** and **point cloud** and voxel maps using **Voxblox**, enhancing sensor fusion and data integration
- Utilized **Gazebo** Car Models and RealSense: Enabled detailed testing and texture mapping for efficient robot path planning

Fast Class-Based Neural Style Transfer (NST) ([GitHub](#))

April 2023 - June 2023

Skills - **Computer Vision, Deep Learning, PyTorch, Semantic Segmentation, RCNN, Encoder-Decoder, Neural Style Transfer (NST)**

- Developed **Real-Time Style Transfer Pipeline**: Achieved **25 fps** on Tesla **T4 GPU** using a custom **1.64MB** Fast NST model
- Boosted Semantic Segmentation with **Fast-SCNN**: Achieved **68.0%** Mean IoU on Cityscape at **123.5 fps**, refining style transfer
- Optimized **Style Transfer Using pre-trained VGG16**: Implemented improved content and style loss (**Gram matrix**) for qualitative style transfer studies on **CityScape** and **PascalVOC** datasets

Visual Inertial SLAM using Extended Kalman Filter (EKF) ([GitHub](#))

February 2023 - March 2023

Skills - **VSLAM, Kalman Filter, Sensor Fusion, IMU and Camera Calibration, SE(3) Kinematics, Map Accuracy, OpenCV**

- Conducted **sensor fusion** for data synchronization between **IMU** and **stereo camera**, implementing **EKF** for real-time positioning and orientation updates of autonomous car pose using **SE(3)** kinematics and landmark locations
- Analyzed **motion** and **observation model** noise sensitivities, achieving **95%** environment **mapping accuracy** through simultaneous car pose and landmark correction using **observation model Jacobians**.

Improvement of Online Camera Calibration using Visual Servoing

April 2023 - June 2023

Skills - **7-DOF Panda Robot, Pose Estimation, Controller Design, PyBullet, OpenGL, Robotictoolbox-Python**

- Enhanced online camera calibration using **Image Jacobian** and **DREAM** Neural Network for camera-to-robot pose estimation
- Implemented **PnP** and **Forward Kinematics** estimating noisy camera pose with DREAM, camera intrinsics, and joint angles
- Computed Image Jacobian for each joint to map joint positions in virtual camera pixel space using **OpenGL** library
- Designed a **closed-loop Proportional controller** and improved camera angle error by **> 90%** and position error by **> 95%**

Course Projects on Machine Learning

October 2022 - December 2022

- Programmed a **MATLAB image classification** problem using **Bayesian Parameter Estimation** and achieved **10%** algorithm error
- Performed Speech Recognition on 430,000 non-text inputs in Python using the **Viterbi algorithm** and **Hidden Markov Model**
- Developed the **Hangman game** in Python predicting the next best guess letter in a word based on the previous letter guesses
- Analyzed **Max log-likelihood** of **bigram** and **mixture-model** word distributions in English with Statistical Language Modeling
- Constructed a **Linear Regression** model in Python predicting the stock market NASDAQ index - assumed **4-gram model** using training data from the year 2000 and achieved a 53% lower RMS prediction error in test data of the year 200