Saurabh H. Mirani

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Technical Skills

- **Languages:** C++17, C++14, C++11 , C, Python
- **C++ libraries:** Eigen, Boost, Taskflow, Fast DDS, nlohmann-json, GoogleTest, TinyXML-2, GRAMPC, TOPP-RA, MoveIt!, OpenCV, PCL, LibTorch, Bullet, FCL, OMPL, OctoMap, Apollo CyberRT
- **Python libraries:** NumPy, SciPy, Pandas, OpenCV, scikit-learn, matplotlib, SymPy, PyTorch, Gym, CasADi, OSQP, PyBullet, OpenCV
- **Software:** ROS, ROS2, Gazebo, MATLAB/Simulink, SolidWorks, EagleCad, RoboDK, AirSim, ArduPilot SITL
- **Platforms:** Linux, Windows, QNX RTOS

Work Experience

Research Engineer (Navigation) - LG, Bengaluru, India Nov 2023 - Present

- Spearheaded the migration from Finite State Machine (FSM) to Hierarchical State Machine (HSM), exploiting 60% of pre-existing states to eliminate redundancies, thereby reducing code duplication and improving modular scalability
- Engineered and patented a cutting-edge cleaning strategy for autonomous robot vacuum cleaners, outclassing competitors by increasing efficiency by 25% and setting a new industry standard
- Leveraged AI (object detection and pose estimation) to develop advanced obstacle avoidance, cutting collision incidents by 40% for small objects such as cables and toys, usually undetected by LIDAR, enhancing navigation efficiency

Robotics Software Engineer - Flexiv Robotics, Santa Clara, U.S.A. Sep 2021 - July 2023

- Collaborated with a team of engineers to successfully integrate advanced motion planning using Informed RRT* algorithm with Cartographer SLAM system, resulting in a fully autonomous mobile robot platform
- Designed and implemented a variant of Dynamic Roadmaps, for real time motion planning under uncertainty, of a dual arm setup with 100% success rate for the given voxel resolution, and O(n) time complexity for collision detection
- Developed a robust hybrid dynamical system for robotic manipulation through the implementation of a real-time model predictive controller (MPC) with GRAMPC, CasADi, and OSQP. This innovative approach integrates continuous trajectory planning with discrete event responses, achieving computation times of less than 200 microseconds and improving processing efficiency by 80%
- Conceptualized, designed, and architected a motion planning app consisting of optimization based motion planning algorithms like TrajOpt using OSQP, IFOPT (Eigen- based interface to IPOPT), sampling based algorithms like RRT, RRT*, Descartes, and continuous collision detection algorithm using Bullet Physics thereby reducing the deployment time from weeks to hours
- Utilized multi-threading techniques to parallelize the execution of multiple RRT threads, enabling the robotic system to explore multiple paths simultaneously and find optimal trajectories
- Established real-time middleware communication via Fast-DDS between the robot control app, motion planning app
- Developed a deep understanding of CI/CD methodologies, including experience with tools such as Jenkins, Bitbucket CI/CD, and Docker containerization technology, to facilitate the development of efficient and robust software pipelines for the motion planning app
- Utilized Agile Scrum techniques to prioritize development tasks and maintain high levels of software quality

Motion Planning Intern - Mathworks, Hyderabad, India May 2018 - July 2018

- Developed MATLAB module for path planning of autonomous robotic arm of high-DOF like KUKAs LBR iiwa
- Executed obstacle avoidance using GilbertJohnsonKeerthi (GJK) distance algorithm in parallel to RRT-star

Robotics Intern - Systemantics, Bengaluru, India Dec 2017 - Jan 2018

- Improved the trajectory computation time for a pick and place operation of a 6 DOF robotic manipulator by 50%
- Designed a gripper for a teach-and-repeat type application of the robot as per client requirement

Education

- **University of California, San Diego** **GPA 3.87/4.0**
  M.S. in Intelligent Systems, Robotics and Control 2019-2021
  Department of Electrical and Computer Engineering
- **Indian Institute of Technology (IIT) Kharagpur** **CGPA 9.36/10.0**
  B.Tech. (Hons), Department of Mechanical Engineering 2015-2019

Research Experience

Motion Planning Networks (MPNet) using Fastron **San Diego, U.S.A.**
Guide: Prof. Michael Yip June 2020–April 2021
- Combined a supervised learning-based neural planner with a supervised learning-based differentiable proxy collision detection algorithm in the Gazebo simulator for the Baxter robot, for continuous action and state spaces
- Used LibTorch (PyTorch in C++) for optimization with joint limit, collision score and path length as objectives
- Reduced the computation time by 50% and improved the success rate from 85% to 99%

Semantic SLAM **San Diego, U.S.A.**
Guide: Prof. Henrik Christensen Sep 2020–Dec 2020
- Used YOLOv3 for object detection and semantic labelling and PoseCNN for pose estimation of the detected object
- Designed and implemented a novel approach to map creation that combined geometric and semantic information using particle filter algorithms, resulting in highly accurate and semantically meaningful maps

Motion planning of autonomous UAVs **Kharagpur, India**
Guide: Prof. Cheruvu Siva Kumar July 2018–April 2019
- Designed and implemented a novel multi-objective optimized path for UAV using Open Motion Planning Library (OMPL) and Flexible Collision Library (FCL), resulting in significant improvements in UAV path planning efficiency
- Developed autonomous 3D occupancy (Octomap) and collision avoidance and tested on Ardupilot SITL Gazebo
- Used stereoscopic camera instead of lidar reducing the cost by 90%, where point cloud was created using OpenCV

RoboSoccer **Kharagpur, India**
Guide: Prof. Jayanta Mukhopadhyay Feb 2016–April 2018
- Built a team of autonomous soccer playing robots in Python & C++ and participated in 21st RoboCup, Japan (2017)
- Performed a comparative study on the variations of RRT, worked on path simplifier and velocity profiling of the path
- Developed a multi-threaded 3-tier Skills-Tactics-Plays architecture for controlling omni-directional robots using ROS

Rehabilitation Robotics **Kharagpur, India**
Guide: Prof. Dilip Kumar Pratihar May 2017–July 2017
- Engineered a lower extremity exoskeleton integrating actuators and feedback sensors to enhance therapeutic outcomes for disabled patients during rehabilitation
- Designed a plantar system to collect gait cycle data by measuring ground reaction forces using strain gauge load cells and angular motion with an Inertial Measurement Unit (IMU)
- Developed a vision-based feedback system for real-time obstacle detection and dynamic gait stability enhancement during rehabilitation

Autonomous stair-climbing Robot **Kharagpur, India**
Self-initiated research Nov 2016–April 2017
- Developed computer vision based target following for navigation using Kanade-Lucas tracking of Shi Tomasi corners
- Applied EEG signal based control, voice control using CMUSphinx along with a touch interface using Raspberry Pi
- Recipient of the Gold medal in the intra-collegiate hardware exhibition 2017 at IIT Kharagpur.

Projects

Image Caption Generation using Deep Learning **San Diego, U.S.A.**
Guide: Prof. Peter Gerstoft May 2021–June 2021

- Developed an Image Caption Generator using an Encoder-Decoder model with a Convolutional Neural Network (CNN) for the encoder to extract features from images
- Implemented an attention model to focus on specific parts of the input image when generating each word
- Utilized a Recurrent Neural Network (RNN), specifically the Long Short-Term Memory (LSTM) network as the Decoder to generate the sentence
- Trained the model on the COCO dataset and achieved a BLEU-4 score of 27 indicating high accuracy
- Implemented Teacher Forcing technique during training to improve model convergence

Path Planning **San Diego, U.S.A.**
Guide: Prof. Nikolay Atanasov May 2020–May 2020

- Developed a continuous collision checker using Ray-Box intersection, by converting the obstacles into Axis-Aligned Bounding Boxes (AABB), to ensure the robots motion between any two given points is collision free
- Implemented weighted A* algorithm using the continuous collision checker to find the shortest path
- Performed a comparative study between different types of collision checkers with RRT* using The Open Motion Planning Library (OMPL)

Reinforcement Learning Applications in Decision-Making **San Diego, U.S.A.**
Guide: Prof. Nikolay Atanasov April 2020–April 2020

- Applied Dynamic Programming to solve Markov Decision Processes (MDP) for the Door-Key problem, optimizing decision-making processes for complex environment-based tasks
- Conducted a comparative analysis of SARSA and Q-learning techniques in reinforcement learning, utilizing three function approximation methods (linear, tiling, and neural-based) within the Acrobot-v1 environment

Particle Filter SLAM **San Diego, U.S.A.**
Guide: Prof. Nikolay Atanasov Feb 2020–Feb 2020

- Developed a solution for SLAM based on Particle Filter for humanoid THOR robot with RGB-D camera and 2D Lidar
- Developed an efficient solution for Laser Correlation Model reducing the computation time by 80%
- Texture mapping was performed to assign the floor colors as seen using RGB-D camera to the corresponding cell in the occupancy grid

Bio-inspired robotics **San Diego, U.S.A.**
Guide: Prof. Nick Gravish Jan 2020–March 2020

- Engineered a bio-inspired bipedal robot, integrating walking and jumping functionalities with a focus on optimizing weight distribution, stability, and torque for smooth movement and overcoming obstacles
- Developed and tested advanced locomotion algorithms, including gait generation and motor torque optimization, improving the robot's dynamic performance and jump height through simulation and real-world validation

Teaching Experience

- **Teaching Assistant**, PSYC 60: Introduction to Statistics, UC San Diego Spring 2021
- **Teaching Assistant**, CSS 1: Introductory Programming for Computational Social Science, UC San Diego Winter 2021
- **Teaching Assistant**, PSYC 60: Introduction to Statistics, UC San Diego Fall 2020
- **Teaching Assistant**, ME22002: Thermodynamics, IIT Kharagpur Spring 2019
- **Mentor**, ROS Workshop, Contextual Robotics Institute (CRI), UC San Diego Winter 2021
- **Mentor**, Autonomous Robotics Workshop, IIT Kharagpur Fall 2016

Publications and Patents

- S. Mirani, Harshita, "Human-like cleaning patterns for autonomous robot vacuum cleaners", The U.S. Patent and Trademark Office, expected to be filed in December 2024
- S. Mirani, Harshita, J. Woochan, "Efficient cleaning patterns for autonomous robot vacuum cleaners", The U.S. Patent and Trademark Office, filed in 2024
- S. Jha, H. Chaudhary, S. Satardey, P. Kumar, A. Roy, A. Deshmukh, D. Bansal, G. Hota, S. Mirani, "Design, Analysis & Prototyping of a Semi-Automated Staircase-Climbing Rehabilitation Robot" in ACM International Conference on Mechatronics and Robotics Engineering (ICMRE), 2018 (Equal contribution by all authors)

Honors and Awards

- Robocup 2017: Represented IIT Kharagpur in the Robocup 2017 Small Size League held in Nagoya, Japan; first Indian team to participate in this league.
- JEE Advanced 2015: Achieved a 99.28 percentile, ranking among the top candidates out of 150,000 participants in this premier engineering entrance exam.
- JEE Mains 2015: Secured 99.98 percentile, attaining an All India Rank of 242 out of 1.4 million candidates.
- KVPY Fellowship 2015: Awarded the prestigious Kishore Vaigyanik Protsahan Yojana (KVPY) Fellowship by the Department of Science and Technology, Government of India; ranked 815 out of 65,000 aspirants pan-India.
- National Standard Examination in Physics (NSEP) 2015: Ranked in the top 1% of participants in the state of Maharashtra.
- Indian National Chemistry Olympiad (INChO) 2015: Qualified for the Olympiad, ranking in the top 1% nationwide.

Relevant Courses

University of California San Diego

- Planning & Learning in Robotics
- Sensing & Estimation in Robotics
- Random Processes
- Statistical Learning
- Bio-inspired robotics
- Nonlinear Systems
- Linear Algebra
- Introduction to Robotics
- ML: Learning Algorithms

IIT Kharagpur

- Design and Analysis of Algorithms
- Soft Computing
- Systems & Control
- Probability and Statistics
- Non-linear Control
- Embedded Systems

Coursera/edX

- Control Of Mobile Robots
- Computational Motion Planninng
- Robotics: Perception
- Robotics: Aerial Robotics
- Robotics: Mobility
- Estimation & Learning