Abhay Singh Bhadoriya

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EDUCATION

Ph.D., Mechanical Engineering Texas A&M University**,** College Station, TX Aug 2024

Thesis: Assisted Path Planning for Heterogeneous Agents with Structural and Motion Constraints

*Key Courses***:** Analysis of Algorithms, Data Structures, Combinatorial & Heuristic Optimization, Survey of Optimization, Mathematical Modelling, Robotic Manipulators, Design of Non-Linear Control Systems

B. Technology, Chemical Engineering Indian Institute of Technology, Bombay, India Aug 2017

RESEARCH PROJECTS

Assisted Path Planning in an Impeded Environment May 2020-Dec 2023

Funding: Air Force Research Laboratory, US

- Developed a novel **Multi-Agent Path Planning** algorithm with **asynchronous** robot motion for complex applications, including warehouse operations or rescue missions, where an assisting agent can help the primary agent to complete a given task in a deterministic environment; **Monte-Carlo Tree Search** (MCTS) based anytime algorithm was also proposed to find a near-optimal solution with limited computation time.
- For the stochastic environment, designed an efficient **real-time algorithm** for the primary agent by combining the ***k*-shortest path** planning algorithm and ***D*Lite*** algorithm; also solved a **Rural Postman Problem** with Time Window constraints for the assisting agent path.

Object Detection and Tracking for Autonomous Vehicles Sept 2019-Aug 2020

Funding: SAFE-D, US Department of Transportation

- Implemented a novel **real-time tracking system** for autonomous vehicles using Modified Multiple Hypothesis Tracking (MHT) and *YOLOv3* for **object detection** during challenging weather conditions (night-time, direct sun glare, fog) improving over baseline model by 52%.
- Synthesized a **sensor fusion algorithm** to combine the data from radar and 5 thermal cameras to achieve a robust 180^{o} field of view.

A Hierarchical Network for Trajectory Proposals Jul 2018-Feb 2019

- Formulated a generalized two-stage **Convolutional Neural Network** architecture to mimic humans' ability to map the perceived surroundings to multiple trajectories for an autonomous vehicle; evaluated the framework on several platforms including KITTI dataset and indoor robots.
- Showcased the results on an in-house drive-by-wire car with LiDAR for **mapping** and Real-Time Kinematic-GPS and IMU for **localization**.

WORK EXPERIENCE

Postdoctoral Researcher, Los Alamos National Laboratory, Los Alamos, NM Oct 2024-Present

- Pioneered a novel **Multiple Traveling Salesman Problem** (MTSP) with fairness constraints by modeling it as a **Mixed-Integer Second Order Cone** program, a computationally efficient alternative to min-max MTSP; developed a custom **branch-and-cut algorithm** for optimal solution.
- Devised a framework to analyze the trade-off between **efficiency vs safety** in autonomous platoons during emergency braking maneuvers with uncertain breaking capacity; Designed and trained a **Temporal Normalizing Flow Neural Network** to estimate the collision probability.

Autonomy Stack Developer, Fox Robotics, Austin, TX May 2024-Aug 2024

- Optimized operational efficiency by **dissecting** intervention data from 50+ autonomous forklifts, engineering a **high-frequency local planner** to actively avoid static and dynamic obstacles, and **improving throughput** by **24%** while maintaining safety standards.
- Developed a hybrid local planner combining **Reinforcement Learning** with the **Model Predictive Path Integral** (MPPI) algorithm to guide the sampling process; introduced efficient trajectory evaluation matrices and integrated the local planner into the existing autonomy codebase.

Electronics and Powertrain Engineer, Vazirani Automotive, Mumbai, India Jul 2017-May 2018

- Designed and developed a 600-kW battery pack **in-house** for the Vazirani Shul electric hyper-car including a custom battery management system (BMS) to **reduce** the **production cost** by **40%**; Conducted comprehensive research to optimize the weight-energy-power ratio.
- Integrated a 3kW cooling system with power-dense lithium-ion battery, including two-phase immersion cooling and phase change material.

SKILLS & CERTIFICATIONS

- **Programming**: C++, Python (PyTorch, TensorFlow, Pandas, NumPy, SciPy), Kotlin, Julia, R, SQL, MATLAB, Latex.
- **Tools**: Git, Docker, CUDA, Robot Operating System (ROS), CPLEX, Gurobi.
- **Skills:** Combinatorial and Stochastic Optimization, Graph Theory, Operations Research, Reinforcement Learning, Model Predictive Control, Nonlinear Programming, Probability and Statistics Theory, State Estimation.
- **Certifications:** Machine Learning, Deep Learning Specialization, Object-Oriented Data Structures in C++.

PUBLICATIONS & AWARDS

- **A. S. Bhadoriya**, D. Deka and K. Sundar. "Equitable Routing - Rethinking the Multiple Traveling Salesman Problem." *arXiv*: 2404.08157 (2024).
- **A. S. Bhadoriya**, et al. "Optimal Path Planning for a Convoy-Support Vehicle Pair Through a Repairable Network." **IEEE Transactions on Automation Science and Engineering** (2023).
- **A. S. Bhadoriya**, et al. "Vehicle Detection and Tracking Using Thermal Cameras in Adverse Visibility Conditions." ***Sensors*** (2022).
- **Research Fellowship**: Emil Buehler Aerodynamic Analog Fellowship; Summer Research Fellowship; Graduate Student Travel Award.
- **Institute Technical Roll of Honor:** Awarded for leading the innovative design at IIT Bombay Racing to build formula student electric racecar.