Abhay Singh Bhadoriya

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RESEARCH INTEREST

Topics: Multi-Agent Collaborative Planning, Robotics and Autonomous Systems, Vehicle Routing, Supply Chain.
Methodologies: Combinatorial and Stochastic Optimization, Linear and Non-linear Programming, Graph Theory, Heuristics, Model Predictive Control, Machine Learning, Deep Learning, Reinforcement Learning.

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

PUBLICATIONS

- **A. S. Bhadoriya**, D. Deka and K. Sundar. "Equitable Routing - Rethinking the Multiple Traveling Salesman Problem." arXiv: 2404.08157 (2024)
- **A. S. Bhadoriya**, S. Rathinam, S. Darbha, D. W. Casbeer, S. G. Manyam. "Assisted Path Planning for a UGV–UAV Team Through a Stochastic Network." *Journal of the Indian Institute of Science* (2025). DOI: 10.1007/s41745-024-00459-z.
- **A. S. Bhadoriya**, C. M. Montez, S. Rathinam, S. Darbha, D. W. Casbeer, S. G. Manyam. "Optimal Path Planning for a Convoy-Support Vehicle Pair Through a Repairable Network." *IEEE Transactions on Automation Science and Engineering* (2023). DOI: 10.1109/TASE.2023.3305392.
- **A. S. Bhadoriya**, V. Vegamoor, S. Rathinam. "Vehicle Detection and Tracking Using Thermal Cameras in Adverse Visibility Conditions." *Sensors* (2022). DOI: 10.3390/s22124567.
- **A. S. Bhadoriya**, S. Darbha, S. Rathinam, D. W. Casbeer, S. J. Rasmussen and S. G. Manyam. "Multi-Agent Assisted Shortest Path Planning using Monte Carlo Tree Search." *AIAA SCITECH Forum* (2023). DOI: 10.2514/6.2023-2655
- S. J. Rasmussen, D. W. Casbeer, **A. S. Bhadoriya**, S. Darbha and S. G. Manyam. "Multi-Agent Task Assignment and Sequencing using Monte Carlo Tree Search and Process Algebra." *AIAA SCITECH Forum* (2023). DOI: 10.2514/6.2023-1473
- **A. S. Bhadoriya**, V. K. Vegamoor, S. Rathinam. "Object detection and tracking for autonomous vehicles in adverse weather conditions." *SAE Technical Paper* (2021). DOI: 10.4271/2021-01-0079
- NN Sriram, G. Kumar, **A. S. Bhadoriya**, M. S. Karthik, S. Saurav, B. Bhowmick and K. M. Krishna. "A hierarchical network for diverse trajectory proposals." IEEE Intelligent Vehicles Symposium (IV) (2019). DOI: 10.1109/IVS.2019.8813986
- **A. S. Bhadoriya**, D. Deka and K. Sundar. "PolyhedralRelaxations.jl - A framework for solving non-convex nonlinear optimization problems to global optimality." (under preparation). Target Journal: *Math Programming Computation*.

RESEARCH PROJECTS

Assisted Path Planning in an Impeded Environment May 2020-Dec 2023
Funding: Air Force Research Laboratory, US

- Developed a novel **Permanent-Labeling** algorithm to optimally solve the **Multi-Agent Assisted Path Planning** problem with **asynchronous motion** constraints, where a secondary agent assists a primary agent to navigate an impeded environment (e.g. **robotic warehouse**).
- **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 secondary 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

- Proposed two novel parametric formulations for **Multiple Traveling Salesman Problem** (MTSP) with workload balancing constraints, a **Mixed-Integer Second Order Cone Program (MISOCP)** and a **Mixed-Integer Linear Program (MILP)**. Both formulations incorporate tunable balancing constraints that allow users to control the degree of workload distribution.
- Designed and implemented a custom **branch-and-cut** based exact algorithm to find optimal solutions. Computational results demonstrate that the proposed approach offers a computationally efficient alternative to traditional Min-Max formulations.
- Developed a polyhedral and **piecewise polyhedral relaxations** based algorithm to solve **non-convex nonlinear optimization** problems to global optimality and corroborated its effectiveness using NLP benchmarks from MINLPLib.

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 in real-time, and **improving throughput** by **24%** while maintaining safety standards.
- Deployed a local planner using the **Model Predictive Path Integral** (MPPI) algorithm, integrating it seamlessly with the Autonomy Stack.

Graduate Research Intern, Los Alamos National Laboratory, Los Alamos, NM Jan 2024-May 2024

- 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.

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.

Team Lead - Electronics, IIT Bombay Racing, Mumbai, India Jul 2016-May 2017

- Led the design and development of the electronics division, **managing a team of 30+ members**, in the IIT Bombay Racing team to build electric racecars and compete with over 120 teams in International Formula Student Competition at Silverstone Circuit, UK.
- Oversaw the development of custom electric powertrain including battery pack and Battery Management System (BMS); Innovative design improvements contributed to the team winning the prestigious SAE Formula Student Award.

SKILLS & CERTIFICATIONS

- **Programming**: C++, Python (PyTorch, TensorFlow, Pandas, NumPy, SciPy), Kotlin, Julia, SQL, MATLAB, Latex
- **Tools**: Git, Docker, CUDA, Robot Operating System (ROS), CPLEX, Gurobi
- **Certifications:** Machine Learning, Deep Learning Specialization, Object-Oriented Data Structures in C++

AWARDS & HONORS

- 2022 - Graduate Student Travel Award, Department of Mechanical Engineering, Texas A&M University
- 2021 - Summer Research Fellowship, Department of Mechanical Engineering, Texas A&M University
- 2019 - Emil Buehler Aerodynamic Analog Fellowship, Texas A&M University
- 2017 - Institute Technical Roll of Honor, Indian Institute of Technology Bombay
- 2017 - Honors in Chemical Engineering, Indian Institute of Technology Bombay

REFERENCES

- Dr. Sivakumar Rathinam Texas A&M University Contact: srathinam@tamu.edu - 202 Spence St, College Station, TX, 77840
- Dr. Kaarthik Sundar Los Alamos National Laboratory Contact: kaarthik@lanl.gov - Bikini Atoll Rd, Los Alamos, NM, 87545