Ishaan Mahajan

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EDUCATION

COLUMBIA UNIVERSITY
MS in Computer Science | Expected December 2025

UNIVERSITY OF WISCONSIN, MADISON
BS in Computer Science and Data Science | May 2024 | GPA: 3.8/4.0
Honors in Computer Science
Coursework: Simulation and Modeling of Robots and Autonomous Vehicles (A) • Computer Vision (A) • Matrix Methods in Machine Learning (A) • Optimization (A) • High-Performance Computing (A) • Big Data Systems (A)

RESEARCH INTERESTS : ROBOTICS

Reinforcement Learning • Deep Learning • Control Algorithms • Navigation • Simultaneous Localization and Mapping • Vehicle Modeling • Dynamics • Simulation

WORK/RESEARCH EXPERIENCE

THE ACCESSIBLE AND ACCELERATED ROBOTICS LAB (A²R LAB) | GRADUATE RESEARCHER
June 2024 - Present | New York, NY | Website

Working on implementing safe-learning mechanisms for robots.

Advised by Professor Brian Plancher

SAFE RL
- Working on developing safe RL for quadcopters using Lyapunov functions and recovery actions.

SIMULATION-BASED ENGINEERING LAB AT UW MADISON | UNDERGRADUATE RESEARCHER
January 2022 - May 2024 | Madison, WI | Website

Worked on Robotics projects using the high fidelity physics-based simulation engine Project Chrono.

Advised by Professor Dan Negrut

LOCALIZATION AND CONTROL POLICIES | Papers | Technical Report | Poster
- Set up and implemented an RTK system for centimeter-level precision on the physical car and in the software autonomy stack.
- Implemented control algorithms like PID, MPC, and a Neural Network controller trained on imitation learning and MPC for Zero-shot transfer.
- Developed a GPS sensor using Stochastic Random Walks in Chrono to simulate a real physical GPS.

LOW FIDELITY DYNAMIC MODELS | Paper | Technical Report
- Developed a low fidelity dynamics model library involving 4DOF, 11DOF, 18DOF, and 24DOF models.
- Development targeted towards applications in State-Estimation, Control, and Machine Learning.
- Developed GPU implementations of the models with the ability to run 300,000 simulations simultaneously.
- CPU implementations of these models are 1000 times faster than real-time.

DIFFERENTIABLE SIMULATORS | Technical Report
- Researched about types of Automatic Differentiation (AD) tools to efficiently fit pre-existing tools into the existing low-fidelity model library.
- Analyzed the speed vs accuracy tradeoffs in computing parameter sensitivities using Finite Differences vs AD.
- Implemented AD tools like Enzyme and PyTorch for computing parameter sensitivities of the low-fidelity models.

ART/ATK RESEARCH PLATFORM | Papers | Technical Report | Poster
- An open source platform consisting of hardware and software components for robot autonomy development.
- Implementing simulations within the software stack based off the physical vehicle to address the sim-to-real gap.
- Continually developing the stack by contributing to software development and sensor configuration to adapt to the current research goals.

SYNECHRON | AI/ML RESEARCH INTERN
May 2023 - August 2023 | Charlotte, NC

- Researched and implemented various LLMs to understand their working and efficiency.
- Created an NLP Query Engine based on an LLM to improve the efficiency of operational tasks for various bank clients.
- Developed a highly scalable solution for the conversion of unstructured data into a structured form using SRGAN and OCR.

NATIONAL UNIVERSITY OF SINGAPORE | ROBOTICS RESEARCH INTERN
May 2022 - July 2022 | Singapore | Report

Worked in the Control and Simulation lab to create a social robot.

Advised by Professor Ge, Shuzhi Sam

- Created an autonomy stack using Docker containers and ROS, encompassing perception and control functionalities, to create an uniform system for all users.
- Implemented SLAM and path-planning algorithms on the robot for indoor navigation.
- Implemented NLP to make the robot listen to human voice commands and navigate accordingly.

STUDENT ORGANIZATION EXPERIENCE

WISCONSIN AUTONOMOUS
September 2020 - May 2024 | Madison, WI | Website

Leading 40 graduate and undergraduate students to implement autonomy for urban driving and racing scenarios.

Advised by Dr. Glenn Bower

GENERAL MOTORS-SAE AUTODRIVE CHALLENGE | AV Infrastructure Lead
June 2022 - Present | Website | Paper
- A 4-year long competition to develop level 4 autonomy on a Chevrolet Bolt EUV for urban driving scenarios.
- Implemented an Extended Kalman Filter along with sensor calibration of the IMU/GPS for state-estimation.
- Developed a HD Map ROS2 based service to work with HD Maps for localization in the absence of a GPS signal.
- Continually developing the software infrastructure for Perception-Controls data transfer and communication.

EV Grand Prix | State-Estimation Lead
June 2022 | Website
- An autonomous EV go-kart racing competition where the team won 3rd out of the 5 teams that participated.
- Implemented a path-planning algorithm based on waypoint generation through the GPS/IMU sensor data.

TEACHING & MENTORING EXPERIENCE

COMS 3159 - PARALLEL OPTIMIZATION FOR ROBOTICS | GRADUATE TEACHING ASSISTANT
Fall 2024 | New York, NY | Website
- Teaching 2 office hours for Columbia's parallel optimization for robotics class catered towards undergraduates.
- Designing homeworks and exams relating to applications of CUDA in robotics locomotion tasks.

COMP SCI 300 - INTRODUCTION TO OBJECT ORIENTED PROGRAMMING | UNDERGRADUATE TEACHING ASSISTANT
Fall 2022 | Madison, WI
- Taught 2 office hours weekly for the fundamental Computer Science course at UW Madison.
- Assisted in the functioning and development of the course over the semester, including designing and reviewing homework assignments and quizzes.
- Helped students understand concepts like Abstraction, Polymorphism, and Inheritance through Java programming assignments.

ACADEMIC COACHING AND TUTORING SERVICES | ACADEMIC TUTOR
Spring 2022 | Madison, WI | Website
- Taught a 1-on-1 tutoring session weekly for the Calculus and Introduction to Differential Equations course at UW Madison.
- Designed problem sets involving the course content to test the student's progress over the semester.
- Conducted drop-in workshops for other UW students taking various Calculus courses.

AWARDS
- UW Madison CS Department Scholarship for PhD acceptance (2024) (Declined)
- Hilldale Undergraduate/Faculty Research Fellowship (2023)
- Chou Kuo-ping Scholarship (2022)
- Study Abroad Scholars (2022)

ACADEMIC SERVICE

- Journal Service: Reviewer for JOSS

PROJECTS

Autonomy State Controls | ME468
Spring 2022 | Madison, WI

- Team of 2 designed and implemented an autonomy stack consisting of state-estimation and control algorithms in simulation.
- Developed a Kalman Filter (KF) for state-estimation based on random initial states of the vehicle, and PID for control.
- KF provided an average position error of <= 15 cms for 5 different trajectories.

Path Planners | CS524
Spring 2023 | Madison, WI | Report

- Team of 2 designed and implemented two control policies, PID and MPC, for comparison and evaluation purposes on a 2D bicycle model.
- Implemented both the policies on different trajectories for urban driving scenarios like obstacle avoidance.
- Code base served as the high-level planner for the control stack in Wisconsin Autonomous for the AutoDrive Challenge.

Low Vision Virtual Reality Toolkit | CS639
Fall 2022 | Madison, WI | Website

- Developed a toolkit to help with low-vision problems in a 4 member team.
- Implemented 4 functionalities - Magnification, Contrast, OCR, and Text-to-Speech.

PUBLICATIONS & PREPRINTS

- Unjhawala, H. M., **Mahajan I.**, Serban, R., & Negrut, D. (2024). A Library of Lower Fidelity Dynamics Models (LFDMs) For On-Road Vehicle Dynamics Targeting Faster Than Real-Time Applications. *Journal of Open Source Software, 9(99), 6548*

- **Mahajan I.**, Unjhawala, H., Zhang, H., Zhou, Z., Young, A., Ruiz, A., Caldararu, S., Batagoda, N., Ashokkumar, S. & Negrut, D. (2024). Quantifying the Sim2real Gap for GPS and IMU Sensors. *arXiv preprint arXiv:2403.11000*

- Zhang, H., Caldararu, S., Young, A., Ruiz, A., Unjhawala, H., **Mahajan I.**, Ashokkumar, S., Batagoda, N., Zhou, Z., Bakke, L. & Negrut, D. (2024). A Study on the Use of Simulation in Synthesizing Path-Following Control Policies for Autonomous Ground Robots. *arXiv preprint arXiv:2403.18021*

- Ashokkumar, S., Jayendra, A., Tobin, S., Leykin, A., Stegeman, R., Dashora, R., Koenig, J., Krishnakumar, M., Look, B., Crooks, M., Hu, B., **Mahajan I.**, Boopathy, P., Batagoda, N., Wang, H., Friere, V., Bower, G., Xu, X., Negrut, D., & Young, A. (2024). Rapid Development of an Autonomous Vehicle for the SAE AutoDrive Challenge II Competition. *SAE WCX*

- Zhang, H., Caldararu, S., **Mahajan I.**, Chatterjee, S., Hansen, T., Dashora, A., Ashokkumar, S., Fang, L., Xu, X., He, S., & Negrut, D. (2023). Using simulation to design an MPC policy for field navigation using GPS sensing. *ECCOMAS Thematic Conference on Multibody Dynamics*

- Hansen, T., Chatterjee, S., Ashokkumar, S., **Mahajan I.**, Zhang, H., Caldararu, S., Dashora, A., Young, A., Shen, H., Fang, L., & Negrut, D. (2023). An Overview of a Framework for Designing Robot Autonomy Stacks in Simulation. *ECCOMAS Thematic Conference on Multibody Dynamics*

- Elmquist, A., Young, A., **Mahajan I.**, Fahey, K., Dashora, A., Ashokkumar, S., Caldararu, S., Freire, V., Xu, X., Serban, R., & Negrut, D. (2022). A software toolkit and hardware platform for investigating and comparing robot autonomy algorithms in simulation and reality. *arXiv preprint arXiv:2206.06537*

- Elmquist, A., Young, A., Hansen, T., Ashokkumar, S., Caldararu, S., Dashora, A., **Mahajan I.**, Zhang, H., Fang, L., Shen, H., Xu, X., & Negrut, D. (2022). ART/ATK: A research platform for assessing and mitigating the sim-to-real gap in robotics and autonomous vehicle engineering. *arXiv preprint arXiv:2211.04886*

TECHNICAL REPORTS

- **Mahajan I.**, Unjhawala, H., & Negrut, D. (2023). ART Broly. *Technical Report TR–2023–14*

- Unjhawala, H., **Mahajan I.**, Serban, R., & Negrut, D. (2023). Computing sensitivities of an Initial Value Problem via Automatic Differentiation: A Primer. *Technical Report TR–2023–08*

- Zhang, H., Unjhawala, H., Caldararu, S., **Mahajan I.** , Bakke, L., Serban, R., & Negrut, D. (2023). Simplified 4DOF Bicycle Model for Robotics Applications. *Technical Report TR–2023–06*

- Zhang, H., Chatterjee, S., Hansen, T., Caldararu, S., **Mahajan I.** , Batagoda, N., Fang, L., Serban, R., & Negrut, D. (2023). Formulating Model Predictive Control (MPC) strategies in conjunction with error dynamics based waypoint-seeking to model robust vehicle control. *Technical Report TR–2023–01*

- Caldararu, S., Zhang, H., **Mahajan I.** , Hansen, T., Chatterjee, S., Batagoda, N., Serban, R., & Negrut, D. (2022). Using random walks to simulate GPS sensing for applications in robotics and autonomous vehicles. *Technical Report TR–2022–02*

INVITED PRESENTATIONS

STATE-ESTIMATION TECHNIQUES IN AUTONOMY AND ROBOTICS
April 2024 | Madison, WI | Website
- Poster Presentation as part of the Hilldale Undergraduate/Faculty Research Fellowship.

USING AND SIMULATING RTK-GPS SENSING FOR APPLICATIONS IN ROBOTICS
December 2023 | Madison, WI | Website
- Presentation at the Machine Ground Interaction Consortium (MaGIC)

TUTORIAL ON USING CHRONO FOR ROBOT AUTONOMY-STACK DESIGN
December 2023 | Madison, WI | Website
- Presentation at the Machine Ground Interaction Consortium (MaGIC)

VOLUNTEERING

ENGINEERING EXPO
April 2022 - Present | Madison, WI | Website
- An annual STEM Outreach Event organized at UW Madison.
- Set up exhibitions, representing WA, for 3000 students and teachers from underrepresented schools.
- Introduce students to basic robotics and autonomy through demonstrations with various sensors.

SPECIAL SCHOOL - NAVJEEVAN SOCIETY
August 2019 - November 2019 | Aurangabad, INDIA | Website
- Taught 30 intellectually disabled students basic math concepts and simple skills like how to operate a computer.
- Organized events like marathons and non-profit recreational activities to spread intellectual disability awareness.

SKILLS

C/C++ • Python • ROS/ROS2 • CUDA • Git • Control • State-Estimation and Localization • OpenMP • Swig • OpenCV • Machine Learning • Computer Vision • Linux/Bash • MacOS • Docker • Java • HTML • CSS • Javascript