

# Ishaan Mahajan

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## EDUCATION

### COLUMBIA UNIVERSITY

MS in Computer Science | Expected May 2026

### UNIVERSITY OF WISCONSIN, MADISON

BS in Computer Science and Data Science | May 2024 | GPA: 3.80/4.0

Dean's List | 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

Localization and State-Estimation • Control Algorithms • Navigation • Simultaneous Localization and Mapping • Vehicle Modeling • Dynamics • Simulation

## WORK/RESEARCH EXPERIENCE

### SIMULATION-BASED ENGINEERING LAB AT UW MADISON | UNDERGRADUATE RESEARCHER

January 2022 - Present | Madison, WI | Website

Working 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 racing and urban driving 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

### 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  $\leq 15$  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

- (Under Review) **Mahajan I.** , Unjhwala, 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. *IEEE/RSJ International Conference on Intelligent Robots and Systems*
- (Under Review) Zhang, H., Caldararu, S., Young, A., Ruiz, A., Unjhwala, 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. *IEEE/RSJ International Conference on Intelligent Robots and Systems*
- 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.** , Unjhwala, H., & Negrut, D. (2023). ART Broly. *Technical Report TR-2023-14*
- Unjhwala, 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., Unjhwala, 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