

# Json Zhenhao Zhou

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## Personal Profile

I'm an experienced C++ and Python software engineer with a focus on the design and programming in high-performance robotics simulation software, AI learning-based robotics control, and embedded systems. I am working on my PhD while double-majoring in Mechanical Engineering and Computer Science at the University of Wisconsin–Madison. My research focuses on the development and validation of digital twins and their applications in the design of autonomy control stacks for robotic systems, autonomous vehicles, and smart infrastructure. My research experiences have allowed me to develop strong programming skills, knowledge in high-performance computing, deep understandings in multi-body dynamics and physics simulation, and computer graphics. I am a member of the Simulation-Based Engineering Lab (SBEL) at the University of Wisconsin–Madison, and an active developer of the open-source multi-physics simulation engine Project Chrono.

## Education

### University of Wisconsin-Madison

Madison, WI

Doctor of Philosophy in Mechanical Engineering

May 2025

- GPA: 3.9.
- Expected Graduation on May 12, 2025.
- **Research Focus:** ML in Robotics Simulation, Sim2Real Autonomy Stack Transfer.

### University of Wisconsin-Madison

Madison, WI

Master of Science in Mechanical Engineering

May 2023

- GPA: 3.9.
- **Courses:** Feedback Control of Autonomous Systems, Advanced Robotics, Computational Fluid Dynamics, Computational Dynamics, Mechanical Design Optimization, Thermodynamics, Heat Transfer.
- **Research Thesis:** An Open-Source Chrono-Based Framework for Large-Scale Traffic Simulation with Human In The Loop

### University of Wisconsin-Madison

Madison, WI

Master of Science in Computer Science

Dec 2022

- GPA: 3.9.
- **Courses:** High Performance Computing, Data Science, Machine Learning, Wireless Communication, Computer Networks, Distributed Computing, Computer Architectures.

### University of Wisconsin-Madison

Madison, WI

Bachelor of Science in Mechanical Engineering

Dec 2020

- GPA: 3.8.
- **Courses:** Robotic Systems, Manufacturing Automation, Design Optimization, Thermal Dynamics, Fluid Dynamics, Static and Dynamic Systems

### University of Wisconsin-Madison

Madison, WI

Bachelor of Science in Computer Science

Dec 2020

- GPA: 3.8.
- **Courses:** Machine Learning, Computer Vision, Computer Graphics, Operating System, Optimization Theory, Database

## Skills

<b>Programming</b>	Python, C/C++/C#, Embedded C, FreeRTOS, CUDA, OpenCL, SYCL, HTML/CSS, Java, JavaScript, Julia, R, SQL
<b>Engineering/Design</b>	Chrono, Solidworks, Blender, MSC Adams, ROS/ROS2, Unity, Unreal Engine, Matlab, Simulink, Rhino, COMSOL
<b>Miscellaneous</b>	Linux Kernel Development, DDS, Shell, LaTeX, Firebase Interface, Windows, git, cmake, Tensorflow, OpenCV, Keras

## Work Experience

### Toyota Research Institute

Cambridge, MA

Robotics Research and Development Intern

May 2024 - Aug 2024

- Research and Development SDE in TRI Robotics Department, Large Behavior Models Team, Dynamics and Simulation Branch.
- Development of CUDA-based collision engine and numerical solver for Model-Based Design and Verification Simulator, Drake, co-developed by TRI and MIT Locomotion Lab. Parallelization of simulation environment on GPU for AI training of manipulation tasks in simulation environment.
- Development of manipulator control using imitation and reinforcement learning on cloud; validation and comparison with plain control, leveraging machine learning frameworks, and deployment on CUDA and embedded control systems.

## UW-Madison

Madison, WI

### Graduate Teaching Assistant

Jun 2022 - Present

- **ME/ECE/COMP SCI 759:** High Performance Computing - Parallel Computing Programming, CUDA, OpenMP, MPI; Parallel Program Optimization, GPU and Accelerator Architectures.
- **ME 451:** Multibody Dynamics - Kinematics and Dynamics; Forward and Inverse Dynamics; Friction and Contact.

## Simulation-Based Engineering Lab at UW-Madison

Madison, WI

### Graduate Research Assistant

Jan 2021 - Present

- Advisor: Professor Dan Negrut.
- Developed autonomous vehicle coordination and simulation, leveraged simulation fidelity and real-time performance for Human-In-The-Loop, Hardware-In-The-Loop and Software-In-The-Loop applications. Head developer of chrono::HIL, a plug-in of Project Chrono (<https://projectchrono.org/>) to provide real-time simulation support for complex traffic scenarios and vehicle dynamics. chrono:HIL provides flexible simulator hardware coupling capabilities, distributed simulation support, soft real-time simulation support, and multiple vehicle dynamic models. Integrated Chrono::HIL with National Advanced Driving Simulator (NADS) at the University of Iowa for ADAS and simulated sensor support.
- Integrated sensor (lidar/radar/camera sensor) simulation using chrono::sensor into traffic scenarios to assist the development of autonomous vehicle control and sensor fusion. Provided simulation support for human-factor research conducted by Cognitive Systems Laboratory at UW-Madison. Program is based on C++ for high performance, leveraging DDS, CUDA, and Socket Programming for distributed computing. Funded by National Science Foundation OAC2209791.
- Development of Gym-Chrono, a Deep Reinforcement Learning environment and pipeline using Project Chrono to enable research on the transfer of learned policy from simulation to reality. Validation of Software-In-The-Loop training using LEGO-SLAM algorithm.
- Robotics driver software suite built upon ROS2 and FreeRTOS for SBEL physical validation robots. Integrated Lidar, IMU, and GPS sensors for real-time data acquisition and processing using C++, python, and ROS2. software-In-The-Loop and hardware-in-the-loop simulation using DDS, TCP/UDP socket for control and SLAM (Simultaneous Localization and Mapping) validations.
- Extraterrestrial rover and robot mechanical component simulation. Applications/development/validation of SCM (Soil Contact Model), SPH (Smoothed Particle Hydrodynamics), and DEM (Discrete Element Method) deformable terrain. Developed the VIPER lunar rover model and the Curiosity Mars rover model in the chrono::robot module. Integrated sensor simulation support to provide Lidar/Radar perception data in harsh lunar environment. The program is based on CUDA and Nvidia Optix for GPU-Based physics solver and ray-tracing. Funded under NASA project to support 2023 VIPER lunar mission.

## Simulation-Based Engineering Lab at UW-Madison

Madison, WI

### Undergraduate Research Assistant

Jun 2020 - Dec 2020

- Advisor: Professor Dan Negrut.
- Developed and validated chrono::granular (later renamed chrono::gpu), a CUDA solver for granular dynamics. chrono::granular can be used to simulate monodisperse granular material; applications include granular material properties testing and deformable terrain for off-road vehicle research; simulator solved problem with more than one billion degrees of freedom on one V100 NVIDIA GPU.
- Developed chrono::synchro, a Project Chrono plugin that supports the space and time-coherent simulation of multiple vehicles in Chrono. Developed MPI and DDS interfaces of chrono::vehicle; utilized of parallel computing for achieving real-time performance.

## Human Computer Interaction Lab at UW-Madison

Madison, WI

### Undergraduate Research Assistant

Sep 2019 - May 2020

- Advisor: Professor Bilge Mutlu.
- Developed a QR Marker object tracking program based on OpenCV in C++. The program helps educational robots to identify objects and their movements in order to facilitate human-computer interaction.
- Designed and developed of simulation environment for robot localization algorithm using ROS2. The simulation environment allows a Turtlebot model to follow certain trajectories in an indoor environment relying purely on QR codes identified by the machine learning algorithm.
- Created of the CAD models for robot's parts using Solidworks and 3D printing software.

## Alstom

Melbourne, FL

### Software Engineering Intern & Embedded System Engineering Intern

May 2019 - Aug 2019

- Cooperated with Alstom's System Validation Team to perform system tests and review code (primarily in C++ and Python) on Alstom DAU (Data Acquisition Unit), a critical wayside component of the Alstom's Automatic Railway Signaling System; Debugging lower-level program, scanning and hacking the Apache server installed to search for possible bugs which may lead to the fatal crash of the system.
- Developed a C++ testing program for Alstom's Wayside Linux-Based Core ACE board to meet Hardware Serial Test Specifications including multi-CPU communication, I2C, UART, SPI, onboard GPIO connection, Watchdog Timer, and other hardware checks. The testing program includes both lower-level hardware programming and higher-level algorithm programming.

## Projects

### Mechanical Engineering Senior Design Project

Madison, WI; Milwaukee, WI

#### Milwaukee Tool

Sep 2019 - May 2020

- Designing a glove impact testing fixture to quantitatively measure the impact protection provided by impact-resistant gloves.
- CAD model design and FEA analysis; created engineering drawings for Milwaukee Tool's workshop to manufacture parts
- Experience with resistance-based force sensor circuits and related component.
- Designed and created ready-to-deliver LabView programs to integrate pneumatic system and data acquisition unit (NI C-DAQ)

- Designing a drone frame and a drone cover which meets the requirements provided with limited ABS Material using Solidworks and PareToWorks
- Performing FEA structural analysis in Solidworks to ensure the design meets performance and endurance requirement.

## Contributed Awards

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- **National Aeronautics and Space Administration (NASA) 80NSSC24CA030, Total \$850,732**, A Software Framework for Advancing Perception Capabilities for Rovers Operating in Harsh Lunar Environments, December 25, 2023 - December 24, 2025, PI: Dan Negrut; Business Contact: Dimitrios Apostolopoulos
- **National Aeronautics and Space Administration (NASA) 80NSSC22PB163, Total \$150,000**, A Software Framework for Advancing Perception Capabilities for Rovers Operating in Harsh Lunar Environments, July 12, 2022 - August 25, 2023, PI: Dan Negrut; Business Contact: Dimitrios Apostolopoulos
- **NSF Award 1739869, Total \$1,200,000**, CPS: TTP Option: Medium: Identifying, Characterizing, and Shaping Multi-Scale Cyber-Human Interactions in Mixed Autonomous Conventional Vehicle Traffic, September 16, 2019 - September 30, 2023, PI: Soyoung Ahn, Dan Negrut, John Lee
- **NSF Award 1835674, Total \$529,000**, Collaborative Research: Elements: Software: NSCI: Chrono - An Open-Source Simulation Platform for Computational Dynamics Problems, August 1, 2019 - July 31, 2023, PI: Dan Negrut, Radu Serban
- **NSF Award 2317946, Total \$250,000**, Collaborative Research: FW-HTF-R: The Future of Trucking: Pathways to Positive Societal Outcomes, October 1, 2022 - September 30, 2025, PI: David Noyce, Parameswaran Ramanathan, Madhav Chitturi, Xiangru Xu

## Publications

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- Mahajan, I, Unjhwala H, Zhang, H, **Zhou, Z.** Young, A, Ruiz A, Caldararu, S, Batagoda, N, Ashokkumar, S, Negrut, D, "Quantifying the Sim2real Gap for GPS and IMU Sensors." arXiv preprint arXiv:2403.11000 <https://arxiv.org/html/2403.11000v1>
- **Zhou, Z.**, Unjhwala, H, Kamaraj, A, Kissel, A, Lee, J, Serban, R, Negrut, D, "A Chrono-Based Framework for Large-Scale Traffic Simulation with Human-In-The-Loop." Proceedings of the *Multibody 2023 11th ECCOMAS Thematic Conference on Multibody Dynamics*, Lisboa, Portugal. July 24-28, 2023. Preprint <https://doi.org/10.13140/RG.2.2.23133.59361>
- Serban, R, Taves, J, **Zhou, Z.** "Real-Time Simulation of Ground Vehicles on Deformable Terrain." Proceedings of the *ASME 2022 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference. Volume 9: 18th International Conference on Multibody Systems, Nonlinear Dynamics, and Control (MSNDC)*. St. Louis, Missouri, USA. August 14-17, 2022. V009T09A012. ASME. <https://doi.org/10.1115/DETC2022-89470>
- Hu, W., **Zhou, Z.**, Chandler, S., Apostolopoulos, D., Kamrin, K., Serban, R., Negrut, D. Traction control design for off-road mobility using an SPH-DAE cosimulation framework. *Multibody System Dynamics* 55, 165-188 (2022). <https://doi.org/10.1007/s11044-022-09815-2>
- Hu, W., **Zhou, Z.**, Serban, R., Negrut, D., Using an SPH-based continuum representation of granular terrain to simulate VIPER rover mobility, 2021/10, Preprint, [https://www.researchgate.net/publication/358872957\\_Off-Road\\_Rover\\_Mobility\\_Simulation\\_Using\\_a\\_Continuum\\_Representation\\_of\\_Deformable\\_Terrains](https://www.researchgate.net/publication/358872957_Off-Road_Rover_Mobility_Simulation_Using_a_Continuum_Representation_of_Deformable_Terrains)
- Hu, W., **Zhou, Z.**, Serban, R, Negrut, D. "Using an SPH-Based Continuum Representation of Granular Terrain to Simulate the Rover Mobility." Proceedings of the *ASME 2021 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference. Volume 9: 17th International Conference on Multibody Systems, Nonlinear Dynamics, and Control (MSNDC)*. Virtual, Online. August 17-19, 2021. V009T09A028. ASME. <https://doi.org/10.1115/DETC2021-71289>

## Conference Presentation

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- Taves J., Elmquist, A., **Zhou, Z.**, Kissel A., Serban, R, Negrut, D, "Synchronization and Scalability of the Multi-Agent Dynamics Environment SynChrono" *The Joint International Conference on Multibody System Dynamics and The Asian Conference on Multibody System Dynamics*, New Delhi, India, OCT 16-20, 2022.
- **Zhou, Z.**, Hu, W., Serban, R, Negrut, D, "Simulation of Robotic Mechanical Systems and Application in Robot-Terrain Interaction Using Project Chrono" *ASME 2021 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*, AUG 17-20, 2021.
- Hu, W., **Zhou, Z.**, Serban, R, Negrut, D, "Using an SPH-Based Continuum Representation of Granular Terrain to Simulate the Rover Mobility" *ASME 2021 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*, AUG 17-20, 2021.