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Huzaifa Mustafa Unjhawala

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Education

University of Wisconsin-Madison May 2026
Ph.D. Mechanical Engineering, Minor in Mathematics, Advisor: Dan Negrut *Current GPA: 3.93/4.0*

University of Wisconsin-Madison Dec 2024
MS Computer Science *Current GPA: 3.9/4.0*

University of Wisconsin-Madison May 2023
MS Mechanical Engineering - Thesis, Advisor: Dan Negrut *GPA: 3.94/4.0*

National Institute Of Technology - Trichy June 2020
B.Tech with Honors in Mechanical Engineering *GPA: 8.9/10.0*

Coursework

Scientific Computing, Applied Mathematics, High Performance Computing, Nonlinear Finite Elements, Stochastic Computational Methods, Non-Linear Optimization, Vehicle Dynamics, Kinematics and Dynamics of Machine Systems, Machine Learning, Foundation Models, Computer Vision.
Awards: Baden-Württemberg Stipendium

Skills

Languages: C/C++, `CUDA`, Python (incl. JAX, PyTorch), Matlab, LaTeX
Tools: Git, Linux (Arch, Ubuntu), docker, CMake, Shell (Bash, Zsh), SWIG, PyBind11
CAD and FEA: ANSYS, Siemens NX, Solidworks, PTC Creao, MSC Adams

Research

GPU Solvers for Fluid-Structure Interaction (FSI) with SPH | *UW–Madison* May 2024 – Present

- Accelerating the Chrono::FSI solver with optimizations in `CUDA`.
- Enabled a **2× speedup** by optimizing memory placement and data movement while performing proximity Search, a major computational expense of the *Smoothed Particle Hydrodynamics (SPH) solver* that solves the fluid phase.
- Adding physics to simulate granular materials as the fluid phase of the FSI problem for use in simulations involving autonomous excavation and mobility in off-road environments.
- See linked code and recent poster for more details.

Machine Learning for Fluid-Structure Interaction (FSI) | *UW Madison* Feb 2024 – Present

- Understanding the applicability of Graph Neural Networks (GNNs) for large scale granular material simulations.
- Accelerated vanilla GNNs by **4× with 2× lesser memory** through smart graph reconstruction and reduced precision during inference while maintaining accuracy.
- Evaluating the use of Graph Neural Networks in-the-loop with a multi-body dynamics solver such as Chrono.
- Research plans along this thrust and early results can be found in here. Code can be found here.

Machine Learning for Constrained Multibody Dynamics systems | *UW Madison* Aug. 2023 – Mar. 2024

- Contributed to MBD-NODE, a physics-informed data-driven model for constrained multibody dynamics.
- The model was found generalize well to out-of-distribution (OOD) scenarios and required very less data for training.
- See Publication below for more details.

Low-Fidelity Vehicle Dynamic Models | *U*W–Madison Jan. 2022 – May 2023

- Developed a `C++` library of Low-Fidelity Vehicle Models that are **1000×** faster than real-time on a CPU.
- Parallelized the models using `CUDA`, enabling simulation of **300,000 vehicles in real-time**.

- Used Bayesian Optimization to tune the parameters of the model to **match real-world data** and vehicles of various scales. These calibrated models are much faster and as accurate as the models in Chrono.
- Open source code can be found here with related papers in the Publications section.

Calibration of Terramechanics Models | *UW–Madison* Jan. 2023 – May 2023

- Contributed to a study that calibrated Soil Contact Model (SCM) terrain parameters using ground truth data from SPH-based virtual bevameter tests in a Bayesian framework, achieving a **10x simulation speedup**.
- Integrated `PyMC` with Chrono for interactive calibration; models and scripts are publicly available as open-source; publication can be found here.

Sensor Simulation Validation | *Simulation Based Engineering Lab, UW Madison* Dec 2023 – Mar 2024

- Validated the performance of GPS and IMU sensor's in simulators such as AirSim and Project Chrono for velocity estimation using a contextual performance difference based approach. See publication here for more details.

Undergraduate Research in Simulation May 2018 – May 2020

- Awarded the Baden–Württemberg Stipendium for a three-month research internship at the Karlsruhe Institute of Technology, Germany, where I worked on multi-body simulation models for axial thrust bearings in MSC Adams.
- Built a transient fluid flow simulation model that was used to optimize the pressure drop of a Magneto-Rheological Damper in ANSYS CFX and AIM.

Work Experience

Komatsu Mining Corp | *Part-Time, Longview, TX* Aug. 2024 – Present

- Generating Discrete Element Method (DEM) simulation data using the DEM-Engine, a dual-GPU DEM library.
- Simulation data is used to train Komatsu's autonomous excavation and loading machinery.
- Some early simulation results can be found here.

National Renewable Energy Laboratory | *Graduate Engineering Intern, Golden, CO* Jul. 2023 – Sep. 2023

- Contributed to HydroChrono – a C++ library for enabling Wave Energy Converter (WEC) simulations with Project Chrono.
- Refactored code and setup testing infrastructure.
- Explored the use of multi-fidelity models for WEC simulations by enabling seamless transition from potential flow solvers used in HydroChrono to high-fidelity SPH solvers used in Project Chrono.
- Open source code can be found here.

Milwaukee Tools | *Mechanical Engineering Intern, Milwaukee, WI* June 2022 – Aug. 2022

- Developed a Hydraulic long-throw press tool from concept to prototype using NX for CAD and ANSYS Mechanical for FEA.
- Shortened tool length by 40% from previous generation to reduce weight by 30%. This directly improves usability and comfort for the end user.

HiPER Automotive | *Simulation Engineer* Jun. 2020 – Jul. 2021

- Achieved 15% fuel savings for customers by analyzing driver behavior and characteristics and optimizing engine maps.

Side Projects

Maintainer of GymChrono | *UW Madison*

- Co-maintaining the open-source Gymnasium environment for Project Chrono, a physics-based simulation engine for use in Reinforcement Learning applications
- Co-hosted a training session at MaGIC whose slides can be found here
- Open source code can be found here

Linear Elastodynamics Finite Element Solver in C++ | *UW Madison*

- Developed a tiny linear elastodynamics FEM solver with a focus on correctness to better understand the underlying principles of FEM. See open source code.
- Relative error on certain test cases were $\leq 5\%$ compared to `ANSYS Mechanical`.

Visual Inertial Odometry in Project Chrono | *UW Madison*

- As part of the Final Project in my Computer Vision class, I worked to implement the `VINS-Fusion` Visual Inertial Odometry (VIO) algorithm Project Chrono. See open source code here.

SAE Baja Racing

Team Captain 2019-2020

- Responsible for overall design ideation, manufacturing plan, vehicle integration, and management of 30 team members.
- Finished **5/150** in *SAE Baja India 2020* and led the team to multiple podium finishes at *Enduro Student India 2020*.

Design Engineer 2017-2019

- Designed the ATVs wheel and pedal assemblies to be 10% lighter than previous years using topology optimization tools on ANSYS Mechanical.
- Analyzed assemblies for various loading conditions and rigorous on field-testing led to 0% failure during *SAE Baja India 2020*.
- Led a team for the design and manufacturing of a custom brake caliper using AI alloys for better braking performance and lighter weight.

Publications

Journal Publications

- Hu, W., Li, P., **Unjhawala, H.M.**, Serban, R., & Negrut, D. (2023). Calibration of an expeditious terramechanics model using a higher-fidelity model, Bayesian inference, and a virtual bevameter test. *Journal of Field Robotics*, 1–20. https://doi.org/10.1002/rob.22276
- **Unjhawala, H. M.**, Zhang, R., Hu, W., Wu, J., Serban, R., & Negrut, D. (2023). Using a Bayesian-Inference Approach to Calibrating Models for Simulation in Robotics. *ASME Journal of Computational and Nonlinear Dynamics*, 18(6), 061004. https://doi.org/10.1115/1.4062199
- **Unjhawala, H. M.** et al. (2024). An Expeditious and Expressive Vehicle Dynamics Model for Applications in Controls and Reinforcement Learning. *IEEE Access*. https://doi.org/10.1109/ACCESS.2024.3368874
- **Unjhawala, H. M.** et al. (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. https://doi.org/10.21105/joss.06548
- Wang, J., Wang, S., **Unjhawala, H.M.** et al. (2024). MBD-NODE: Physics-Informed Data-Driven Modeling and Simulation of Constrained Multibody Systems. *Multibody System Dynamics*. https://doi.org/10.1007/s11044-024-10012-6

Under Review

- Zhou, Z., **Unjhawala, H. M.**, Kamaraj, A., Kissel, A., Lee, J., Serban, R., & Negrut, D. (Under Review). A Chrono-Based Framework for Large-Scale Traffic Simulation with Human-In-The-Loop. *IEEE Journal of Intelligent Vehicles*.

Arxiv Preprint

- Mahajan, I., **Unjhawala, H. M.**, 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. https://arxiv.org/abs/2403.11000
- Wang, J., Zhang, H., **Unjhawala, H. M.**, Negrut, P., Wang, S., Slaton, K., Serban, R., Wu, J.-L., & Negrut, D. (2024). SimBench: A rule-based multi-turn interaction benchmark for evaluating an LLM's ability to generate digital twins. arXiv. https://arxiv.org/abs/2408.11987
- Zhang, H., Caldararu, S., Young, A., Ruiz, A., **Unjhawala, H. M.**, 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. https://arxiv.org/abs/2403.18021