Nolan Black, Ph.D. | Simulation Engineer

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Education

Ph.D., Mechanical Engineering / Computer Science

Drexel University, Philadelphia, PA *September 2020 – December 2024*

Thesis: Multiscale Structural Optimization through Second-order Homogenization and Machine Learning

B.S./M.S., Mechanical Engineering

Drexel University, Philadelphia, PA *September 2016 – June 2020*

Areas of Interest

Computational Mechanics
- Multiscale solid mechanics
- Topology optimization

Machine Learning
- Physics-informed machine learning
- Multi-fidelity data analysis

Research Experience

Pasteur Labs | Scientific ML Startup Denver, CO

Simulation R&D Engineer *January 2025 – Present*

- Automated data generation workflows for CFD, computational mechanics, and multiphysics data generation that accelerated the training of ML surrogate models
- Designed a data generation API that connects existing CAE modeling frameworks, enabling surrogate modeling training on data from Ansys, Siemens, and open-source software
- Designed and programmed differentiable interfaces to perform structural optimization of pre-trained ML surrogates in aerospace applications (Python/PyTorch)

Drexel University | GAANN Fellowship Philadelphia, PA

Graduate Research Assistant *September 2020 – January 2025*

- Developed high-performance finite-element models for multiscale design optimization (C^{++}/PETSc)
- Investigated novel methods of Machine Learning (ML) for physics-informed simulation (C^{++}/Python/PyTorch)
- Integrated ML techniques to design nature-inspired metamaterials with tailorable physical properties

Lawrence-Livermore Nat. Lab. | Center for Design Optimization Livermore, CA

NSF PhD INTERN *January 2024 – May 2024*

- Implemented parallel solvers for mixed finite element methods in a high-performance computing environment (C^{++})
- Developed nonlinear finite element programs for hyperelastic, hierarchical materials for applications in structural optimization

Select Publications

Black, Nolan and Najafi, Ahmad R. (2024), *Stress-constrained optimization of multiscale structures with parameterized microarchitectures using machine learning*. Struct. Multidiscip. Optim., 10.1007/s00158-024-03821-y.

Black, Nolan and Najafi, Ahmad R. (2023), *Deep neural networks for parameterized homogenization in concurrent multiscale structural optimization*. Struct. Multidiscip. Optim., 10.1007/s00158-022-03471-y.

Black, Nolan and Najafi, Ahmad R. (2022), *Learning finite element convergence with the Multi-fidelity Graph Neural Network*. Comput. Methods Appl. Mech. Eng., 10.1016/j.cma.2022.115120.

Black, Nolan and Najafi, Ahmad R., *Second-order homogenization in multiscale structural optimization*. Manuscript under peer review.

Black, Nolan and Najafi, Ahmad R., *Neural networks for nonlinear homogenization in multiscale structural optimization*. Manuscript under peer review.

Select Conference Presentations

Black, Nolan and Najafi, Ahmad R., "Multiscale structural optimization with strain gradient effects using second order homogenizatio ". World Congress on Computational Mechanics (WCCM2024), Vancouver, BC, July 21-26, 2024.

Black, Nolan and Najafi, Ahmad R., "Second-order Homogenization for Structural Optimization Applications". Engineering Mechanics Institute Conference 2024 (EMI2024), Chicago, IL, May 28-31, 2024.

Black, Nolan and Najafi, Ahmad R., "Multiscale Design Optimization with Local Failure Criteria through Machine Learning". 17th U.S. National Congress on Computational Mechanics (USNCCM17), Albuquerque, NM, July 23-27, 2023.

Black, Nolan and Najafi, Ahmad R., "Neural Network Surrogates for Multiscale Structural Optimization". 2022 International Mechanical Engineering Congress and Exposition (IMECE 2022), Columbus, OH, Oct. 30 – Nov. 02, 2022.

Black, Nolan and Najafi, Ahmad R., "Multi-Fidelity Graph Neural Networks as Surrogate Models for Finite Element Analysis". 19th U.S. National Congress on Theoretical and Applied Mechanics (USNCTAM19), Austin, TX, June 19-24, 2022.

Black, Nolan and Najafi, Ahmad R., "Deep Learning in Concurrent Multiscale Structural Optimization". 19th U.S. National Congress on Theoretical and Applied Mechanics (USNCTAM19), Austin, TX, June 19-24, 2022.

Black, Nolan and Najafi, Ahmad R., "Incorporating Architected Materials in Multiscale Structural Optimization with Deep Learning". Engineering Mechanics Institute Conference 2022 (EMI2022), Baltimore, MD, May 31-June 3, 2022.

Scholarships, Fellowships, and Honors

- NSF Non-academic Research Internship (INTERN) Award (2024)
- Koerner Family Foundation Fellowship (2022)
- Harry L. Brown, Jr. Memorial Fellowship (2021)
- Fellow, U.S. E.D. Graduate Assistance in Areas of National Need (2020-Present)
- A.J. Drexel Scholarship, Drexel University (2016–2020)

Professional Affiliations and Service

- Student Representative, Graduate Studies Committee, Drexel University (2022–2023)
- Entrepreneurial Lead, NSF I-Corp (2022–2023)
- Member, The American Society of Mechanical Engineers (2016–Present)

Teaching and Mentorship

MEM592
Applied Engineering Analytical & Numerical Methods II, Drexel University
Co-teacher and Teaching Assistant

Graduate Research Mentor
Drexel University
Served as primary mentor for one M.S. thesis.

Undergraduate Research Mentor
Drexel University
Served as primary mentor for three undergraduate researchers.

Professional Experience

Zimmer Biomet | Zimmer Knee Creations R&D — Exton, PA
Development Engineering Coop — *April 2019 – April 2020*

- Developed functional medical devices using rapid prototyping to perform orthopedic procedures on the hand and wrist
- Established design criteria to meet surgeon input and verified design features in cadaveric lab testing
- Adapted, tested, and re-validated existing products to meet new standards of quality based on risk management
- Prepared and executed test protocols to analyze new product aging, transit, and functional capabilities

NAVSEA | Department of the Navy — Philadelphia, PA
Entry-level Engineer — *April 2017 – September 2018*

- Drafted procedures and diagrams for US Navy shipboard engineering systems
- Coordinated small-team projects to overhaul procedures and diagrams, thereby increasing operating efficiency
- Communicated objectives with ship's force onboard Nimitz-class carriers, LCU, and Arleigh Burke destroyers