AMIN HEYRANI NOBARI

GitHub | Google Scholar | Website
Email: ahnobari@mit.edu | Phone Number: (617)-949-1017
Department of Mechanical Engineering
Massachusetts Institute of Technology

Research Vision

I work at the intersection of AI, optimization, and engineering design, where I develop principled, precise, and computationally efficient models that **integrate deep learning with the mathematical and physical foundations of engineering**. My research spans kinematic design, CAD, numerical simulation, and structural and physics-based optimization, with a focus on building general-purpose AI systems that remain grounded in scientific theory. I have introduced foundational embeddings for solving previously intractable inverse problems, created large-scale open-source datasets and GPU-accelerated simulation platforms for topology optimization and mechanism design, and developed deep-learning architectures that generalize across geometric domains, resolutions, and boundary conditions. Together, these contributions form the basis for my long-term vision: **Engineering Foundation Models rooted** in physical law and principles; models capable of accelerating scientific discovery, transforming computational engineering practice, and enabling new modes of design across robotics, CAD, and engineering physics.

Education

PhD in Mechanical Engineering | Massachusetts Institute of Techonology 2022–2026
GPA: 5.0/5.0
Thesis Title:
Generative Optimization In Engineering Design: Addressing Precision In Generative AI For Engineering Design
Thesis Committee: Prof. Faez Ahmed (MIT), Prof. John Joseph Leonard (MIT), Prof. Daniel Frey (MIT), Dr. David Cox (Director of IBM Watson AI Lab)

MSc in Mechanical Engineering | Massachusetts Institute of Techonology 2020–2022
GPA: 5.0/5.0
Thesis Title: Generative Adversarial Networks for Inverse Design Problems in Engineering

BSc in Mechanical Engineering | University of Toronto 2016–2020
GPA: 3.97/4.0
Graduated with High Honors

Research & Professional Experience

Research Assistant 2020–Present
MIT DeCoDE Lab **Advisor**: Faez Ahmed

Lead projects and colleagues in the development of a vast array of research topics. These include building entire open-source platforms for GPU-accelerated simulation, FEA, and topology optimization, open-source efforts for massive engineering datasets, building and training AI foundation models for engineering design, physics-based optimization, and CAD geometry generation and processing. These works culminated in publications in highly respected computer-science and engineering design venues (two NeurIPS papers,

two TMLR papers, four papers in the Journal of Mechanical Design, one paper in KDD, and four papers in IDETC)

Undergraduate Research Assistant 2018–2020
University of Toronto Multiphase Flow and Spray Systems Laboratory (MUSSL) **Advisor**: Nasser Ashgriz

Developed multiple experimental setups for sprays, supersonic jets, multi-phase fluid interactions, and created the first dataset of high-resolution spray images and trained the first machine learning model to predict spray characteristics and upstream pressure of fluid using visual signals from cameras in a spray chamber. Moreover, I worked with experts to develop schlieren photography setups for supersonic jets, experimental setups for microscopic high-speed imaging of ultrasonic atomizers using custom microcontroller code for lighting and capturing images, pressure, and other sensor readings with nanosecond accuracy.

Design Engineer Intern 2018–2020
MazLite **Mentor**: Amirreza Amighi

Worked with the design team to develop high-precision designs for explosion-proof imaging of spray systems, including designing high-precision custom Lens systems, microcontroller programming for high-accuracy image capturing, and controlling lighting alignment and image processing. Also worked with the software team to develop the user interface for interacting with the hardware and displaying statistics and visual data from the spray-imaging device.

Teaching Experience

AI & ML for Engineering Design, Teaching Staff Fall 2022 | 2023 | 2024 | 2025

Helped the development of a new graduate-level course and the design and continual refinement of the course material over four years, developing challenge problem assignments that are open-ended exploratory problems that enabled students to engage deeply with the material through self-guided discovery. Developed interactive demos for course material to help students gain practical experience with the theoretical concepts taught in the class. Over four years, I mentored students individually and in teams, helping them build intuition and critical thinking skills for the course material, ultimately leading to advancements in their research and course projects, some of whom went on to publish these works.

Selected Research

Foundation Models For Physics-Based Optimization NeurIPS 2025

In this work, I introduce one of the first general-purpose foundation models for structural topology optimization, capable of operating across arbitrary shapes, resolutions, and boundary conditions. Built on neural implicit fields and physics-informed generative optimization, the model learns to generalize beyond fixed geometries and replaces conventional solvers with fast, resolution-free inference, yielding major speed and quality improvements over classical methods. This contribution establishes a foundational step toward foundation models for physics-based PDE-driven optimization.

Activation Informed Merging of Large Language Models NeurIPS 2025

In collaboration with IBM and Red Hat AI Research, I led this research to propose activation-informed merging, a computationally cheap technique for combining multiple expert agents by aligning them in activation

and weight space using continual-learning principles. Unlike naïve parameter averaging, this method preserves the base model's general knowledge while integrating expert capabilities, producing merged models that outperform all constituent agents (e.g., CAD and spatial-reasoning experts combine to improve performance on CAD generation).

Combinatorial Optimization Through Foundational Embeddings TMLR 2024

In this work, I tackle the previously intractable problem of path synthesis for mechanical linkages, where the design space spans $\approx 10^{57}$ possible mechanism skeletons and highly discontinuous feasibility landscapes. By training foundational embeddings on 100 million synthetic mechanisms and integrating them with an interior-point search, the method reduces combinatorial search to milliseconds, enabling high-precision (3 orders of magnitude more accurate than optimization or other deep-learning approaches) mechanism design in under 15 seconds compared to days of optimization. This framework represents a new class of AI-accelerated mixed-variable optimization, tackling problems that were previously considered unsolvable in classical design optimization.

CAD Modelling Using LLM and VLM Foundation Models Best Paper at IDETC 2025

This research introduces CAD-Coder, a vision–language agent capable of generating precise 3D CAD models directly from images through sequential CAD code synthesis. Unlike mesh- or point-cloud–based 3D methods, CAD-Coder operates natively in the parametric CAD domain, allowing exact geometric reconstruction while preserving engineering intent and editability. The work establishes a new paradigm for AI-driven precision geometry, earning the IDETC 2025 Best Paper Award.

Awards & Honors

Natural Sciences and Engineering Research Council of Canada Graduate Fellow 2022–2025
Fellowship Value: $40,000/year for 3 years

Best Paper Award 2025
IDETC Conference 2025

Wunsch Foundation Silent Hoist and Crane Award for Outstanding Graduate Research 2025
Massachusetts Institute of Technology Department of Mechanical Engineering

Mathworks Fellow 2024
Fellowship Value: $100,000

Mathworks Fellow 2023
Fellowship Value: $100,000

Mathworks Fellow 2022
Fellowship Value: $100,000

Otto Holden Scholarship 2020
University of Toronto

Wallace G. Chalmers Engineering Design Scholarship 2019
University of Toronto

Chester B. Hamilton Scholarship 2019
University of Toronto

University of Toronto Excellence Research Grant 2019
University of Toronto

Shell Canada Limited Awards 2018
University of Toronto

NSERC Undergraduate Research Grant 2018
University of Toronto
Walberg Undergraduate Scholarship 2017
University of Toronto
J.J. McAllister Foundation Award 2016
University of Toronto

Complete List of Publications

Journal & Computer Science Conference Publications

Nobari, A. H., Alim, K., ArjomandBigdeli, A., Srivastava, A., Ahmed, F., & Azizan, N. (2025). Activation-informed merging of large language models. *The Thirty-ninth Annual Conference on Neural Information Processing Systems*. https://openreview.net/forum?id=T4qJuQCFAK

Nobari, A. H., Regenwetter, L., Giannone, G., & Ahmed, F. (2025). NITO: Neural implicit fields for resolution-free and domain-adaptable topology optimization. *Transactions on Machine Learning Research*. https://openreview.net/forum?id=XHXAvACdgv

Nobari, A. H., Regenwetter, L., Picard, C., Han, L., & Ahmed, F. (2025). Optimize any topology: A foundation model for shape- and resolution-free structural topology optimization. *The Thirty-ninth Annual Conference on Neural Information Processing Systems*. https://openreview.net/forum?id=eD0lYGQKn0

Heyrani Nobari, A., Rey, J., Kodali, S., Jones, M., & Ahmed, F. (2024). Meshpointnet: 3d surface classification using graph neural networks and conformal predictions on mesh-based representations. *Journal of Mechanical Design*, *146*(5), 051712. https://doi.org/10.1115/1.4064673

Nobari, A. H., Srivastava, A., Gutfreund, D., Xu, K., & Ahmed, F. (2024). LInk: Learning joint representations of design and performance spaces through contrastive learning for mechanism synthesis. *Transactions on Machine Learning Research*. https://openreview.net/forum?id=a1MRjOL6WJ

Regenwetter, L., Nobari, A. H., & Ahmed, F. (2022). Deep generative models in engineering design: A review. *Journal of Mechanical Design*, *144*(7), 071704. https://doi.org/10.1115/1.4053859

Heyrani Nobari, A., Chen, W., & Ahmed, F. (2021). Pcdgan: A continuous conditional diverse generative adversarial network for inverse design. *Proceedings of the 27th ACM SIGKDD Conference on Knowledge Discovery & Data Mining*, 606–616. https://doi.org/10.1145/3447548.3467414

Nobari, A. H., Chen, W., & Ahmed, F. (2021). Range-constrained generative adversarial network: Design synthesis under constraints using conditional generative adversarial networks. *Journal of Mechanical Design*, *144*(2), 021708. https://doi.org/10.1115/1.4052442

Tahadjodi Langroudi, A., Zare Afifi, F., Heyrani Nobari, A., & Najafi, A. (2020). Modeling and numerical investigation on multi-objective design improvement of a novel cross-flow lift-based turbine for in-pipe hydro energy harvesting applications. *Energy Conversion and Management*, *203*, 112233. https://doi.org/https://doi.org/10.1016/j.enconman.2019.112233

Peer-Reviewed Conference Publications

Doris, A. C., Alam, M. F., Nobari, A. H., & Ahmed, F. (2025). Cad-coder: An open-source vision-language model for computer-aided design code generation. *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*, *51st Design Automation Conference (DAC)*.

Heyrani Nobari, A., Regenwetter, L., & Ahmed, F. (2024). Towards domain-adaptive, resolution-free 3d topology optimization with neural implicit fields. *International Design Engineering Technical Conferences and*

Computers and Information in Engineering Conference, *Volume 3A: 50th Design Automation Conference (DAC)*, V03AT03A012. https://doi.org/10.1115/DETC2024-142135

Heyrani Nobari, A., Srivastava, A., Gutfreund, D., & Ahmed, F. (2022). Links: A dataset of a hundred million planar linkage mechanisms for data-driven kinematic design. *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*, *Volume 3A: 48th Design Automation Conference (DAC)*, V03AT03A013. https://doi.org/10.1115/DETC2022-89798

Heyrani Nobari, A., Rashad, M. F., & Ahmed, F. (2021). Creativegan: Editing generative adversarial networks for creative design synthesis. *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*, *Volume 3A: 47th Design Automation Conference (DAC)*, V03AT03A002. https://doi.org/10.1115/DETC2021-68103

Nobari, A. H., Khorasani-Gerdehkouhi, F., Gulam, N., & Ashgriz, N. (2020). Application of deep learning convolutional neural network for spray characterization. *Proceedings of the 7th international conference on fluid flow, heat and mass transfer (FFHMT'20)*.

Pre-Print & Under Review

Nobari, A. H., & Ahmed, F. (2025). Pgd-to: A scalable alternative to mma using projected gradient descent for multi-constraint topology optimization. https://arxiv.org/abs/2511.13905

Picard, C., Regenwetter, L., Nobari, A. H., Srivastava, A., & Ahmed, F. (2024). Generative optimization: A perspective on ai-enhanced problem solving in engineering. https://arxiv.org/abs/2412.13281

Regenwetter, L., Obaideh, Y. A., Nobari, A. H., & Ahmed, F. (2024). Biked++: A multimodal dataset of 1.4 million bicycle image and parametric cad designs. https://arxiv.org/abs/2402.05301

Invited Talks

Foundation Models In Engineering talk at the invited talk at the From Data to Design workshop workshop — ASME IDETC 2025

Activation Informed Merging talk for the RedHat AI Innovation Seminar Series — April 2025

Deep Learning & Topology Optimization Guest lecture for *1.583 Topology Optimization of Structures* course at MIT — Fall 2024

Generative Optimization talk at the From Data to Design workshop — ASME IDETC 2024

Presnted **Foundational Embedding Combinatorial Optimization** for an invited presentation at the MIT-IBM investors demo — 2024

Presented and displayed physical prototype of linkage mechanism tracing IBM at the MIT-IBM Office — 2023

Services

Journal reviewer for ASME Journal of Mechanical Design (JMD)
Conference reviewer for Conference on Computer Vision and Pattern Recognition (CVPR)
Conference reviewer for ASME IDETC-CIE
Social Chair of the Persian Student Association at MIT

Related Programming Skill

Python | C++ | CUDA | MATLAB | HTML/CSS/JS | nodeJS

Selected Public Open-Source Repositories

PyFANTOM GitHub | Documentation

Open-source GPU-accelerated simulation and FEA python package that enables high-resolution topology optimization in 2D and 3D using custom matrix-free multigrid CUDA kernels as well as custom fast kernels for unstructured meshes, dramatically speeding up design iteration and enabling research-scale experiments that were previously computationally prohibitive and required recompiling code for different boundary conditions.

LInK & LINKS GitHub | Web Based Simulator/Game

Interactive mechanism design engine + web-UI for exploring massive design spaces: transforms combinatorially intractable linkage search into an efficient, user-friendly environment for rapid prototyping and design exploration.

Optimize Any Topology & OpenTO GitHub | HuggingFace

Versatile topology-optimization framework that supports arbitrary geometries and boundary conditions; serves as a reusable backbone for physics-informed AI design experiments and accelerates convergence compared to traditional solvers. Checkpoints dataset and code all publicly made available.

References

Faez Ahmed
Associate Professor of Mechanical Engineering & Doherty Chair in Ocean Utilization
Department of Mechanical Engineering
Massachusetts Institute of Technology
Email: faez@mit.edu

Akash Srivastava
Director and Chief Architect of Core AI (IBM) | Founder of Red Hat AI Innovation Team
IBM | Red Hat
Email: akash@redhat.com | akash.srivastava@ibm.com

Navid Azizan
Alfred Henry (1929) and Jean Morrison Hayes Career Development Professor
Laboratory for Information & Decision Systems
Massachusetts Institute of Technology
Email: azizan@mit.edu

Wei Chen
Assistant Professor
Department of Mechanical Engineering
Texas A&M University
Email: w.chen@tamu.edu