MD FERDOUS ALAM

Website ◇ Google scholar ◇ LinkedIn ◇ Github
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Department of Mechanical Engineering ◇ Massachusetts Institute of Technology

RESEARCH INTERESTS

My core vision is to build the next generation of design and manufacturing automation by taking a synergistic software-hardware approach. I envision a universal design and manufacturing operating system that employs AI systems at its core for intelligent digital design, robotic manufacturing and process control. During my PhD and continuing thereafter, I have been working towards this vision by developing novel AI algorithms for generative 3D Computer-Aided Design and robotic manufacturing. A significant focus of my research also includes real-time systems integration of AI-software with novel manufacturing hardware. I have shown one of the first successful deployments of real-time AI-assisted process control in a custom-built additive manufacturing system. The algorithms that I have developed can learn to manufacture complex 3D metamaterial while requiring 10x less data samples than traditional approaches.

Currently, I am a post-doc at MIT MechE exploring generative AI for computational design and engineering. Recently, I earned my Ph.D. from the Ohio State University where I worked on intelligent robotic manufacturing systems and generative computational design. Previously, I also worked as a research intern and later a research collaborator at the Autodesk AI Lab on generative 3D design. My core expertise includes generative AI, representation learning/reinforcement learning, robotics and AI software integration in manufacturing hardware.

RESEARCH AND PROFESSIONAL EXPERIENCE

Massachusetts Institute of Technology (MIT) *05/2023 - present*
Postdoctotal Associate, Department of Mechanical Engineering *Advisor: Faez Ahmed*

- Research: Lead personnel on several projects spanning Generative AI models for advanced design and engineering, representation learning of 3D data (CAD), manufacturability in design and large language models for the design and manufacturing domain
- Supervision: Ph.D. and undergraduate students

The Ohio State University *08/2018 - 05/2023*
Graduate Research and Teaching Associate *Advisor: David J. Hoelzle*

- Research: Lead personnel in the development and deployment of novel reinforcement learning algorithms for autonomous design and manufacturing systems for real-time decision making, development of theoretical and empirical foundations of transfer learning for high dimensional robot learning tasks.
- Supervision: Graduate and undergraduate students

AI Lab, Autodesk Inc. *05/2022 - 05/2023*
Research intern and collaborator *Mentor: Rodger Luo*

- Research: Lead personnel in developing AI models for learning representations of 3D volumetric design tasks and sequential generative design, led collaboration efforts with multiple researchers across several industry research labs

Shahjalal University of Science and Technology (SUST), Bangladesh *03/2016 - 07/2018*
Lecturer

- Role: Instructor of several undergraduate classes in mechanical engineering, developed courses in engineering design, programming and electronics

EDUCATION

Ph.D. in Mechanical Engineering *8/2018 - 5/2023*
The Ohio State University, Columbus, OH Advisor: David J. Hoelzle
Focus: Intelligent robotic manufacturing and generative computational design

M.S. in Mechanical Engineering *8/2018 - 12/2021*
The Ohio State University, Columbus, OH Advisor: David J. Hoelzle
Focus: Intelligent robotic manufacturing and generative computational design

B.Sc. in Mechanical Engineering *5/2010 - 9/2015*
Bangladesh University of Engineering and Technology, Bangladesh Advisor: Md. Ashiqur Rahman
Focus: Design for sustainability

DISSERTATION

Md Ferdous Alam. "Efficient Sequential Decision Making in Design, Manufacturing and Robotics." Doctoral dissertation, Ohio State University, 2023.

JOURNAL PUBLICATIONS

[J1] **Md Ferdous Alam**, Faez Ahmed, "GenCAD: Image-Conditioned Computer-Aided Design Generation with Transformer-Based Contrastive Representation and Diffusion Priors", *Transaction on Machine Learning Research (TMLR)*, 2024 (under review) Paper Website

[J2] **Md Ferdous Alam**, Sarp Sezer, Zhi Zhang, Max Shtein, Kira Barton & David J. Hoelzle, "Reinforcement learning for autonomous manufacturing systems", *Nature Machine Intelligence* (to be submitted) Code

[J3] Cyril Picard, Kristen Edwards, Annie C. Doris, Brandon Man, Giorgio Giannone, **Md Ferdous Alam**, Faez Ahmed, "From Concept to Manufacturing: Evaluating Vision-Language Models for Engineering Design", (under review), 2023 Paper video

[J4] **Md Ferdous Alam**, Parinaz Naghizadeh & David J. Hoelzle, "Advantage-based policy transfer with metrics of transferability for Reinforcement Learning", *Transaction on Machine Learning Research (TMLR)*, 2024 (under review) Paper Code Website

[J5] **Md Ferdous Alam**, Yi Wang, Chin-Yi Cheng & Rodger Luo, "Representation learning for sequential volumetric design tasks", *Journal of Mechanical Design*, 2024 Paper Website

[J6] Anna C Doris, Daniele Grandi, Ryan Tomich, Md Ferdous Alam, Hyunmin Cheong & Faez Ahmed, "DesignQA: A Multimodal Benchmark for Evaluating Large Language Models' Understanding of Engineering Documentation", *Journal of Computing and Information Science in Engineering (JCISE)*, 2024 Paper

[J7] **Md Ferdous Alam***, Austin Lentsch*, Nomi Yu, Sylvia Barmack, Suhin Kim, Daron Acemoglu, John Hart, Simon Johnson, Faez Ahmed, "From automation to augmentation: policy and practice to redefine engineering design and manufacturing in the age of nextgen-ai", MIT Press, 2023 Paper

[J8] Zhi Zhang, Antony George, **Md Ferdous Alam**, Chris Eubel, Chaitanya Krishna Prasad Vallabh, Max Shtein, Kira Barton, David Hoelzle, "Autonomous manufacturing testbed to evaluate machine learning algorithm performance", ASME Journal of Manufacturing Science and Engineering (JMSE), 2023 Paper

[J9] **Md Ferdous Alam**, Max Shtein, Kira Barton & David J. Hoelzle, "Reinforcement learning enabled autonomous manufacturing using transfer learning and probabilistic reward modeling", in IEEE Control Systems Letters (L-CSS) Paper

JOURNAL STYLE CONFERENCE PUBLICATIONS (PEER-REVIEWED)

[C1] Anna C Doris, Daniele Grandi, Ryan Tomich, **Md Ferdous Alam**, Hyunmin Cheong & Faez Ahmed, DesignQA: Benchmarking Multimodal Large Language Models on Questions Grounded in Engineering Documentation", in ASME IDETC 2024

[C2] **Md Ferdous Alam**, Max Shtein, Kira Barton & David J. Hoelzle, "Reinforcement learning enabled autonomous manufacturing using transfer learning and probabilistic reward modeling", in IEEE Conference on Decision and Control (CDC), 2022, Paper

[C3] **Md Ferdous Alam**, Max Shtein, Kira Barton & David J. Hoelzle, "Sample efficient transfer in reinforcement learning for high variable cost environments with an inaccurate source reward model", in American Control Conference (ACC), 2022 **(Invited paper)** Paper Code

[C4] **Md Ferdous Alam**, Max Shtein, Kira Barton & David J. Hoelzle, "A physics guided reinforcement learning framework for an autonomous manufacturing system", American Control Conference (ACC), 2021, Paper Code

[C5] **Md Ferdous Alam**, Max Shtein, Kira Barton & David J. Hoelzle, "Autonomous Manufacturing Using Machine Learning: A Computational Case Study With a Limited Manufacturing Budget", in Manufacturing Science and Engineering Conference (MSEC), 2020 **[Best paper award]**, Paper

ABSTRACTS

[A1] **Md Ferdous Alam** & Faez Ahmed, "On the Use of Diffusion Models for Image-Conditional Computer-Aided Design", ASME IDETC, 2024

[A2] **Md Ferdous Alam**, Max Shtein, Kira Barton & David J. Hoelzle, "Incorporating Physics Based Knowledge in Manufacturing Decision Making via Transfer Reinforcement Learning", INFORMS annual meeting, 2022 (**invited presentation**)

TEACHING EXPERIENCE

Teaching Staff *09/2023 - 11/2024*
Massachusetts Institute of Technology

- 2.155/2.156: Artificial Intelligence and Machine Learning for Engineering Design — Fall 2023
  Role: Office hours, grading, project mentoring, designing assignments
  Nmber of students: 70

Graduate Teaching Associate *08/2022 - 12/2022*
The Ohio State University

- MEE 3751: Kinematics and Mechanism Design — Fall 2022
  Role: Recitation, grading, proctoring exams
  Number of students: 200
- MEE 3760: Design and Analysis of Machine Elements — Fall 2022
  Role: Recitation, grading
  Nmber of students: 200

Lecturer *03/2016 - 08/2018*
Shahjalal University of Science and Technology, Bangladesh *Medium of instruction: English*

- MEE 128: Programming methodology for mechanical engineering — Spring 2018
  Role: course developer, instructor
- MEE 124: Mechanical engineering drawing — Spring 2017, Spring 2018
  Role: course developer, instructor
- MEE 121: Introduction to Mechanical Engineering — Fall 2016, Fall 2017
  Role: course developer, instructor

GRANTS

[1] "MechTool-LLM: Integrating Large Language Models with Engineering Tools for Advanced Mechanical Engineering, Google research scholar award in applied science, amount: $\$75k$ (awarded)

PI: Faez Ahmed (MIT Mechanical Engineering)

Role: Co-Principal Investigator (Co-PI)

[2] "From Automation to Augmentation: Redefining Engineering Design and Manufacturing in the Age of NextGen AI", MIT's call for proposal in the broad domain of generative AI, amount: $\$70k$ (awarded)

PIs: Faez Ahmed (MIT Mechanical Engineering), Simon Johnson (MIT Sloan), John Hart (MIT Mechanical Engineering), Daron Acemoglu (MIT Economics)

Role: supporting co-author

AWARDS AND RECOGNITIONS

- I received the Google Research Scholar Award in applied science in 2024
- My research was focused on the plenary talk by Prof. Barton at CDC 2022 in the talk 'How Do We Learn to Use Learning in Manufacturing Systems'
- I was awarded the student travel grant for the Conference on Decision and Control (CDC), 2022
- I was awarded the student travel grant for the American Control Conference (ACC), 2022
- I achieved 3rd place in the 3-minute thesis competition at MAE department, OSU, 2021
- I was awarded the student travel grant for American Control Conference (ACC), 2021
- I was featured in the MAE department news board, 2021
- I received the **Best paper award** in Manufacturing Science and Engineering Conference (MSEC), 2020
- I received the Dean's List Scholarship for undergraduate academic excellence at Bangladesh University of Engineering and Technology, 2010

INVITED PRESENTATIONS

- "The role of representation in AI for design", invited talk in the Data2Design workshop, ASME IDETC-CIE, Washington DC, 2024
- "Towards intelligent CAD system: Generative models for CAD", invited talk in the OnShape CAD Informatics workshop, ASME IDETC-CIE, Washington DC, 2024
- "On the opportunities and challenges of generative AI", invited talk in the Digital Enterprise Transformation in the Age of Artificial Intelligence seminar at CFA Columbus, 2023
- "Artificial Intelligence for generative design and digital manufacturing systems", invited talk in the Department of Mechanical and Aerospace Engineering at New York University (Tandon), 2024
- "Incorporating Physics Based Knowledge in Manufacturing Decision Making via Transfer Reinforcement Learning", invited presentation in the Physics-based ML approach for materials and manufacturing systems session at INFORMS annual meeting, 2022
- "Machine learning driven autonomous design and manufacturing", invited presentation at the Intel pathfinding team, 2022
- "State-of-the-art in learning algorithms", invited presentation in the Department of Mechanical Engineering at SUST, 2019

ADVISING AND MENTORSHIP

Student	Mentoring institution	Current affiliation
Nomi Wu	PhD student, MIT	PhD student, MIT
Annie Clare Doris	PhD student, MIT	PhD student, MIT
Eddie Qiao	EECS freshman, MIT	EECS freshman, MIT
Sarp Sezer	MAE senior, OSU	Aerospace engineer, Boeing
Chris Eubel	MAE senior, OSU	Robotics engineer, Path robotics
Christina Duong	CSE sophomore, OSU	CSE senior, OSU
A K M Ashikuzzaman	ME senior, SUST	PhD student, University of Minnesota

SERVICES

Journal Reviewer

- IEEE Transaction on automatic control (TAC), Mechatronics (Elsevier), Journal of Dynamic Systems, Measurement and Control, ASME Journal of Mechanical Design (JMD)

Conference Reviewer

- Conference on decision and control (CDC), American Control Conference (ACC), IEEE Conference on Control Technology and Applications (CCTA), North American Manufacturing Research Conference (NAMRC), Manufacturing Science and Engineering Conference (MSEC), IEEE/CVF Winter Conference on Applications of Computer Vision (WACV)

Affiliation

- Institute of Electrical and Electronics Engineers (IEEE), American Society of Mechanical Engineers (ASME), INFORMS

Mechanical Engineering Graduate student Association *08/2021 - 05/2022*
Vice President

CODES

Autonomous manufacturing robot *08/2018 - Present*
Language: Python, MATLAB, Tools used: scikit-learn, Pytorch, LABVIEW, git

- Implementation of sequential decision making algorithms in a custom manufacturing research bot

Deconstructed ML *08/2018 - Present*
Language: Python, Tools used: scikit-learn, Pytorch, OpenAI Gym, Robosuite

- Modular implementation of statistical machine learning algorithms and state-of-the-art deep learning algorithms for tutorial purposes i.e. MLP, CNN, LSTM, GAN, Transformer
- Modular implementation of state-of-the-art reinforcement learning algorithms i.e. DQN, PPO, DDPG, SAC

Representation learning for sequential 3D designs *05/2022 - Present*
PyTorch, python, AWS, Flask, git

- Code base for highly modular transformer models from scratch using PyTorch
- Transformer based auto-encoder for extracting latent dimension of sequential 3D designs
- Developed pipeline for creating novel dataset of sequential 3D designs
- Modular code for training transformer in AWS and visualization of 3D designs in browser based server application

FACULTY TRAINING

Future Academic Scholars Training I for MAE Fall 2022
The Ohio State University

- Taught undergraduate control class for OSU faculty members as a mock class
- Focused on pedagogy and engineering education in the USA undergraduate classroom

Future Academic Scholars Training II for MAE Spring 2023
The Ohio State University

- Wrote grant proposal as part of the training for a successful academic position in a research university
- Focused on various funding opportunities in the USA including government agencies, national labs and industries