MD FERDOUS ALAM

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Department of Mechanical Engineering ◇ Massachusetts Institute of Technology

RESEARCH INTERESTS

My core research interests span artificial intelligence (AI), machine learning (ML), deep learning, and control theory for decision-making in complex systems. My research vision is to build AI-assisted generative design tools for complex tasks, smart manufacturing systems for increased productivity, and autonomous manufacturing robots for high-dimensional unstructured tasks. To achieve this vision, I am focusing on developing efficient AI/ML algorithms with systems integration.

Currently, I am a post-doc at MIT MechE and working on AI for algorithmic/generative design of CAD models and digital manufacturing. During my Ph.D., I developed data-efficient reinforcement learning algorithms using knowledge transfer between tasks and probabilistic reward modeling. I, along with my team members, built a state-of-the-art autonomous manufacturing robot that can make decisions in real-time to design and manufacture a complex geometry 3D artifact without any human intervention and require 10× fewer data samples than traditional approaches. During my research internship at the Autodesk AI Lab, I developed transformer-based representation learning and autoregressive generative models for computational 3D design tasks.

RESEARCH AND PROFESSIONAL EXPERIENCE

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

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

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

- Role: 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 of undergraduate students.

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

- Role: Lead personnel in developing AI models for learning representations of high dimensional volumetric design tasks and sequential generative design, worked in collaboration with multiple researchers across several industries

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: AI/ML for design, manufacturing, robotics

M.S. in Mechanical Engineering *8/2018 - 12/2021*
The Ohio State University, Columbus, OH Advisor: David J. Hoelzle
Focus: AI/ML for design, manufacturing, robotics

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

DISSERTATION

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

PUBLICATIONS IN PREPARATION

[P1] **Md Ferdous Alam**, Faez Ahmed, "Learning complex edge operations in CAD from boundary representations."

JOURNAL PUBLICATIONS

[J1] **Md Ferdous Alam**, Faez Ahmed, "Image conditional computer-aided design" (to be submitted)

[J2] **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, 2024

[J3] Cyril Picard, Kristen Edwards, Annie C. Doris, **Md Ferdous Alam**, Brandon Man, Giorgio Giannone, Faez Ahmed, "From Concept to Manufacturing: Evaluating Vision-Language Models for Engineering Design (Part 2)" *Journal of Mechanical Design* (under review) arXiv/Preprint

[J4] Kristen Edwards, Cyril Picard, Annie C. Doris, Brandon Man, Giorgio Giannone, **Md Ferdous Alam**, Faez Ahmed, "From Concept to Manufacturing: Evaluating Vision-Language Models for Engineering Design (Part 1)" *Journal of Mechanical Design* (under review) arXiv/Preprint

[J5] **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)*, 2023 (under review) arXiv/Preprint Code Website

[J6] **Md Ferdous Alam**, Yi Wang, Chin-Yi Cheng, Linh Tran & Rodger Luo, "Representation learning for sequential volumetric design tasks", *Journal of Mechanical Design*, 2023 (under review) arXiv/Preprint Website

[J7] **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

[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] Designqa: A Multimodal Benchmark for Evaluating Large Language Models' Understanding of Engineering Documentation, Anna Doris, Daniele Grandi, Ryan Tomich, **Md Ferdous Alam**, Hyunmin Cheong, Faez Ahmed, in IDETC/CIE 2024, Paper

[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/PRESENTATIONS

[N1] **Md Ferdous Alam**, Faez Ahmed, "On the Use of Diffusion Models for Image-Conditional Computer-Aided Design", IDETC/CIE, 2024

[N2] Kristen M. Edwards, Cyril Picard, Anna C. Doris, Giorgio Giannone, **Md Ferdous Alam**, Brandon Man, Faez Ahmed, "Vision Language Models for Engineering Design and Manufacturing", IDETC/CIE, 2024

[N3] **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**)

GRANTS

[1] "A Domain-specific Large Language Model for Engineering Tasks", Google Research scholar program, amount: $60k **(awarded)**

PI: Faez Ahmed (MIT Mechanical Engineering)

Role: 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

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, project mentoring

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

- MEE 3751: Kinematics and Mechanism Design Fall 2022
  Role: Recitation, grading, proctoring exams

- MEE 3760: Design and Analysis of Machine Elements — Fall 2022
  Role: Recitation, grading

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

AWARDS AND RECOGNITIONS

- I have been awarded the Google Research Sholar Award 2024 in Applied Science
- My research was focused on the MIT Shaping the future of work initiative
- 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

- "Generative AI for design and manufacturing", MIT Shaping the work initiative, April 2024
- "Tutorial on Coding with LLMs", invited talk at LLM-MechE Tutorial for MechE faculties, Fall 2023
- "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
- "Efficient decision making in design, manufacturing and robotics", invited talk in the School of Mechanical, Aerospace, and Materials Engineering at Southern Illinois University, Carbondale, 2023
- "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

SERVICES

Journal Reviewer

- IEEE Transaction on automatic control (TAC), Mechatronics (Elsevier), Journal of Dynamic Systems, Measurement and Control, 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), European Conference on Computer Vision (ECCV), Journal of Mechanical Design (JMD)

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

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 junior, OSU
A K M Ashikuzzaman	ME senior, SUST	PhD student, University of Minnesota

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

REFERENCES

- **Faez Ahmed**
  Brit (1961) and Alex (1949) d'Arbeloff Career Development Professor in Engineering Design
  Department of Mechanical Engineering
  Massachusetts Institute of Technology
  contact information: upon request

- **David Hoelzle**
  Associate Professor of Mechanical and Aerospace Engineering
  The Ohio State University
  contact information: upon request

- **Kira Barton**
  Professor of Mechanical Engineering
  Professor of Robotics
  Miller Faculty Scholar
  University of Michigan
  contact information: upon request

- **Parinaz Naghizadeh**
  Assistant Professor
  Electrical and Computer Engineering & The Design Lab
  University of California, San Diego
  contact information: upon request