

Mutahar Safdar

PhD Candidate in Mechanical Engineering

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EDUCATION

Ph.D. in Mechanical Engineering

January 2021 – December 2025 (Expected)

McGill University, Montreal, Quebec, Canada

- **CGPA:** 3.850/4.000
- **Academic Advisors:** Prof. Yaoyao Fiona Zhao, Dr. Guy Lamouche
- **Thesis Title:** Toward machine learning assisted directed energy deposition of metal matrix composites
- **Highlights:** Quebec Research Fund (FRQ) Scholar, Graduate Mobility Award, Doctoral Internship Award, Heller Fellowship in Engineering, McGill Engineering Doctoral Award, Mitacs Accelerate Fellowship, Helmholtz Visiting Researcher Grant, ASME Best Paper Award, First Author International Journal Articles (x8), International Conference Papers (x3), Industrial AI Tools (x3), Book Brief (x1)

M.S. in Mechanical Engineering

February 2018 – February 2020

Korea Advanced Institute of Science and Technology (KAIST), Daejeon, South Korea

- **CGPA:** 3.750/4.300
- **Academic Advisor:** Prof. Soonhung Han
- **Thesis Title:** Point-based persistent identification of transition features for parametric CAD data exchange
- **Highlights:** Brain Korea Travel Award, TransCAD Software Patent, First Author International Journal Articles (x2), International Conference Paper (x1)

B.S. in Mechanical Engineering (with honors)

September 2013 – August 2017

University of Engineering and Technology (UET), Lahore, Punjab, Pakistan

- **CGPA:** 3.898/4.000
- **Academic Advisor:** Prof. Fiaz Hussain Shah
- **Thesis Title:** Design of steam turbine at supercritical pressure and temperature steam
- **Highlights:** Recognized 2nd Rank in Mechanical Engineering Batch, 8/8 Deans Honor Roll

RESEARCH EXPERIENCE

Doctoral Researcher at McGill University

January 2021 – August 2025

Additive Design and Manufacturing Laboratory (ADML) Mechanical Engineering Department

- Spearheaded end-to-end AI development of a 3+2 Canada-Germany joint research project entitled “AI-SLAM: Artificial Intelligence Sensing for Process Enhancement in Laser Additive Manufacturing”
- Designed industry-scale experiments to generate domain representative and machine learning worthy process data
- Developed data processing pipelines connecting raw sensor representations to processed and machine-learning-ready formats
- Investigated the potential of disparate sensing systems for machine learning based *in situ* micro-scale defect detection
- Investigated key spatiotemporal learners for process anomaly detection using melt pool image streams
- Developed deep-learning-based semantic segmentation and sensor fusion frameworks to expedite process development of powder laser directed energy deposition process in industry
- Deployed machine learning models developed on production machines for in-process defect detection in laser additive manufacturing
- Presented research findings in international conferences (ASME, IISE & IFAC) and published results in several international journals

Visiting Researcher at Helmholtz Association Germany**January 2024 – April 2024**Institute for Advanced Simulation Materials Data Science and Informatics (IAS-9) Juelich Research Center

- Selected for short-term self-organized research stay at the Helmholtz Association of Germany during the PhD program at McGill University.
- Conducted a comparison of vision transformer models in segmenting carbide dilution band of additively deposited metal matrix composites to support per pixel quantitative metallography
- Learned advanced tools to manage scientific data and track machine learning experiments
- Demonstrated the functionality of Hugging Face Hub for machine learning development to the host institute

Visiting Student at National Research Council Canada**September 2021 – April 2025**Aerospace Manufacturing Technologies Center & Digital Technologies Research Center

- Trained in optical and scanning electron microscopy to analyze metallography samples from additive manufacturing processes
- Analyzed additively deposited nickel tungsten carbide metal matrix composites in scanning electron microscope to generate data from machine learning models
- Collected laser-ultrasound data from additively deposited nickel tungsten carbide metal matrix composites to evaluate its potential for machine learning applications

Researcher at Korea STEP Center**March 2020 – December 2020**Korea Standard for the Exchange of Product Model Data Center

- Worked as a full-time researcher on a project titled “Development of Data Visualization Standard for Smart Manufacturing: Digital Twin, PLM-MES, and P&ID”
- Implemented an interface between Product Lifecycle Management PLM (design/engineering) and Manufacturing Execution System MES (manufacturing) departments with a case study involving data from Hanwha Ocean (formerly Daewoo Shipbuilding and Marine Engineering)

- Demonstrated the interface at Daewoo Shipbuilding and Marine Engineering headquarters
- Published the architecture of the interface and the case study in a conference paper

Graduate Research Assistant at KAIST**February 2018 – February 2020**Intelligent Computer-Aided Design (iCAD) Laboratory Mechanical Engineering Department

- Developed a point-based persistent identification scheme by combining geometry and topology information to address the challenge of ambiguous entities in CAD models and to support inter-CAD exchange of transition features
- Implemented the point-based naming issue in a specialized CAD system TransCAD and successfully demonstrated its potential to support part and assembly model exchange
- Collaborated with laboratory members to work on MACRO project aimed at the development of CAD-CAD translations in commercial design software CATIA and NX
- Presented MS thesis methodology at the international CAD conference. Published the findings in an international journal
- Led the write-up of an error report on the past decade of MACRO translator development at iCAD KAIST

TEACHING EXPERIENCE**Graduate Student Assistant @ Mechanical Engineering, McGill University Winter 2021 & Fall 2021-23**MECH360: Principles of Manufacturing & MECH560: Eco-design and Product Lifecycle Assessment

- Graded and evaluated student's mid-term & final-term exams, projects, and course assignments
- Provided detailed and constructive feedback to students

Graduate Teaching Assistant @ Mechanical Engineering, McGill University**Fall 2021, 2022, 2023**MECH560: Eco-design and Product Lifecycle Assessment

- Prepared and delivered tutorials on Sustainable Minds and openLCA, two life cycle assessment tools, to support undergraduate and graduate students in their mid-term and final-term projects
- Designed assignments on life cycle assessment calculations for assessing environmental impact of products
- Supported the course instructor in class activities such as organizing project presentations
- Assisted the course instructor in delivering theory lectures when required

RESEARCH SUPERVISION & COLLABORATIONS**Co-Supervisor/ HQP Mentor**

- Co-supervised a senior undergraduate student with Mechanical Engineering major and Computer Science minor, on her honors thesis entitled "Development and implementation of computer-vision-based deep learning models for anomaly classification in laser powder bed fusion"

- Mentored two summer undergraduate research interns with Mechanical Engineering major and AI minor, on a project related to the application of deep learning based semantic segmentation applications in additive manufacturing
- Mentored a summer undergraduate research intern with Mechanical Engineering major and AI minor, on a project related to the development of a large database of additive manufacturing melt pool image and video datasets
- Supported a mixed-level team with the re-design of openLCA software user interface as an expert user
- Trained all mentees in scientific writing and literature survey skills, co-authored the first peer-reviewed publications of all mentees
- Supported mentees with applications for graduate admissions leading to successful placements at the University of Pennsylvania, ETH Zurich, and Nanyang Technological University

Project Lead/ Collaborator

- Spearheaded a collaboration with the National Institute of Standards and Technology (NIST), Arizona State University (ASU), and the National Research Council Canada (NRCC) to develop a three-step knowledge transferability analysis framework for data-driven additive manufacturing
- Collaborated with Nanyang Technological University (NTU) and the Advanced Remanufacturing & Technologies Center (ARTC) of the Agency for Science, Technology and Research (A*STAR) to develop an audio-visual cross-modality knowledge transfer framework in laser additive manufacturing
- Spearheaded a collaboration with the Montreal Institute for Learning Algorithms (MILA) to develop a scientific human-AI teaming framework to expedite information extraction from data-driven additive manufacturing literature
- Collaborated with the National Institute of Standards and Technology (NIST) and Arizona State University (ASU) on a framework for digital twin quality evaluation in additive manufacturing
- Spearheaded a collaboration with RWTH Aachen University and Juelich Research Center (FZJ) of the Helmholtz Association for evaluating the potential of vision transformer models in quantitative metallography of additively manufactured metal matrix composite microstructures
- Spearheaded the AI development of a Canada-Germany joint project with industrial partners Fraunhofer Institute for Laser Technology (ILT), BCT GmbH, Braintoy AI, Apollo-Clad Laser Cladding, a division of Apollo Machine and Welding Ltd.

ACHIEVEMENTS

Significant Recognitions

- 2025 **1st Rank** within the manufacturing and construction technical group in Fonds de recherche du Québec (FRQ) doctoral research scholarship competition
- 2024 **Best Paper Award** from Computers and Information in Engineering (CIE) Conference of ASME in Advanced Modeling and Simulation (AMS), one of the two Best Paper Awards given by the CIE division of ASME each year
- 2024 **1st Place Award** in ASME Hackathon on the Air Force Research Laboratory's FactoryNet challenge to support machine vision AI systems in manufacturing domain, competed with students from 18 different institutions from 3 different countries

- 2024 and 2023 **Invited Submissions** in the ASME Journal of Computing and Information Science in Engineering (JCISE)
- 2021 Named **Heller Fellow** at McGill University for being *an outstanding PhD student in the engineering faculty*. The award is worth 10,000 CAD and is given to only one PhD student in the entire engineering faculty each year
- 2023 **Graduate Research Enhancement and Travel (GREAT) Award** nominee at McGill University to support international conference travel to attend 22nd World Congress of the International Federation of Automatic Control, the award partially compensated for the travel expenses
- 2019 **Brain Korea Travel Award** nominee at KAIST for international conference travel to attend 16th International CAD Conference, the award fully compensated for the travel expenses
- 2017 Recognized **Highest CGPA** (2nd among 200) in undergraduate batch at UET Lahore
- 2017 **Dean's Honor Roll** (8 out of 8) throughout undergraduate studies at UET Lahore, awarded to students with 3.70 or above GPA out of 4.00 in a semester
- 2011 **High School Honor Roll** for being top of the class

Competitive Fellowships, Scholarships, and Research Awards (amounts in CAD)

- Received an **International Graduate Mobility Award** worth \$1,377 for a research stay in Edmonton Canada from Graduate and Postdoctoral Studies (GPS) at McGill University
- Received a **Doctoral Internship Award** worth \$1,000 for an internship from Graduate and Postdoctoral Studies (GPS) at McGill University
- Received a **Doctoral Research Award** from Fonds de recherche du Québec (FRQ) worth \$66,667 for continuation of PhD research at McGill University
- Received a research award worth \$12,000 from the Quebec Government's **Offensive for Digital Transformation (OTN)** program
- Received research funding from the **National Research Council Canada (NRCC)** worth \$20,400 to support fourth year of the PhD program at McGill University
- Received **Helmholtz Visiting Researcher Grant** worth \$19,250 from the Helmholtz Association of Germany under their visiting program promoted by the **Helmholtz Information and Data Science Academy (HIDA)**
- Received **Mitacs Accelerate Fellowship** research award worth \$30,000 from Mitacs Inc. of Canada to work on a self-initiated project for the development of recommender systems based on item and user data
- Received **McGill Engineering Doctoral Award Fellowship (MEDA)** worth \$37,000/year totaling \$111,000 from the engineering faculty of McGill University during the first three years of the PhD program, received an additional \$3,000/year following first three years
- Received merit-based **International Student Scholarship** from 2018-2020 worth \$10,360 during M.S. program at iCAD research group of KAIST
- Received merit-based **Tuition and Fee Waiver** from 2018-2020 worth \$20,800 during M.S. program at iCAD research group of KAIST
- Received **University Merit Awards** in varying amounts for being a top ranked student based on CGPA in 4 out of 8 semesters during undergraduate studies

PUBLICATIONS & PRESENTATIONS

***Peer-reviewed or Refereed Publications | [†] Equal Contribution | [§] Presenting Author**

Book Publications

[B1] Safdar, M., Lamouche, G., Paul, P. P., Wood, G., & Zhao, Y. F. (2023). Engineering of additive manufacturing features for data-driven solutions: sources, techniques, pipelines, and applications*. Springer Nature. (ISBN: 978-3-031-32153-5).

Journal Publications

[J16] (Under Review) Safdar, M., Kazimi, B., Ruzaeva, K., Wood, G., Zimmermann, M., Lamouche, G., Wanjara, P., Sandfeld, S., & Zhao, Y. F. Accelerated quantification of reinforcement degradation in additively manufactured Ni-WC metal matrix composites via SEM and vision transformers. *Materials Characterization*.

[J15] (Under Revision) Safdar, M., Wood, G., Zimmermann, M., Lamouche, G., Wanjara, P., & Zhao, Y. F. Linking heterogeneous microstructure informatics with expert characterization knowledge through customized and hybrid vision-language representations for industrial qualification. *Advanced Engineering Informatics*.

[J14] (Revision Submitted) Xie, J., Safdar, M., Zhao, B. C., Lu, Y., Ko, H., Yang, Z., & Zhao, Y. F. Towards reproducible machine learning-based process monitoring and quality prediction research for additive manufacturing. *Engineering Applications of Artificial Intelligence*.

[J13] Jabbour, W., Safdar, M., Xie, J., & Zhao, Y. F. (2025) A multi-source compilation for analytics applications in additive manufacturing*. *Scientific Data*, 12(1), 1-13.

[J12] Safdar, M., Wood, G., Zimmermann, M., Lamouche, G., Wanjara, P., & Zhao, Y. F. (2025). Detecting extent of co-existing anomalies in additively deposited metal matrix composites through explainable selection and fusion of multi-camera deep learning features*. *Virtual and Physical Prototyping*, 20(1), e2515240.

[J11] Safdar, M.[†], Xie, J.[†], Mircea, A.[†], & Zhao, Y. F. (2025). Human-artificial intelligence teaming for scientific information extraction from data-driven additive manufacturing literature using large language models*. *Journal of Computing and Information Science in Engineering*, 25(7), 074501.

[J10] Safdar, M.[†], Xie, J.[†], & Zhao, Y.F. (2025). Advancing machine learning in additive manufacturing: Perspectives on data challenges, model development, and industrial adoption*. *Engineering Science in Additive Manufacturing*, 1(1), 025040004.

[J9] Xie, J., Safdar, M., Chen, L., Moon, S. K., & Zhao, Y. F. (2025). Audio-visual cross-modality knowledge transfer for machine learning-based in-situ monitoring in laser additive manufacturing*. *Additive Manufacturing*, 104692.

[J8] Safdar, M., Li, Y. F., El Haddad, R., Zimmermann, M., Wood, G., Lamouche, G., Wanjara, P., & Zhao, Y. F. (2024). Accelerated semantic segmentation of additively manufactured metal matrix composites: Generating datasets, evaluating convolutional and transformer models, and developing the MicroSegQ+ Tool*. *Expert Systems with Applications*, 251, 123974.

- [J7] **Safdar, M.**, Paul, P. P., Lamouche, G., Wood, G., Zimmermann, M., Hannesen, F., Bescond, C., Wanjara, P., & Zhao, Y. F. (2024). Fundamental requirements of a machine learning operations platform for industrial metal additive manufacturing*. *Computers in Industry*, 154, 104037.
- [J6] **Safdar, M.**, Xie, J., Ko, H., Lu, Y., Lamouche, G., & Zhao, Y. F. (2024). Transferability analysis of data-driven additive manufacturing knowledge: a case study between powder bed fusion and directed energy deposition*. *Journal of Computing and Information Science in Engineering*, 24(5), p. 051010
- [J5] Xie, J., Zhang, C., Sage, M., **Safdar, M.**, & Zhao, Y. F. (2023). A sequential cross-product knowledge accumulation, extraction and transfer framework for machine learning-based production process modelling*. *International Journal of Production Research*, 62(12), 4181-4201.
- [J4] Zhang, Y.[†], **Safdar, M.**[†], Xie, J., Li, J., Sage, M., & Zhao, Y. F. (2022). A systematic review on data of additive manufacturing for machine learning applications: the data quality, type, preprocessing, and management*. *Journal of Intelligent Manufacturing*, 34(8), 3305-3340.
- [J3] **Safdar, M.**, Jauhar, T. A., Kim, Y., Lee, H., Noh, C., Kim, H., Lee, I., Kim, I., Kown, S., & Han, S. (2020). Feature-based translation of CAD models with macro-parametric approach: issues of feature mapping, persistent naming, and constraint translation*. *Journal of Computational Design and Engineering*, 7(5), 603-614.
- [J2] **Safdar, M.**, Han, S., Kwon, S., & Song, I. (2020). Point-oriented persistent identification of entities for exchanging parametric CAD data*. *Computer-Aided Design and Applications*, 17(2), 274-287.
- [J1] Kim, Y., Lee, H., **Safdar, M.**, Jauhar, T. A., & Han, S. (2019). Exchange of parametric assembly models based on neutral assembly constraints*. *Concurrent Engineering*, 27(4), 285-294.

Conference Proceedings

- [C7] **Safdar, M.**[§], Xie, J., Mircea, A., & Zhao, Y. F. (2024, August). Human-artificial intelligence teaming for scientific information extraction from data-driven additive manufacturing research using large language models. In International Design Engineering Technical Conferences and Computers and Information in Engineering Conference (Vol. 88346, p. V02AT02A028). American Society of Mechanical Engineers.
- [C6] Xie, J.[§], **Safdar, M.**, Romascanu, A. M., Lu, Y., Ko, H., Yang, Z., & Zhao, Y. F. (2024, August). Towards reproducible machine learning-based process monitoring and quality prediction research for additive manufacturing. In International Design Engineering Technical Conferences and Computers and Information in Engineering Conference (Vol. 88346, p. V02AT02A033). American Society of Mechanical Engineers.
- [C5] Lu, Y., Xie, J.[§], **Safdar, M.**, Elhambakhsh, F., Ko, H., Yang, Z., Li, S., & Zhao, Y. F. (2024, August). An overarching quality evaluation framework for additive manufacturing digital twin*. In 2024 IEEE 20th International Conference on Automation Science and Engineering (CASE) (pp. 676-682). IEEE.
- [C4] **Safdar, M.**, Xie, J.[§], Ko, H., Lu, Y., Lamouche, G., & Zhao, Y. F. (2023, August). Transferability analysis of data-driven additive manufacturing knowledge: a case study between powder bed fusion and directed energy deposition*. In International Design Engineering Technical Conferences and Computers and Information in Engineering Conference (Vol. 87295, p. V002T02A078). American Society of Mechanical Engineers.

[C3] Cherif, L.[†], **Safdar, M.**^{‡§}, Lamouche, G., Wanjara, P., Paul, P., Wood, G., Zimmermann, M., Hannesen, F., & Zhao, Y. F. (2023). Evaluation of Key Spatiotemporal Learners for Print Track Anomaly Classification Using Melt Pool Image Streams*. IFAC-PapersOnLine, 56(2), 4733-4739.

[C2] Jauhar, T. A.[§], **Safdar, M.**, Kim, I., & Han, S. (2020, November). Web-based Product Data Visualization and Feedback between PLM and MES*. In Proceedings of the 25th International Conference on 3D Web Technology (pp. 1-4).

[C1] **Safdar, M.**[§], Han, S., Kwon, S., & Song, I. (2019). Point-oriented identification for exchanging parametric CAD data*. In Proceedings of the 16th annual international CAD conference (CAD'19) (pp. 59-63).

Poster Presentation

[P2] Ibrahim, M., Osman, W., Granade, C.[§], **Safdar, M.**, Chen, Y., Zhao, Y. F. (2024). openLCA in Education: Evaluating the potential of ChatGPT 4.0 and user interface enhancement to support product lifecycle assessment. Poster presented at openLCA Conference, April 15-16, 2024, Berlin, Germany.

[P1] **Safdar, M.**[§], Han, S., Kwon, S., & Song, I. (2019). Implementation of a point-based naming method for history-based translator TransCAD. Poster presented at the Summer Conference of Society for Computational Design and Engineering, August 19-22, 2019, Jeju Island, South Korea.

Technical Talks and Oral Presentations

[T9] **Canadian Society for Mechanical Engineering (CSME)** 2025 International Congress, “Applying artificial intelligence in directed energy deposition additive manufacturing of metal matrix composites: Lessons and experiences for industrial implementation”, May 28, 2025, ETS, Montreal, Quebec, Canada

[T8] **Institute of Industrial and Systems Engineers (IISE)** 2024 Annual Conference and Expo, “Evaluating the potential of disparate sensing systems for machine learning-based in-situ microstructure defect detection in directed energy deposition”, May 19, 2024, Montreal Convention Center, Montreal, Quebec, Canada

[T7] **Institute for Materials Data Science and Informatics (IAS9)**, Juelich Research Center, “A tutorial on hugging face hub for ML model training and experiment tracking”, March 06, 2024, Aachen, Germany

[T6] **Trottier Institute for Sustainability in Engineering and Design (TISED)**, “Workshop on lifecycle assessment and openLCA”, October 27, 2023, McGill University, Montreal, Quebec, Canada

[T5] **Innovation Network Smart-Digital-Green (SDG)** 2022 Student Forum 5.0, “Data-driven anomaly prediction and parameter optimization for industrial adoption of directed energy deposition”, June 08, 2022, Laval University, Quebec City, Quebec, Canada

[T4] **Canadian Center for Welding and Joining (CCWJ)**, “Data-driven anomaly classification in directed energy deposition”, October 26, 2021, University of Alberta, Edmonton, Alberta, Canada

[T3] **Daewoo Shipbuilding and Marine Engineering (DSME)** (now Hanwha Ocean), “Demonstration of an interface between PLM and MES to visualize feedback in the shipbuilding industry”, August 31, 2020, Geoje Island, South Korea

[T2] Winter conference of **Society for Computational Design and Engineering (CDE)**, “Persistent identification for parametric CAD data exchange”, February 10, 2020, PyeongChang, South Korea

[T1] Winter conference of **Society for Computational Design and Engineering (CDE)**, “A point-based naming method for the exchange of parametric CAD models”, January 11, 2019, PyeongChang, South Korea

PROFESSIONAL ACTIVITIES, AFFILIATIONS, & SERVICES

- **Technical Committee Member**, Member of ASME Computers and Information in Engineering Conference, Systems Engineering Information Knowledge Management Committee 2023, 2024, 2025
- **Session Organizer**, Organizer of ASME Computers and Information in Engineering Conference, Knowledge Capture, Reuse, and Management Session, 2023, 2024, 2025
- **Student Member**
 - American Society of Mechanical Engineers (2022 – present)
 - Canadian Society of Mechanical Engineers (2023 – present)
 - Society of Manufacturing Engineers (2023 – present)
 - Institute of Industrial and Systems Engineers (2023 – present)
- **Reviewer**
 - npj Advanced Manufacturing 2025
 - ASME International Design Engineering Technical Conferences & Computers and Information in Engineering Conference 2023, 2024, 2025
 - SME North American Manufacturing Research Conference 2023
 - ASME Manufacturing Science and Engineering Conference 2023
 - IFAC World Congress 2023
- **Workshop Host**, Sustainability in Engineering at McGill 2023
- **Laboratory Tour Guide**, McGill Open House 2023 & 2024
- **Official Certified First Aid Provider**, McGill University, Department of Mechanical Engineering (2023 – 2026)
- **Graduate Studies Ambassador**, McGill University, 2023
- **Student Volunteer**, Association for Computing Machinery (ACM), 25th Web3D Conference (Virtual/Seoul), 2020
- **Official Nominated Class Representative and Proctor**, UET Lahore, Junior and Senior Years, (2016 – 2017)

DATASETS, HACKATHONS & SOFTWARE

- **Melt-Pool-Kinetics** dataset: A multi-source melt pool compilation for vision-based analytics applications in additive manufacturing
- **DED-AM-MMC** dataset: Multi-defect feature dataset for SHAP-based analysis in directed energy deposition additive manufacturing

- **DEDAM-1 & DEDAM-2** datasets: Annotated optical metallography datasets for semantic segmentation deep learning application
- **DeepBead**: An industrial AI tool to support on-machine integration of deep learning models with optical monitoring systems for defect detection in laser additive manufacturing
- **SciHIT IE**: A scientific human-AI teaming platform for manufacturing information extraction using LLMs (domain expert)
- **MicroSegQ+**: A deep learning-based image segmentation tool for manufacturing industry
- **PLM-MES Interface**: An interface between open-source PLM and MES systems to visualize design feedback
- **TransCAD**: A specialized computer-aided design tool for inter-CAD feature translation
- **Android CAD Modeler**: A simple touch-based CAD modeler for smartphones with support for common features
- **ASME CIE Hackathon 2024**: Contestant on *FactoryNET Challenge* by the US Air Force Research Laboratory
- **ASME CIE Hackathon 2023**: Contestant on *Material Selection Challenge* by Autodesk Research