

Muhammad Tayyab KHAN

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Education

Nanyang Technological University (NTU)

Singapore

Ph.D., Mechanical & Aerospace Engineering, Industrial AI

Jan. 2023 – Expected Aug. 2026

- **A*STAR SINGA Scholar.** CGPA 4.75/5.0
- **Thesis:** *Design-to-Plan: An LLM-Driven Multi-Agent Framework for Automated Manufacturing Process Planning from Product Design Data*
- **Advisors:** Assoc. Prof. Seung Ki Moon (NTU) & Dr. Wenhe Feng (A*STAR SIMTech)

University of Engineering & Technology (UET)

Lahore, Pakistan

Bachelor of Science in Mechanical Engineering

Oct. 2017 – Aug. 2021

- **Honors (Highest Distinction):** CGPA 3.985/4.0 (Gold Medalist)

Research Experience

A*STAR, Singapore Institute of Manufacturing Technology (SIMTech)

Singapore

PhD Research Attachment

Jan. 2023 – Present

- Developed advanced algorithms for automatic feature recognition (AFR) and dimensional attribute extraction from 3D CAD models using **graph convolutional neural network (GCNN)**. Achieved 96.87% accuracy, 97.16% precision, 96.67% recall, and 96.87% F1-score, with perfect dimensional attribute extraction accuracy for diverse hybrid additive-subtractive manufacturing features.
- Implemented **vision-language models (VLMs)** for AFR on complex CAD geometries, evaluating both open-source and closed-source models using structured and task-aware prompting strategies. Enabled scalable feature recognition across diverse industrial designs with up to 75% accuracy.
- Contributed to the strategic A*STAR research project ***Manufacturing of Multi-material Net-shape Parts with Heterogeneous Properties*** by developing AFR and geometric reasoning pipelines for complex multi-material CAD models. Enabled reliable manufacturability analysis and downstream process planning for advanced hybrid manufacturing workflows.
- Designed an end-to-end AI pipeline for structured information extraction from 2D engineering drawings by integrating **object detection** and **optical character recognition (OCR)**. Benchmarked state-of-the-art document understanding models, achieving 89.2% precision, 99.2% recall, a 94.0% F1-score, and a low hallucination rate of 10.8%.
- Contributed to a flagship project under the **Sectoral AI Centre of Excellence for Manufacturing (AIMfg)** by developing advanced AI pipelines for 2D drawing information retrieval and 3D CAD feature recognition. Improved overall system accuracy by 20% using object detection, VLMs, and GCNN-based methods.
- Designed and implemented a **Retrieval-Augmented Generation (RAG)** framework combining Vector RAG and **knowledge graph (KG)-based RAG**, integrated with Neo4j for manufacturability analysis and manufacturing process planning. Developed a novel **metal additive manufacturing (AM) KG** covering nine distinct AM processes. Achieved a 25% improvement in contextual and answer relevance. Created a novel RAG evaluation dataset using prompt-based high-quality data generation with advanced LLM techniques. Employed an **LLM-as-judge** framework for automated evaluation of retrieval and generation quality.

- Developed a deterministic-first, **context-aware framework for mapping** 2D drawing intent to 3D CAD features for manufacturing automation. Combined semantic enrichment, interpretable correspondence scoring, and controlled LLM-assisted escalation with human-in-the-loop (HITL) validation, achieving 83.67% precision, 90.46% recall, and 86.29% F1-score on 20 real industrial CAD–drawing pairs.
- Building a **LangGraph-driven multi-agent** AI platform for manufacturing intelligence, implementing a production-grade **agent-to-agent (A2A)** communication protocol with asynchronous messaging and thread-based workflow tracking. Enables coordinated decision-making and HITL decision support across multiple specialized manufacturing agents.
- Developing a **generative AI-driven hierarchical three-tier architecture** (Orchestrator, Helper Agents, Utility Services) with a custom **Manufacturing Agent Messaging Protocol (MAMP)** for cloud-agnostic agent coordination. Automates manufacturing specification extraction and process planning from engineering documents through a seven-stage interactive pipeline with 2D–3D context fusion, **ReAct**-based agentic reasoning, and VLM-based safety guardrails.

Department of Mechanical Engineering, UET Teaching Fellow

Lahore, Pakistan
Dec. 2021 – Dec. 2022

- Developed and instructed a new undergraduate laboratory course on Mechanical Vibrations.
- Taught core mechanical engineering courses and laboratory sessions for B.Sc. students.
- Supervised multiple B.Sc. final-year design and semester-long projects, providing mentorship from project initiation through completion.

Research Assistant

Aug. 2020 – Jul. 2021

- Evaluated human gait patterns using Inertial Measurement Units (IMUs) and machine learning techniques during the Timed-Up-and-Go (TUG) test, enabling quantitative assessment of mobility and functional performance.
- Conducted biomechanical analysis of cricket bowling actions using Xsens IMUs, capturing high-fidelity motion data to study joint kinematics and movement efficiency.

Skills

- **Programming Languages:** Python, SQL, Cypher, MATLAB
- **AI/ML Libraries:** PyTorch, TensorFlow, Hugging Face Transformers, Keras, Scikit-Learn
- **LLM & Agent Frameworks:** LangChain, LangGraph, CrewAI
- **Computer Vision & Graphics:** OpenCV, PythonOCC (Open Cascade)
- **Data & Knowledge Systems:** Neo4j, Graph Databases, Relational Databases
- **Manufacturing Tools:** CAD/CAM Systems, SolidWorks, AutoCAD, Autodesk Fusion, ANSYS Fluent
- **Soft Skills:** Technical & grant writing, industrial collaboration, critical thinking, cross-functional teamwork

Peer-Reviewed Publications

1. [Khan, M. T.](#), Chen, L., Feng, W., and Moon, S. K. (2026). "Design-to-Plan: A Large Language Model-Based Multi-Agent Framework for Manufacturing Process Planning from 3D CAD Models and 2D Engineering Drawings." *Journal of Manufacturing Systems* (Q1). (Under Review)
2. [Khan, M. T.](#), Chen, L., Feng, W., and Moon, S. K. (2026). "Context-Aware Mapping of 2D Drawing Annotations to 3D CAD Features Using LLM-Assisted Reasoning for Manufacturing Automation." *arXiv preprint*

arXiv:2602.18296. (Accepted, *The 21st IEEE Conference on Industrial Electronics and Applications (IEEE ICIEA 2026)*)

3. Park, S. J., Cho, S., Ng, P. H. N., Lee, J., Kim, J., Jeon, S., Khan, M. T., Chen, L., Wu, Q., and Moon, S. K. (2026). "Insights Into the Industrial Applications and Future Directions of Bulk Metallic Glasses Via Additive Manufacturing." *International Journal of Precision Engineering and Manufacturing* (Q1). <https://doi.org/10.1007/s12541-026-01449-0>
4. Khan, M. T., Chen, L., Yong, Z., Tan, J. M., Feng, W., and Moon, S. K. (2026). "From drawings to decisions: A hybrid vision-language framework for parsing 2D engineering drawings into structured manufacturing knowledge." *Robotics and Computer-Integrated Manufacturing* (Q1), 99, 103186.
5. Khan, M. T., Yong, Z., Chen, L., Feng, W., Tan, N. Y. J., and Moon, S. K. (2025). "A Multi-Stage Hybrid Framework for Automated Interpretation of Multi-View Engineering Drawings Using Vision Language Model." *arXiv preprint arXiv:2510.21862*. (*13th International Conference on Industrial Engineering and Applications (ICIEA 2026)*) (**Best Oral Presentation Award**)
6. Khan, M. T., Chen, L., Ng, Y. H., Feng, W., Tan, N. Y. J., and Moon, S. K. (2025). "Leveraging vision-language models for manufacturing feature recognition in computer-aided designs." *ASME Journal of Computing and Information Science in Engineering* (Q1), 25(10), 104501.
7. Khan, M. T., Yong, Z., Chen, L., Tan, J. M., Feng, W., and Moon, S. K. (2025). "Automated Parsing of Engineering Drawings for Structured Information Extraction Using a Fine-tuned Document Understanding Transformer." *2025 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, Melbourne, Australia, pp. 0091–0095, <https://doi.org/10.1109/IEEM63636.2025.11357576>
8. Khan, M. T., Chen, L., Feng, W., and Moon, S. K. (2025). "Large Language Model-Powered Decision Support for a Metal Additive Manufacturing Knowledge Graph." *arXiv preprint arXiv:2505.20308*. (Published in *11th International Conference of Asian Society for Precision Engineering and Nanotechnology (ASPEN 2025)*)
9. Khan, M. T., Chen, L., Ng, Y. H., Feng, W., Tan, N. Y. J., and Moon, S. K. (2026). "Fine-Tuning Vision-Language Model for Automated Engineering Drawing Information Extraction." In: Guan, S. (eds) *Proceedings of the 9th International Conference on Innovation in Artificial Intelligence. ICIAI 2025. Lecture Notes in Electrical Engineering*, vol 1458. Springer, Singapore. https://doi.org/10.1007/978-981-95-0887-7_31
10. Khan, M. T. and Waheed, A. (2025). "Foundation model driven robotics: A comprehensive review." *arXiv preprint arXiv:2507.10087*. (Under Review)
11. Khan, M. T., Feng, W., Chen, L., Ng, Y. H., Tan, N. Y. J., and Moon, S. K. (2024, August). "Automatic feature recognition and dimensional attributes extraction from CAD models for hybrid additive-subtractive manufacturing." *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (Vol. 88346, p. V02AT02A035). American Society of Mechanical Engineers.

Conference Presentations

1. Khan, M. T. (2026). "Generative AI-Powered Multi-Agent System for Manufacturing Process Planning and Decision-Making." *The 1st S&A Student Symposium - Nurturing Ideas, Building Tomorrow*, A*STAR Advanced Remanufacturing and Technology Centre (ARTC), Singapore.
2. Khan, M. T., Feng, W., and Moon, S.K. (2025). "Retrieval Augmented Knowledge Based Decision Support for Metal Additive Manufacturing." *13th Asia-Korea Conference on Science and Technology 2025 (AKC2025)*, NUSS Kent Ridge, NUS, Singapore.
3. Khan, M. T., Yong, Z., Chen, L., Feng, W., and Moon, S. K. (2025). "Generative AI-powered multi-agent system for manufacturing process planning and decision-making." *Singapore Scientific Conference (SSC); Forging a Sustainable Future Through Science & Technology*, Marina Bay Sands Expo and Convention Centre, Singapore.

4. [Khan, M. T.](#) (2025). "A hybrid vision-language framework for parsing 2D engineering drawings into structured manufacturing knowledge." *1st Symposium on Autonomous Manufacturing and Humanoid Robot (AMHR)*, Hyundai Motor Group Innovation Center (HMGICS), Singapore.
5. [Khan, M. T.](#), Feng, W., and Moon, S.K. (2023). "Hybrid Manufacturing: Automatic Feature Recognition Based on CAD Models for Knowledge Graph." *Proceedings of the 2nd International Conference on Design for 3D Printing (ICD3DP)*, Jeju, South Korea.

Technology Disclosures

1. [Khan, M. T.](#), Chen, L., and Moon, S. K. (2026). "A Generative AI-Driven Hierarchical Multi-Agent System for Automated Manufacturing Specification Extraction and Process Planning from Engineering Documents." Technology Disclosure (TD), NTU Ref. No. 2026-115. Accepted by NTUitive (NTU Innovation & Enterprise), Singapore.

Professional Service

Professional Membership

- **Institute of Electrical and Electronics Engineers (IEEE):** Graduate Student & Young Professional Member (Aug. 2025 – Present)
- **American Society of Mechanical Engineers (ASME):** Student Member (Jan. 2018 – Feb. 2019)

Conference Reviewer

- **The 52nd Annual Conference of the IEEE Industrial Electronics Society (IECON 2026)**
- **The 21st IEEE Conference on Industrial Electronics and Applications (IEEE ICIEA 2026)**
- **IAPR TC8 Workshop on Machine Vision for Industrial Inspection (MVI2)**, held in conjunction with the 28th International Conference on Pattern Recognition (ICPR)

Volunteer

- **1st S&A Student Symposium (A*STAR SIMTech & ARTC):** Session Chair, Oral Session – Autonomous Manufacturing (2026)
- **Singapore Scientific Conference (SSC):** Student Helper (2025)
- **ASME UET Chapter:** Student Volunteer (2018 – 2019)

Social Engagement and Leadership Roles

TEDxNTU

Co-Chairperson

Singapore
Oct. 2025 – Present

- Leading the TEDxNTU organizing committee, coordinating cross-functional teams across finance, marketing, logistics, and curation to deliver impactful TEDx events.
- Overseeing finance, operations, HR, vendor management, and strategic planning to ensure seamless execution of the TEDxNTU 2026 event.

Treasurer

Aug. 2023 – Sep. 2025

- Managed budgeting, financial planning, and treasury operations for TEDxNTU events.

- Coordinated vendor payments, contracts, and procurement for event logistics and venue arrangements.

Representative, TEDxKL Workshop

Kuala Lumpur, Malaysia

- Represented TEDxNTU at the TEDx Kuala Lumpur workshop, supported by NTU Student Affairs Office under the Overseas Exposure Programme (OEP).
- Engaged in leadership training and inter-TEDx knowledge exchange on event organization and outreach.

Young Peace and Development Corps (YPDC)

Lahore, Pakistan

Vice President

Jun. 2019 – Jul. 2021

- Led youth engagement initiatives under the HEC National Youth Program, organizing seminars to foster peace and community development.

Blood Donors Society, UET

Lahore, Pakistan

Social Worker

Aug. 2020 – Jul. 2021

- Coordinated blood donation drives across Lahore, supporting hospitals and emergency needs through donor outreach.

Honors and Achievements

- Awarded the *Best Oral Presenter Award* at the 13th International Conference on Industrial Engineering and Applications (ICIEA 2026), Kyoto, Japan (2026).
- Awarded the highly competitive *A*STAR Singapore International Graduate Award (SINGA)* for a fully funded Ph.D., recognizing outstanding academic and research excellence (2023).
- Awarded *four Gold Medals* for securing First Position in Mechanical Engineering at the University of Engineering and Technology (UET) Lahore (2021).
- Secured a competitive *Research Grant* supporting the publication of peer-reviewed conference papers (2021).
- Received the *International Prize* from the University of Engineering and Technology Alumni of Canada (UE-TAC) for academic excellence (2020).
- Nominated to the *Dean's Honor List* for eight consecutive semesters (2017–2021).
- Awarded a *Merit Certificate* by the Chief Minister of Punjab for securing Second Position in the BISE Lahore examinations (2018).
- Granted the *High Achievers Development Workshop Certificate* by the Punjab Educational Endowment Fund (PEEF) (2017).
- Awarded the *National Talent Scholarship* by the Board of Intermediate and Secondary Education (BISE) Lahore (2017).
- Honored as a *Silver Medalist* for securing Second Position in the BISE Lahore examinations (2017).
- Awarded a laptop under the *Chief Minister's Laptop Scheme* in recognition of academic excellence (2017).
- Awarded a *Fully Funded Academic Scholarship* by the Punjab College of Science, Lahore (2015).

Licenses & Certifications

- [University Teaching for Teaching Assistants](#), Nanyang Technological University, Singapore
- [Multi-Agent Systems with CrewAI](#), DeepLearning.AI
- [Building and Evaluating Advanced RAG](#), DeepLearning.AI

- [Neo4j Fundamentals](#), Neo4j GraphAcademy
- [Claude Code: A Highly Agentic Coding Assistant](#), DeepLearning.AI
- [Introduction to Programming with MATLAB](#), Vanderbilt University (Coursera)
- [Machine Learning for All](#), University of London (Coursera)
- [Graph Data Modeling Fundamentals](#), Neo4j GraphAcademy
- [3D Printing Applications](#), University of Illinois at Urbana–Champaign (Coursera)
- [Python Basics](#), University of Michigan (Coursera)
- [Introduction to Engineering Mechanics](#), Georgia Institute of Technology (Coursera)
- [Material Processing](#), Georgia Institute of Technology (Coursera)
- [Understanding Research Methods](#), University of London (Coursera)