

**CAREER SUMMARY:** Machine Learning and AI researcher specializing in DNNs (shallow CNNs, Transformers, VAEs), Generative AI (GANs, Diffusion, LLMs), Computer Vision (object detection, segmentation, feature extraction), robotics, and AR/VR/DT applications.

## EDUCATION

<b>Doctor of Philosophy</b> in Mechanical Engineering, <i>University of Cincinnati, OH</i>	2024 – ongoing*
<b>Research Focus:</b> Reinforcement Learning, GANs, shallow CNNs, Diffusion, Multi-model LLM	GPA: 4.0/4.0
<b>Master of Science</b> in Mechanical Engineering, <i>University of Cincinnati, OH</i>	2021 – 2023
<b>Research Focus:</b> Computer Vision, AR/VR-based object visualization, Design Automation, DT application	GPA: 4.0/4.0

## RESEARCH EXPERIENCE

<b>Graduate Research Assistant, Center for Global Design and Manufacturing, UC Smart Manufacturing Lab</b>	01/2025 – Present
<b>Project Partners:</b> <i>Industry 4.0/5.0 Committee Members (Siemens, P&amp;G, Standard Power, Worthington, Valvoline, Kinetic Vision)</i>	
<ul style="list-style-type: none"> <li>Developed an interpretable, LLM-based human AI mutual learning framework that leverages tacit knowledge and generates valuable insights based on node-based feature extraction from graph neural networks (GNN) and reinforcement learning</li> <li>Achieved an initial accuracy of 45% and relevance of 55% in beta-testing while providing real-time guidance to workers in bottling operation</li> </ul>	
<b>Graduate Research Assistant, Center for Global Design and Manufacturing, UC Smart Manufacturing Lab</b>	05/2023 – 12/2024
<b>Project Partners:</b> <i>Eaton Corporation</i>	
<ul style="list-style-type: none"> <li>Designed an algorithm that integrates topology optimization and design for additive manufacturing (DfAM) parameters, resulting in 3x improvement in heat transfer efficiency for heat exchanger (HX) designs</li> <li>Optimized the HX design process by applying GANs to generate and estimate 3D model HX models, reducing the overall HPC cluster processing time from 24 hours to just 8 hours.</li> </ul>	
<b>Graduate Teaching Assistant, Department of Mechanical and Materials Engineering</b>	01/2024 – 04/2024
<b>Course Assistant:</b> <i>MECH 6071, Computation Methods for Additive Manufacturing Process</i>	
<ul style="list-style-type: none"> <li>Guided students in developing a YOLO-v7-based object detection model for classifying out-of-distribution models (achieved 70-75% accuracy on real-world objects)</li> <li>Delivered lectures on deep neural networks and algorithms for computer vision for additive manufacturing processes and advanced engineering design</li> </ul>	

**Graduate Research Assistant, Center for Global Design and Manufacturing** 01/2023 – 04/2023

**Research Institute:** *UC Siemens Simulation Technology Center*

Programmed Siemens NX application through NXOpen API to analyze 3D triangulated models (capturing, segmenting, and evaluating these features for advanced manufacturing processes)

**Graduate Research Assistant, Center for Global Design and Manufacturing** 07/2021 – 12/2022

**Project Partners:** *Raytheon Technologies*

- Developed NX API-based C++ algorithms to extract computer-aided design (CAD) features and process parameters from 3D models, allowing automated STL generation from 3D point clouds
- Built an automatic geometric fitting pipeline using primitive geometries (spheres, cylinders, plane) to construct 3D models for organic geometries (achieved 76% accuracy in test cases)

## RELEVANT WORKS

<b>artCAN AI: Human-AI Co-Creation for Enhanced Well-Being through Digital Art Therapy</b>	03/2025
<ul style="list-style-type: none"> <li>Designed an AI-powered chatbot (capable of communicating through voice, text, and image) for digital art therapy that generates synthetic images based on user prompts by leveraging Stable Diffusion</li> <li>Enhanced the digital art design user experiences (generating a 10-15% increase in user engagement during beta testing)</li> </ul>	
<b>IIoT-enabled digital twin for legacy and smart factory machines with LLM integration</b>	12/2024
<ul style="list-style-type: none"> <li>Successfully integrated data for legacy and smart machines into a unified digital twin with low-latency data flow (1.3s) in the DT environment.</li> <li>Created a multi-agent LLM model (trained with LoRA and RLHF with RAG) to address user queries in operation maintenance of factories (achieving an accuracy of 82% and repeatability of 92% in query classification for process optimization)</li> </ul>	
<b>Deep Learning-Based Recognition of Manufacturing Components Using Augmented Reality for Worker Training</b>	03/2024
Programmed and automated an image generation algorithm that generates 4K quality realistic virtual images and masks for object detection within Blender through Blender API and Python	
<b>ImVR: Enabling Immersive Design and Digital Twin Visualization of Complex Organic Geometries</b>	12/2023

- Formulated a VR based scalable framework and Environment generation with Digital Avatar for collaboration work with in VR environment for visualization of complex 3D models and computation results (namely FEA).
- Generated a fine-tuned LLM VR assistant through prompt training and fine tuning of GPT-3.5-Turbo that acts as a digital assistant (developed assistant was found to have lower hallucination and higher understanding of complex engineering concepts with 75% accuracy in different technological concepts)

### Automatic Generation of Cranial Implants and Molds using Patient CT Scan Data

05/2022

Created an open-source software for the automatic design of cranial implants from MRI/DICOM/CT scan data through object detection and 3D feature extraction (helped reduce reliance on skilled labor and caused a reduction in design time from 24 hours to 3 minutes)

### SKILLS

- *Programming Language:* Python, C/C++, C#, MATLAB, Java, JavaScript, TypeScript, ReactJS, HTML, CSS, Blender API
- *Machine Learning Libraries/Tools:* OpenCV, PyTorch, TensorFlow, Keras, Sklearn, Huggingface-transformers, YOLO (Darknet, Ultralytics), u-NET
- *Generative AI Tools:* spaCY, NLTK, NL4DV, Style-GAN, Bicycle-GAN, Tensor-RT-LLM, Diffusers (Hugging Face), GPU, CUDA, cuDNN, SLURM, OpenMPI, Docker
- *High-Performance Computing:* Scientific Computing & Simulation (PetSc, OpenFOAM, PyVista, VTK, CARLA-Autonomous Driving), Geometry and 3D Computation (Trimesh, VTK, PCL)
- *Computational Tools/Libraries:* NVIDIA Issac Sim, NVIDIA Omniverse, Unreal Engine, Unity, Steam, Siemens NX, Siemens NX-API, Siemens Teamcenter PLM, Simcenter, Star-CCM+, ANSYS, Autodesk Netfabb, nTopology, Siemens PlantSimulation, Fusion360, Tableau, SolidWorks
- *Commercial Software:* Arduino Uno, Intel RealSense D435i, Pixhawk, Kinova Gen3 Lite
- *Hardware & Embedded Systems:* PyCharm, Visual Studio, Google Collab, Git, Bitbucket, Wandb
- *Developer Tools/Version Control:*

### RESEARCH AND INDUSTRY GRANT PROPOSALS: Successfully presented research idea and assisted research advisor Dr. Sam Anand in presenting research proposals and securing funding to multiple industries/organizations

- UC MME Industry 4.0/5.0 Institute – Investigators Sam Anand – Tacit Domain Knowledge and AI-Driven Reinforcement Learning Framework for Factory Operations and Process Optimization (\$40K), Discipline-agnostic design optimization enabled by LLM (\$40K), SMART-DT: Scalable Multi-Agent Reinforcement Learning and Collaborative AI for Digital Twin Platform of Infrastructure and Facility Operations (\$40K), LLM- Assisted Automated Virtual Reality Training for Human-Machine Interaction & Manufacturing Tasks (\$40K), 2025
- UC MME Industry 4.0/5.0 Institute - Investigators Sam Anand – IIoT for legacy and smart factory machine with LLM feedback and Digital Twin (\$40K), Human Digital Twin Estimation and Motion Prediction Framework with LLM Integrated Automated Component Recognition (\$80K), 2024
- Non-Profit Grant: 16921 – Investigators Sam Anand, Jonathan Forbes – NeuroTech Advancement C1-2 Prostheses (\$25,000.00), 2024
- Industry Grant (Eaton): W912HZ-21-BAA-01 – Investigator Sam Anand, Prashant Khare – Phase 1 Lightweight Machine Learning Based Intelligent Design of Heat Exchangers for Additive Manufacturing (\$380,000.00), 2023
- Industry Grant (Raytheon): 1256773 – Investigator Sam Anand – CAD-Based Computational Tools for Metal Additive Manufacturing (\$86,245.00), 2021

### PUBLICATIONS (High Impact Factor: Peer-reviewed conference and journal articles)

- [1] Gautam A, Aryal MR, Deshpande S, Padalkar S, Nikolaenko M, Tang M, Anand S. IIoT-enabled digital twin for legacy and smart factory machines with LLM integration. *Journal of Manufacturing Systems.* 2025; 80:511–523. <https://doi.org/10.1016/j.jmsy.2025.03.022>. **(Ranked in the top 10% of all papers in the NAMRC Conferences; Nominated for Student Research Presentation Competition)**
- [2] Strelko O, Aryal M. R., Zack A, Alfawares Y, Remenyi R, Bayan IK, Briones YL, Holovenko Y, Maksymenko M, Sirko A, et al. Early Challenges in the Implementation of Automated CranialRebuild Freeware for Generation of Patient-Specific Cranial Implant Using Additive Manufacturing: A Pilot Project in Review. *Biomimetics.* 2024; 9(7):430. <https://doi.org/10.3390/biomimetics9070430>
- [3] Aryal, M. R., Deshpande, S, Aurisano, J, & Anand, S. "ImVR: Enabling Immersive Design Exploration and Process Integration for Additive Manufacturing of Complex Organic Geometries." *Proceedings of the ASME 2024 19th International Manufacturing Science and Engineering Conference. Volume 1: Additive Manufacturing; Advanced Materials Manufacturing; Biomanufacturing; Life Cycle Engineering.* Knoxville, Tennessee, USA. June 17–21, 2024. V001T01A001. ASME. <https://doi.org/10.1115/MSEC2024-121253>
- [4] Deshpande, S, Aryal, MR, & Anand, S. "Deep Learning-Based Recognition of Manufacturing Components Using Augmented Reality for Worker Training of Assembly Tasks." *Proceedings of the ASME 2024 19th International Manufacturing Science and Engineering Conference.* Knoxville, Tennessee, USA. June 17–21, 2024. V002T07A007. ASME. <https://doi.org/10.1115/MSEC2024-125279>
- [5] Kaye, J., Ramanathan, V., Aryal, M., Anand, S., Tew, J., & Forbes, J. A. (2024). Development of a Neuronavigation-Compatible System for Selective Access of Trigeminal Rootlets in Radiofrequency Lesioning: A Cadaveric Morphometric Study. *Journal of Neurological Surgery Part B: Skull Base,* 85(S 01), S220.
- [6] Xu, A., Venugopal, V., Aryal, M.R. et al. Toward global availability of low-cost, patient-specific cranial implants: creation and validation of automated CranialRebuild freeware application. *Acta Neurochir* **165**, 2219–2224 (2023). <https://doi.org/10.1007/s00701-023-05663-x>

- [7] Forbes, J., Xu, A., Alfawares, Y., Ghalsasi, O., Venugopal, V., **Aryal, M.**, McConaha, M., Cheng, J.; Matur, A.; Yang, G., Ngwenya, L., Anand, S. 170. Towards Global Availability of Patient-Specific Cranial Implants: Creation and Validation of CranialRebuild Freeware Application. *Neurosurgery* 69(Supplement\_1):p 22-23, April 2023. | DOI: 10.1227/neu.0000000000002375\_170
- [8] Alfawares, Y., Matur, A., **Aryal, M.**, Zhang, B., Kaye, J., Andaluz, N., Phillips K., Sedaghat A., Anand S. & Forbes, J. (2023). Toward Motion Preservation across the Craniocervical Junction: Modeling and Design of C1-C2 Prosthetic Following Endonasal Odontoidectomy. *Journal of Neurological Surgery Part B: Skull Base*, 84(S 01), S237.
- [9] **Aryal, M. R.**, & Pun, S. (2022). Additive manufacturing of prosthetic hands: a brief overview. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, 16(3), 1099-1112.
- [10] **Aryal, M. R.**, Pun, S., Yadav, A. K., & Basnet, B. (2021). Study, design, and analysis of geothermal cooling system and its possibilities in the Terai Region of Nepal. *Journal of The Institution of Engineers (India): Series C*, 102, 777-787.
- [11] **Aryal, M.**, Sengupta, S., Rebola, C., & Anand, S. (2025). artCAN AI: Human-AI Co-Creation for Enhanced Well-Being through Digital Art Therapy. *Scientific Reports (Nature)*. Manuscript completed; Under Revision\*.
- [12] **Aryal, M.**, & Anand, S. (2025). Comparing Diffusion-Based Synthetic Models with Physics-Based CAD Rendering for Manufacturing Tool Simulation: A Case Study. *Proceedings of the ASME International Mechanical Engineering Congress & Exposition (IMECE 2025)*. Manuscript prepared\*

## HONORS AND AWARDS

- **Paper Finalist - Student Research Presentation Competition**, Issued by NAMRI/SME Scientific Community, 03/2025
- **Fenton D Snodgrass Memorial Scholarship**, Issued by University of Cincinnati, 09/2024
- **Graduate Student Engineer of the Month**, Issued by the College of Engineering and Applied Sciences (CEAS) at the University of Cincinnati, 05/2024
- **Graduate Research Fellowship Award**, Issued by Graduate Student Government at University of Cincinnati, 04/2024
- **Professor Kirti "Karman" Ghia Endowed Graduate Student Scholarship**, Issued by College of Engineering and Applied Sciences (CEAS) at University of Cincinnati, 03/2024
- **Youngblood Richard Hagedorn Scholarship**, Issued by University of Cincinnati, 01/2024
- **IRIS Graduate Research Fellow**, Issued by Institute for Research in Sensing (IRIS) UC, 08/2023
- **Graduate Incentive Scholarship**, Issued by University of Cincinnati, 08/2021
- **Outstanding Research Article**, Issued by Unity Journal (Nepal Army), 07/2021
- **Outstanding Research Article**, Issued by Japanese Universities Alumni Association Nepal (JUAAN), 06/2021

## PATENTS/INVENTION DISCLOSURE

- [1] **Invention Disclosure:** 2025-093 – Deep Learning-Based Recognition of Manufacturing Components Using Augmented Reality for Worker Training of Assembly Tasks (Contributors: Deshpande, S., **Aryal, M. R.**, Anand, S.)
- [2] **Invention Disclosure:** 2025-075 – IIoT-enabled Digital Twin for legacy and smart factory machines with LLM integration and 2025-076 IIoT-enabled Digital Twin for legacy and smart factory machines with LLM integration (Software Contributors: Gautam, A., **Aryal, M. R.**, Deshpande, S., Padalkar, S., Tang M., Anand, S.)
- [3] **Invention Disclosure:** 2025-065 – artCAN AI: Human-AI Co-Creation for Enhanced Well-Being through Digital Art Therapy and 2025-066 artCAN AI: Human-AI Co-Creation for Enhanced Well-Being through Digital Art Therapy (Software Contributors: **Aryal, M. R.**, Rebola, C., Sengupta, S., Anand, S.)
- [4] **Patent:** Kaye, J., **Aryal, M. R.**, Forbes, J. & Anand, S (2024). U.S. Provisional Application Serial No. 63/568,785
- [5] **Patent:** Venugopal, V., McConaha, M., Ghalsasi, O., Xu, A., Anand, S., Forbes, J., Cheng J. & **Aryal, M. R.** (2023). U.S. Patent Application No. 18/212,873.

## PROFESSIONAL AFFILIATION/ LICENSURE

2023 – Now	Peer-Reviewer, <b>International Journal on Interactive Design and Manufacturing (IJIDeM)</b>	France
2022 - Now	Peer-Reviewer, <b>Journal of the Brazilian Society of Mechanical Sciences and Engineering</b>	Brazil
2022 - 23	Peer-Reviewer, <b>Progress in Additive Manufacturing</b>	United States
2020 - 21	Peer-Reviewer, <b>International Journal of Renewable Energy Research</b>	Thailand
2019 - Now	Certified Mechanical Engineer, <b>Nepal Engineering Council (Registration No. 5243)</b>	Nepal

## STUDENT MENTORING

Mentored Master's students with their research/thesis completion. Below indicated is the current student mentored along with the research topics:

- Anuj Gautam (M.S. Thesis) Application of LLM for Digital Twin of Smart Manufacturing, 2024
- Snehita Kilari (M.S. Thesis) Generation of Digital Twin for AGV/MOV systems, 2025 (Ongoing)