# Tushar Nayak

(412) 478-5677 | tusharn@andrew.cmu.edu | linkedin.com/in/nayaktushar | tushar-nayak.github.io

Deep Learning & Computer Vision Researcher/Engineer focused on multimodal perception, 2D–3D registration and reconstruction, geometric & physics-informed deep learning. Building real-time medical systems that recover structure from sparse visual observations.

## EDUCATION

**Carnegie Mellon University** — Pittsburgh, PA
*Master of Science - Biomedical Engineering (Research) – [3.8/4.0]* — May 2026
- Courses: Computer Vision, Learning for 3D Vision, Computational Modeling & Analysis, Medical Image Analysis.
- TA: Computer Vision, Applied Deep Learning, ML in Biomedical Research, Fundamentals of Computational Bioengineering.
- Awards and Leadership: CMU-BME Department Head's Fellowship, CMU-BME Department Ambassador.

**Manipal Institute of Technology** — Manipal, India
*Bachelor of Technology - Biomedical Engineering, Minor in Data Science* — May 2023
- Awards: Best Paper* - 2nd International Conference on Artificial Intelligence, Computational Electronics & Communication
- Leadership: IEEE-EMBS Student Chapter Chair & Research Head; IEEE-RAS Student Chapter Exec. Board & Webmaster.

## SKILLS

**Deep Learning:** GNNs, Neural ODEs, PINNs, Attention Mechanisms & Transformers, U-Nets, VLMs, Occupancy Networks.
**3D Vision:** Reconstruction, Neural Rendering, Deformable Registration, Implicit Representations, Differential Rendering.
**Computer Vision:** Detection, Segmentation, Multi-view Geometry, Camera Geometry, Optical Flow, Structure from Motion.
**Frameworks:** PyTorch, PyTorch3D, PyGeometric, TorchDiffEq, TensorFlow, Keras, CUDA, OpenCV, Git, Docker, Linux.
**Languages:** Python, MATLAB, C++, R, Julia, LaTeX.

## RESEARCH

**Computational Engineering and Robotics Lab, Carnegie Mellon University** — Pittsburgh, PA
*Graduate Researcher, Real-time 3D Vascular Deformation Estimation* — Aug 2024 – present
- Architected FluoroGRID, a **multi-modal quad-encoder graph neural network** fusing live 2D fluoroscopy feeds with 3D pre-operative volumes to **map 3D deformations from 2D input in real time** to reduce continuous operative radiation.
- Engineered a geometrically regularized loss function leveraging discrete differential geometry to enforce structural limits, achieving **sub-millimeter precision** and real-time inference speeds (**>120fps on CUDA, >30fps on CPU**).
- Built a physics-grounded synthetic data pipeline **simulating viscoelastic tool-tissue interactions and fluoroscopy ray-tracing**, generating an expansive dataset of **370,000+ 3D–2D training data pairs**.

**The ∀ Lab and Image Science Lab, Carnegie Mellon University** — Pittsburgh, PA
*Research Assistant, Longitudinal Glioblastoma Evolution Visual Forecasting* — Feb 2025 – Aug 2025
- Developed a **Neural ODE**-based forecasting pipeline to visually predict longitudinal glioblastoma growth using multimodal MRI.
- Built an **Attention U-Net & temporal embedding model** to simulate the evolution of latent tumor in continuous time.
- Presented findings at the **CMU BME Forum 2025**, currently modeling tumor evolution as an explicit dynamics problem.

**Biomedical Informatics Computing Lab, Manipal Institute of Technology** — Manipal, India
*Undergraduate Researcher, Multi-Stage Multi-Modal Oral Cancer Detection* — Jan 2022 – May 2023
- Designed an ensemble model combining **3 transfer-learning models with self-attention** mechanisms for oral cancer detection.
- Achieved **95% accuracy** across lesion photos, OCT, and histological modalities, with class activation mapping for explainability.
- Published & presented research findings on this pipeline, alongside diagnostic models for Lung Cancer, Mpox, & Dengue*.

## PROJECTS

***Sparse 2D Echocardiograph to 3D Cardiac Volume Reconstruction*** (CMU) — Aug 2025 - present
- Developed **coordinate-based neural implicit representation** model for cardiac volume reconstruction with surface priors from only three sparse 2D echocardiography slices **achieving 3D Dice 0.864 and 3D IoU 0.765** on the MITEA-CAP dataset.
- Implemented **differentiable multi-view projection with learnable pose optimization** for joint slice alignment & geometry recovery, used Fourier positional encoding to capture high-frequency boundaries under sparse supervision.
- Exploring a **stabilized Gaussian occupancy field** pipeline, clubbing differentiable rasterization and pose optimization.

***Deformable 3D Reconstruction of Live Endoscopic Surgical Scenes*** (CMU) — Apr 2026 - present
- Prototyping a **deformable 3D Gaussian Splatting pipeline with VLM semantic embeddings** for endoscopic scenes.
- Preliminary results show a +8.5dB PSNR, 75% depth error reduction, and initial zero-shot text querying on ENDOSCAPES dataset.

***Dual View Mammogram-based Breast Cancer Prediction*** (CMU) — Jan 2026 - May 2026
- Developed a **spatial alignment pipeline** to register MLO mammograms to CC view using breast-mask **centroid matching and affine translation**, for better dual-view feature correspondence by **reducing cross-view centroid distance by 99.91%**.
- Built a **cross-view attention classifier** that fused aligned mammograms for binary prediction at **80%** on CBIS-DDSM dataset.

***Neural PDE-based Anisotropic Diffusion for MRI Denoising*** (CMU) — Feb 2026- Mar 2026
- Unrolled Perona-Malik PDE with **learned conduction weights**, achieving **+23% PSNR** and **47% lower Edge MSE** on BR35H.

***Perception and Visual Learning*** (Education Team, Open Horizon Robotics) — Mar 2026 - present
- Authoring a **comprehensive open-source computer vision course** covering Classical 2D Vision, Deep Learning for Vision, 3D Computer Vision, Vision Geometries, Image-based Localization & Mapping, Vision Synthesis and Perception Physics.