Vivek Gopalakrishnan

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Research Overview

I am a 4th year PhD candidate in Medical Engineering and Medical Physics at the Harvard-MIT Program in Health Sciences and Technology. My research centers on *patient-specific machine learning*, developing personalized, physics-informed computer vision models capable of extracting 3D information from 2D imaging. I am particularly interested in applications in diagnostics, image-guided interventions, and surgical robotics.

Research Areas: *computer vision, medical physics, X-ray imaging, biomedical image analysis.*

Education

Massachusetts Institute of Technology   *2021 - Present*
Ph.D. in Medical Engineering and Medical Physics   Advisor: Polina Golland

Johns Hopkins University   *2020 - 2021*
M.S.E. in Biomedical Engineering   Advisors: Joshua Vogelstein and Carey Priebe

Johns Hopkins University   *2017 - 2021*
B.S. in Biomedical Engineering   Advisor: Joshua Vogelstein

Research Experience

Computer Science and Artificial Intelligence Laboratory, MIT   *2021 - Present*

- PhD candidate in the Medical Vision Group building intelligent intraoperative image guidance systems.
- Developed `DiffDRR`, an open-source differentiable X-ray renderer with over 50,000 downloads [W1].
- Developed `xvr`, the first 2D/3D registration algorithm to achieve consistent sub-mm accuracy [C8, P1].
- Building 3D vision systems for neurosurgery [C9, C10], orthopedics [C5, A1], and radiotherapy [P2].
- Collaborating with surgical robotics startups to integrate these algorithms into FDA-approved devices.

Department of Biomedical Engineering, Johns Hopkins University   *2018 - 2021*

- Undergraduate researcher in the NeuroData Lab studying statistical graph theory for neuroscience.
- Developed novel machine learning algorithms to analyze populations of graph-valued data [C4, C11].
- Applied these methods to discover neuroconnectively similar subtypes of autism spectrum disorder from multi-subject connectomics data [C3].

Publications

Journals and Full-length Conference Proceedings

C11 **Vivek Gopalakrishnan**, Jaewon Chung, Eric Bridgeford, Benjamin Pedigo, Jesús Arroyo, Lucy Upchurch, G. Allan Johnson, Nian Wang, Youngser Park, Carey Priebe, and Joshua Vogelstein. "Multiscale Comparative Connectomics". *Imaging Neuroscience*, 2025.

C10 Sarah Frisken, **Vivek Gopalakrishnan**, David Chlorogiannis, Nazim Haouchine, Alexandre Cafaro, Alexandra Golby, William Wells, and Rose Du. "Spatiotemporally Constrained 3D Reconstruction from Biplanar Digital Subtraction Angiography". *International Journal of Computer Assisted Radiography and Surgery*, 2025.

C9   Charles Downs, Matthijs van der Sluijs, Sandra A.P. Cornelissen, Frank te Nijenhuis, Robert van Oostenbrugge, Wim H. van Zwam, **Vivek Gopalakrishnan**, Xucong Zhang, Ruisheng Su, and Theo van Walsum. "Improving Automatic Cerebral 3D-2D CTA-DSA Registration". *International Journal of Computer Assisted Radiology and Surgery*, 2025.

C8   **Vivek Gopalakrishnan**, Neel Dey, and Polina Golland. "Intraoperative 2D/3D Image Registration via Differentiable X-ray Rendering". *Computer Vision and Pattern Recognition (CVPR)*, 2024.
🏆 **Best Poster Award** at the MIT-MGB AI Cures Conference.

C7   Joshua Marchant, Natalie Ferris, Diana Grass, Magdelena Allen, **Vivek Gopalakrishnan**, Mark Olchanyi, Devang Sehgal, Maxina Sheft, Amelia Strom, Berkin Bilgic, Brian Edlow, Elizabeth Hillman, Meher Juttukonda, Laura Lewis, Shahin Nasr, Aapo Nummenmaa, Jonathan Polimeni, Roger Tootell, Lawrence Wald, Hui Wang, Anastasia Yendiki, Susie Huang, Bruce Rosen, Randy Gollub. "Mesoscale Brain Mapping: Bridging Scales and Modalities in Neuroimaging". *Neuroinformatics*, 2024.

C6   Sarah Frisken, Nazim Haouchine, David Chlorogiannis, **Vivek Gopalakrishnan**, Alexandre Cafaro, William Wells, Alexandra Golby, Rose Du. "VESCL: An Open-Source 2D Vessel Contouring Library". *International Journal of Computer Assisted Radiography and Surgery*, 2024.

C5   Andrew Abumoussa, **Vivek Gopalakrishnan**, Benjamin Succop, Michael Galgano, Sivakumar Jaikumar, Yueh Lee, and Deb Bhowmick. "Machine Learning for Automated and Real-Time 2D-3D Registration of the Spine Using Only a Single Radiograph". *Neurosurgical Focus*, 2023.

C4   Jaewon Chung, Eric Bridgeford, Jesus Arroyo, Benjamin Pedigo, Ali Saad-Eldin, **Vivek Gopalakrishnan**, Liang Xiang, Carey Priebe, and Joshua Vogelstein. "Statistical Connectomics". *Annual Review of Statistics and Its Application*, 2021.

C3   Nian Wang, Robert Anderson, David Ashbrook, **Vivek Gopalakrishnan**, Youngser Park, Carey Priebe, Yi Qi, Rick Laoprasert, Joshua Vogelstein, Robert Williams, and G. Allan Johnson. "Variability and Heritability of Mouse Brain Structure: Microscopic MRI Atlases and Connectomes for Diverse Strains". *NeuroImage*, 2020.

C2   **Vivek Gopalakrishnan**, Eliezer Bose, Usha Nair, Yuwei Cheng, and Musie Ghebremichael. "Pre-HAART CD4+ T-Lymphocytes as Biomarkers of Post-HAART Immune Recovery in HIV-Infected Children with or without TB Co-Infection". *BMC Infectious Diseases*, 2020.

C1   Jong Soo Lee, Elijah Paintsil, **Vivek Gopalakrishnan**, and Musie Ghebremichael. "A Comparison of Machine Learning Techniques for Classification of HIV Patients with Antiretroviral Therapy-Induced Mitochondrial Toxicity". *BMC Medical Research Methodology*, 2019.

Preprints

P2   **Vivek Gopalakrishnan**, Neel Dey, and Polina Golland. "PolyPose: Localizing Deformable Anatomy in 3D from Sparse 2D X-ray Images using Polyrigid Transforms". *arXiv*, 2025 (*Under Review*).

P1   **Vivek Gopalakrishnan**, Neel Dey, David Chlorogiannis, Andrew Abumoussa, Darren B. Orbach, Sarah Frisken, and Polina Golland. "Rapid Patient-Specific Neural Networks for Intraoperative X-ray to Volume Registration". *arXiv*, 2025 (*Under Review*).

Peer-Reviewed Workshops

W5   Federica Facente, Benjamin Billot, **Vivek Gopalakrishnan**, Manasi Kattel, Wen Wei, Polina Golland, Hervé Delingette, Nicholas Ayache, Pierre Berthet-Rayne. "Multi-stage CNN for Fast Registration of 3D Preoperative CTs to 2D Intraoperative X-rays". *Collaborative Intelligence and Autonomy in Image-guided Surgery Workshop at MICCAI*, 2025 (to appear).

W4   Noe Bertramo, Gabriel Duguey, and **Vivek Gopalakrishnan**. "DiffUS: Differentiable Ultrasound Rendering from Volumetric Imaging". *Advances in Simplifying Medical Ultrasound Workshop at MICCAI*, 2025 (to appear).

W3   Mohammadhossein Momeni*, **Vivek Gopalakrishnan***, Neel Dey, Polina Golland, and Sarah Frisken. "Differentiable Voxel-based X-ray Rendering Improves Sparse-View 3D CBCT Reconstruction". *Machine Learning and the Physical Sciences Workshop at NeurIPS*, 2024.

W2 **Vivek Gopalakrishnan**, Jingzhe Ma, and Zhiyong Xie. "Grad-CAMO: Learning Interpretable Single-Cell Morphological Profiles from 3D Cell Painting Images". *Computer Vision for Microscopy Image Analysis Workshop at CVPR*, 2024.
🏆 **President's Innovation Award** from the Society of Biomolecular Imaging and Informatics.

W1 **Vivek Gopalakrishnan** and Polina Golland. "Fast Auto-Differentiable Digitally Reconstructed Radiographs for Solving Inverse Problems in Intraoperative Imaging". *Clinical Image-based Procedures Workshop at MICCAI*, 2022.

Abstracts

A1 Michael Hachadorian and **Vivek Gopalakrishnan**. "Recovery of 3D Component Position in Reverse Shoulder Arthroplasty from Postoperative Radiographs via 2D/3D Registration". *American Shoulder and Elbow Surgeons Fellows' Symposium*, 2025.

Invited Talks

Patient-Specific Machine Learning for 3D Intraoperative Image Guidance

- *United Imaging Intelligence*, Boston, MA — 2025
- *Noah Medical*, San Francisco, CA — 2025
- *Indian Institute of Science*, Bangalore, India — 2025
- *GE HealthCare AI*, Bangalore, India — 2025
- *Boston Medical Imaging Workshop*, MIT, Cambridge, MA — 2024

Differentiable X-ray Rendering for Fast Intraoperative 2D/3D Image Registration

- *GE HealthCare AI*, Bangalore, India — 2024
- *MIT Visual Computing Seminar*, Cambridge, MA — 2024

Learning Interpretable Single-Cell Morphological Profiles from 3D Cell Painting Images

- *Society of Biomolecular Imaging and Informatics*, Boston, MA — 2023

Fast Auto-Differentiable DRRs for Intraoperative Imaging Problems

- *Boston Medical Imaging Workshop*, Brigham and Women's Hospital, Boston, MA — 2022
- *Image-Guided Neurosurgery Meeting*, Boston, MA — 2022
- *Medical Image Computing and Computer Assisted Interventions CLIP*, Singapore — 2022

Multiscale Comparative Connectomics

- *Presentations by Undergraduates in Life Sciences and Engineering*, Baltimore, MD — 2021
- *PathAI*, Online — 2021
- *Neuromatch Conference*, Online — 2020

Mentorship

Research

- Zengtian Deng (PhD), UCLA — Summer 2025
  Co-supervised with Dr. Bibo Shi, Noah Medical
  Project: Implementing **xvr** [P1] in a deployed robotic surgical system

- Michelle Wu (Undergrad), MIT — Summer 2025
  Co-supervised with Professor Polina Golland, MIT
  Project: A fully automated system for postoperative evaluation of shoulder replacement surgery

- Jonathan Tjandra (Undergrad), MIT   Spring 2025
  Co-supervised with Professor Polina Golland, MIT
  Project: Learning to identifying lung nodules from chest radiographs from synthetic data

- Erik Xie (Undergrad), MIT   Fall 2024 & Spring 2025
  Co-supervised with Professor Polina Golland, MIT
  Project: Custom CUDA kernels for accelerated X-ray rendering

- Hossein Momeni (Undergrad), Truman State University   Summer 2024 & Fall 2024
  Co-supervised with Professor Sarah Frisken, Harvard Medical School
  Project: Differentiable X-ray rendering improves Sparse-view 3D CBCT reconstruction [W3]
  Current position: PhD student at UC Berkeley (EECS)

Community

- Graduate Resident Advisor, McCormick Hall, MIT   2024 - Present

Teaching

Advances in Computer Vision (Graduate)   Spring 2025
Head Teaching Assistant, Massachusetts Institute of Technology

NeuroData Design II (Undergraduate/Graduate)   Spring 2021
Head Teaching Assistant, Johns Hopkins University

NeuroData Design I (Undergraduate/Graduate)   Fall 2020
Head Teaching Assistant, Johns Hopkins University

Computational Cardiology Laboratory (Undergraduate)   Fall 2020
Teaching Assistant, Johns Hopkins University

Linear Algebra (Undergraduate)   Fall 2020
Teaching Assistant, Johns Hopkins University

Service

PhD Interview Committee, Harvard-MIT Health Sciences and Technology	2025
Reviewer, Medical Image Analysis (MEDIA)	2025
Reviewer, Information Processing in Medical Imaging (IPMI)	2025
Reviewer, IEEE Transactions on Medical Imaging (🏆 *Distinguished Reviewer*)	2024
Reviewer, Journal of Imaging Informatics in Medicine	2024
Reviewer, Medical Imaging Computing and Computer Assisted Interventions (MICCAI)	2024, 2025
Reviewer, Medical Imaging with Deep Learning (MIDL)	2024
Reviewer, NeurIPS Medical Imaging meets NeurIPS Workshop	2023
Reviewer, ICLR Neural Fields across Fields Workshop	2023

Fellowships

MIT HEALS Graduate Fellowship, MIT	2025
Neuroimaging Training Program Grant, MIT	2024
Takeda Fellowship, MIT	2023
Neuroimaging Training Program Grant, MIT	2022
Joseph C. Pistritto Research Fellowship, Johns Hopkins University	2019

Awards

Rising Star in AI, University of Michigan	2025
Best Poster Award, MIT-MGB AI Cures Conference	2024
President's Innovation Award, Society of Biomolecular Imaging and Informatics	2023
Provost's Undergraduate Research Award, Johns Hopkins University	2020
Fondazione Bruno Kessler Internship Award, Intel International Science and Engineering Fair	2017
Second Place Winner, Microbiology, Intel International Science and Engineering Fair	2017
Semi-Finalist, Regeneron Science Talent Search	2017
Second Place Winner, Massachusetts State Science & Engineering Fair	2017
Second Place Winner, Massachusetts State Science & Engineering Fair	2016

Software

`xvr`: Training patient-specific 2D/3D registration models in 5 min	2025
Primary author and maintainer (https://github.com/eigenvivek/xvr/)	
`DiffDRR`: GPU-accelerated & differentiable X-ray rendering in PyTorch	2022
Primary author and maintainer (https://github.com/eigenvivek/DiffDRR/)	