Vivek Gopalakrishnan

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Research Overview

I am a fourth-year PhD candidate in the Harvard-MIT Program in Health Sciences and Technology, advised by Dr. Polina Golland. The goal of my research is to address unmet clinical needs through the development of biomedical machine learning methods, deepening our ability to understand and treat disease. My current focus is on making minimally invasive surgery easier for clinicians and safer for patients by designing fast 3D computer vision algorithms that advance the standard of intraoperative image guidance.

Research Areas: *computer vision, medical physics, image-guided surgery, diagnostics.*

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 student in the Medical Vision Group. Developed `DiffDRR`, a differentiable X-ray renderer, and maintain an open-source PyTorch implementation with 150+ stars [W1]. Used `DiffDRR` to develop patient-specific 2D/3D registration algorithms with sub-millimeter accuracy [C5, C8] and unsupervised cone-beam computed tomography reconstruction methods [W3]. Currently using synthetic X-ray generation to train 3D image guidance systems for minimally invasive surgery and diagnostic algorithms for difficult-to-detect diseases.

Department of Biomedical Engineering, Johns Hopkins University   *2018-2021*
Undergraduate researcher in the Neurodata Lab. Developed novel machine learning algorithms to analyze populations of graph-valued objects [C4, C10]. Applied these methods to discover neuroconnectively similar subtypes of autism spectrum disorder from multigraph 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. "Constrained 2D-to-3D Reconstruction from Biplanar Digital Subtraction Angiography". *International Journal of Computer Assisted Radiology and Surgery*, 2025 (*to appear*).

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 (*to appear*).

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.

Peer-Reviewed Workshops

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.

Preprints

P2 **Vivek Gopalakrishnan**, Neel Dey, and Polina Golland. "Deformable 2D/3D Registration without Regularization via Polyrigid Transformations". *arXiv*, 2025 (*to appear*).

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.

Invited Talks

CV in the OR: Differentiable X-ray Rendering for Intraoperative Inverse Problems

- *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: Quickly Solving 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* 2021
  Faculty-selected speakers from Johns Hopkins, Morgan State, and Coppin State University
- *PathAI*, Online 2021
- *Neuromatch Conference*, Online 2020

Awards

Best Poster Award, MIT-MGB AI Cures Conference 2024
Neuroimaging Training Program Grant, MIT 2024
President's Innovation Award, Society of Biomolecular Imaging and Informatics 2023
Takeda Fellowship, MIT 2023
Neuroimaging Training Program Grant, MIT 2022
Provost's Undergraduate Research Award, Johns Hopkins University 2020
Joseph C. Pistritto Research Fellowship, Johns Hopkins University 2019

Mentorship

Research

- Michelle Wu (Undergrad), MIT Summer 2025
  Co-supervised with Professor Polina Golland, MIT

- Jonathan Tjandra (Undergrad), MIT Spring 2025
  Co-supervised with Professor Polina Golland, MIT

- Erik Xie (Undergrad), MIT Fall 2024 & Spring 2025
  Co-supervised with Professor Polina Golland, MIT

- Hossein Momeni (Undergrad), Truman State University Summer 2024 & Fall 2024
  Co-supervised with Professor Sarah Frisken, Harvard Medical School
  Current position: Incoming PhD student at UC Berkeley (EECS)

Community

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

Teaching

6.8300 Advances in Computer Vision (Graduate)   Spring 2025
Head Teaching Assistant, Massachusetts Institute of Technology

EN.BME.438/638 NeuroData Design II (Undergraduate/Graduate)   Spring 2021
Head Teaching Assistant, Johns Hopkins University

EN.BME.437/637 NeuroData Design I (Undergraduate/Graduate)   Fall 2020
Head Teaching Assistant, Johns Hopkins University

EN.BME.487 Computational Cardiology Laboratory (Undergraduate)   Fall 2020
Teaching Assistant, Johns Hopkins University

AS.MATH.201 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

Software

`xvr`: Training patient-specific 2D/3D registration models in 5 min   2025
    Primary author and maintainer (https://github.com/eigenvivek/xvr/)
`DiffPose`: A toolbox for patient-specific 2D/3D registration   2024
    Primary author and maintainer (https://github.com/eigenvivek/DiffPose/)
`DiffDRR`: GPU-accelerated & differentiable X-ray rendering in PyTorch   2022
    Primary author and maintainer (https://github.com/eigenvivek/DiffDRR/)