Vivek Gopalakrishnan

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Research Overview

I am a fourth-year PhD candidate in Medical Engineering and Medical Physics at 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 that deepen our ability to understand and treat disease. My current focus is on developing scalable synthetic data generation strategies to solve challenging problems in diagnostic and interventional radiology.

Research Areas: *computer vision, 2D/3D reconstruction, image-guided surgery, image-based 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

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 100+ 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.

Xellar Biosystems, Newton, MA *Summer 2023*
Discovered mechanisms by which supervised deep learning models in drug discovery cheat by exploiting confounding factors, and developed an interpretability metric to quantify the level of confounding [W2].

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, P1]. Applied these methods to discover neuroconnectively similar subtypes of autism spectrum disorder from multigraph connectomics data [C3].

Ragon Institute of MGH, MIT and Harvard, Cambridge, MA *Summer 2018*
Developed predictive models of disease progression and immune recovery in HIV-positive children with TB co-infection using survival analysis [C2], and identified biomarkers for antiretroviral toxicity by applying machine learning methods to data from patients with HIV [C1].

Tufts University BioSeq Program, Somerville, MA *2016-2017*
Proposed and conducted independent high school research using next-generation sequencing (NGS) to generate a novel human oral microbiome dataset. Analyzed NGS data to identify microbial markers of oral health. Presented at the 2017 Intel International Science and Engineering Fair.

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
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

Publications

Journals and Full-length Conference Proceedings

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

P1 **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". 2022.

Invited Talks

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

Teaching

6.8300 Advances in Computer Vision (Graduate)   Spring 2025
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

Mentorship

Academic

- Mohammadhossein Momeni (Undergrad), Truman State University   Summer 2024 & Fall 2024
  Co-supervised with Professor Sarah Frisken, Harvard Medical School
- Erik Xie (Undergrad), MIT   Fall 2024
  Co-supervised with Professor Polina Golland, MIT

Community

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

Service

Reviewer, IEEE Transactions on Medical Imaging (🏆 *Distinguished Reviewer, 2024*)   2024
Reviewer, Journal of Imaging Informatics in Medicine   2024
Reviewer, Medical Imaging Computing and Computer Assisted Interventions (MICCAI)   2024
Reviewer, Medical Imaging with Deep Learning (MIDL)   2024

Software

`DiffDRR`: GPU-accelerated & auto-differentiable digitally reconstructed radiographs in PyTorch   2022
     Primary author and maintainer (https://github.com/eigenvivek/DiffDRR/)