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Vivek Gopalakrishnan

I am a third-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 making minimally invasive neurosurgery easier for clinicians and safer for patients by designing fast 3D computer vision algorithms that advance the standard of intraoperative image guidance.

Education

2021-   **Massachusetts Institute of Technology**, Cambridge, MA
PhD in Medical Engineering and Medical Physics (*Concentration:* Computer Science)
Advisor: Dr. Polina Golland

2020-2021   **Johns Hopkins University**, Baltimore, MD
MS in Biomedical Engineering (*Concentration:* Biomedical Data Science)
Thesis: *Multiscale Statistical Hypothesis Testing for k-Sample Graph Inference*
Advisors: Dr. Joshua Vogelstein and Dr. Carey Priebe

2017-2021   **Johns Hopkins University**, Baltimore, MD
BS in Biomedical Engineering (*Concentration:* Biomedical Data Science)

Research Experience

2021-   **MIT Computer Science and Artificial Intelligence Laboratory**, Cambridge, MA
PhD candidate in the Medical Vision Group. Developing novel neural field architectures to reconstruct 3D cerebrovasculature from latent fluid dynamic information encoded in cerebral angiograms (in collaboration with neurosurgery faculty at Harvard Medical School). Particular emphasis on fast and robust optimization methods [J5, J6, J8]. **This work received the Best Poster Award at the MIT-MGB AI Cures Conference 2024.**

Summer 2023   **Xellar Biosystems**, Newton, MA
Computer vision intern developing methods to analyze single 3D cells from z-stack fluorescence microscopy for advanced drug discovery [A2, J9]. **This work received the President's Innovation Award from the Society for Biomolecular Imaging and Informatics.**

2020-2021   **Johns Hopkins University**, Baltimore, MD
Team leader and project manager for an undergraduate design team. Developed a multimodal spatio-temporal registration algorithm to power a dynamic fusion image guidance system for minimally invasive heart surgery.

2018-2021   **Johns Hopkins University**, Baltimore, MD
Undergraduate researcher in the Neurodata Lab. Developed novel machine learning algorithms to analyze populations of graph-valued objects [J5, J4]. Applied these methods to discover neuroconnectively similar subtypes of autism from multigraph connectomics data [A1, J2].

Summer 2018   **Ragon Institute of MGH, MIT and Harvard**, Cambridge, MA
Developed predictive models of disease progression and immune recovery in HIV-positive children with TB co-infection [J3], and identified biomarkers for antiretroviral toxicity by applying machine learning methods to data from patients with HIV [J1].

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

Fellowships & Awards

2024	**Best Poster Award**, MIT-MGB AI Cures Conference
2023	**President's Innovation Award**, Society of Biomolecular Imaging and Informatics
2023	**Takeda Fellowship**, MIT
2022	**Neuroimaging Training Program Grant**, MIT
2020	**Provost's Undergraduate Research Award**, Johns Hopkins University
2019	**Joseph C. Pistritto Research Fellowship**, Johns Hopkins University
2017	**Internship Award at Fondazione Bruno Kessler**, 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
2016	**Second Place Winner**, Massachusetts State Science & Engineering Fair

Publications

PAPERS

[J9] **Vivek Gopalakrishnan**, Jingzhe Ma, and Zhiyong Xie. "Grad-CAMO: Learning Interpretable Single-Cell Morphological Profiles from 3D Cell Painting Images". *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops* (Jun. 2024). arXiv: 2403.17615.

[J8] **Vivek Gopalakrishnan**, Neel Dey, and Polina Golland. "Intraoperative 2D/3D Image Registration via Differentiable X-ray Rendering". *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition* (Jun. 2024). arXiv: 2312.06358.

[J7] 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* (Jun. 2023). doi: 10.3171/2023.3.FOCUS2345

[J6] **Vivek Gopalakrishnan** and Polina Golland. "Fast Auto-Differentiable Digitally Reconstructed Radiographs for Solving Inverse Problems in Intraoperative Imaging". *Clinical Image-based Procedures: 11th International Workshop, CLIP 2022, Held in Conjunction with MICCAI 2022, Singapore, Proceedings.* (Sept. 2022) arXiv: 2208.12737 [cs.CV]
Nominated for Best Paper Award

[J5] **Vivek Gopalakrishnan**, Jaewon Chung, Eric Bridgeford, Benjamin D. Pedigo, Jesús Arroyo, Lucy Upchurch, G. Allan Johnson, Nian Wang, Youngser Park, Carey E. Priebe, and Joshua T. Vogelstein. "Discovery of Multi-Level Network Differences Across Populations of Heterogeneous Connectomes". (Apr. 2022). arXiv: 2011.14990 [q-bio, stat].

[J4] Jaewon Chung, Eric Bridgeford, Jesus Arroyo, Benjamin D. Pedigo, Ali Saad-Eldin, **Vivek Gopalakrishnan**, Liang Xiang, Carey E Priebe, and Joshua T Vogelstein. "Statistical Connectomics". *Annual Review of Statistics and Its Application* (Mar. 2021). doi: 10.1146/annurev-statistics-042720-023234

[J3] **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* (Oct. 2020). doi: 10.1186/s12879-020-05458-w.

[J2] Nian Wang, Robert J Anderson, David G Ashbrook, **Vivek Gopalakrishnan**, Youngser Park, Carey E Priebe, Yi Qi, Rick Laoprasert, Joshua T Vogelstein, Robert W Williams, and G Allan Johnson. "Variability and Heritability of Mouse Brain Structure: Microscopic MRI Atlases and Connectomes for Diverse Strains". *NeuroImage* (Aug. 2020). doi: 10.1016/j.neuroimage.2020.117274.

[J1] 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 from Those Without Mitochondrial Toxicity". *BMC Medical Research Methodology* (Nov. 2019). doi: 10.1186/s12874-019-0848-z.

ABSTRACTS

[A2] **Vivek Gopalakrishnan**, Jingzhe Ma, and Zhiyong Xie. "Learning Interpretable Single-Cell Morphological Profiles from 3D Cell Painting Images". *Society of Biomolecular Imaging and Informatics 2023, Boston.* (Oct. 2023).
President's Innovation Award

[A1] **Vivek Gopalakrishnan** and Joshua Vogelstein. "Towards Discovering Heterogeneity in Autism via Multi-Network Connectomics". *Biomedical Engineering Society 2019, Philadelphia.* (Oct. 2019).

Invited Talks

2024 **GE HealthCare AI**, Bangalore, India
Differentiable X-ray Rendering for Fast Intraoperative 2D/3D Image Registration
MIT Visual Computing Seminar, Cambridge, MA
Differentiable X-ray Rendering for Fast Intraoperative 2D/3D Image Registration

2023 **Society of Biomolecular Imaging and Informatics**, Boston, MA
Learning Interpretable Single-Cell Morphological Profiles from 3D Cell Painting Images

2022 **Boston Medical Imaging Workshop**, Brigham and Women's Hospital, Boston, MA
Fast Auto-Differentiable DRRs: Quickly Solving Intraoperative Imaging Problems
Image-Guided Neurosurgery Meeting, Boston, MA
Fast Auto-Differentiable DRRs: Quickly Solving Intraoperative Imaging Problems
Medical Image Computing and Computer Assisted Interventions CLIP, Sentosa, Singapore
Fast Auto-Differentiable DRRs: Quickly Solving Intraoperative Imaging Problems

2021 **Presentations by Undergraduates in Life Sciences and Engineering**, Online
Multiscale Comparative Connectomics
Co-hosted by Johns Hopkins, Morgan State, and Coppin State University (faculty-selected speaker)
PathAI, Online
Multiscale Comparative Connectomics

2020 **Neuromatch Conference**, Online
Statistical Methods for Multiscale Comparative Connectomics (https://youtu.be/JgnHR6Bwef8)

Teaching Experience

HARVARD-MIT

Spring 2023 **Teaching Assistant**, PRISM Science Club, *Ragon Institute*

JOHNS HOPKINS UNIVERSITY

Spring 2021 **Head Teaching Assistant**, NeuroData Design II, *EN.BME.438/638*
Fall 2020 **Head Teaching Assistant**, NeuroData Design I, *EN.BME.437/637*
Fall 2020 **Teaching Assistant**, Computational Cardiology Laboratory, *EN.BME.487*
Fall 2020 **Teaching Assistant**, Linear Algebra, *AS.MATH.201*
2018-2020 **Head PILOT Leader**, Linear Algebra and Multivariable Calculus, *Department of Academic Support*

Software

2022 `DiffDRR`: GPU-accelerated & auto-differentiable digitally reconstructed radiographs in PyTorch
Primary author and maintainer (https://github.com/eigenvivek/DiffDRR/)
`Gershgorin.jl`: Visualizing the Gershgorin discs of a matrix
Primary author and maintainer (https://github.com/eigenvivek/Gershgorin.jl)
2021 `graspologic`: Package for graph statistical algorithms
Contributor (https://github.com/microsoft/graspologic)

Service

2024	**Reviewer**, IEEE Transactions on Medical Imaging
2024	**Reviewer**, Medical Image Computing and Computer Assisted Interventions 2024
2024	**Reviewer**, Medical Imaging with Deep Learning 2024
2023	**Reviewer**, NeurIPS 2023 Medical Imaging meets NeurIPS Workshop
2023	**Reviewer**, ICLR 2023 Neural Fields across Fields Workshop