Statement of Purpose

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My fascination with machine learning methods used to accelerate progress in biomedical fields was fostered by my experiences as an undergraduate working on projects ranging from predicting rib cage structures to mapping out blood vessel networks. Looking ahead, I believe that pursuing a **PhD in Computer Science and Engineering at University of Washington** will prepare me for a research career focused on developing **deep learning techniques that are widely applicable across neuroscience and medicine.**

A few weeks into my freshman year at Boston College, I applied to work at Prof. Donglai Wei's Computer Vision Lab. Having prior experience with computer vision techniques in interdisciplinary settings, I was intrigued by the lab's specialization in **connectomics**—a field focused on **reconstructing the brain's wiring diagram from small samples of tissue imaged at nanometer resolutions**. Over the course of a few months navigating the literature, acquainting myself with the PyTorch Connectomics codebase, and figuring out how to submit SLURM jobs on the Boston College Linux Cluster, connectomics was demystified ever so slightly.

Through my first research project at the lab, I was introduced to Shixuan Gu, who was then a master's student at Carnegie Mellon University. He hypothesized that the Frenet-Serret formulas from differential geometry could be used to improve the detection of aneurysms and synaptic connections by "straightening" blood vessel and dendrite geometries before they are fed into machine learning models. After I implemented and ran experiments for dendritic spine segmentation, we hastily prepared a manuscript detailing how enforcing this equivariance allowed our **point cloud models** to maintain high performance with **significantly less data and fewer augmentations** on our datasets. Despite my eagerness to land my first deep learning publication, our submission was rejected at MICCAI 2023.

Taking feedback from the rebuttal to heart, I evaluated the performance of modern point cloud architectures, implemented 5-fold cross-validation across our benchmarks, and manually inspected our annotations for the 4,476 dendritic spines we had. I performed detailed analyses studying how our transform induced cross-domain generalization—allowing models trained on the dendrites in the mouse somatosensory cortex to demonstrate **strong zero-shot performance on structures in the mouse visual cortex and human frontal lobe**. We submitted the manuscript to IEEE Transactions on Medical Imaging last month [D]. While I hope to do work that accelerates scientific progress, this project taught me that proper science is "slow," requiring meticulous attention to detail and the humility to recognize mistakes.

During the summer of 2023, I was awarded a $4,800 stipend by the Boston College Eagle Intern Fellowship, which gave me the opportunity to branch out into **biomedical imaging** as an intern at the EPFL CVLab in Switzerland. Under the guidance of Dr. Jiancheng Yang and Prof. Pascal Fua, I contributed to the **Heart Augmented Reality Training System**, which aimed to develop a **surgery simulator for practicing catheter insertion**. The setup involved a simple box equipped with cameras to track catheter movements, which were mapped onto a 3D heart model displayed on screen, providing a more interactive training experience.

Sitting across from two PhD students, I gained valuable insights into their work on applying neural fields to novel view synthesis and implicit surface representation problems. Incorporating what I had learned, I was tasked with integrating models pretrained on the TotalSegmentator organ segmentation dataset with Dr. Yang's prior work on **latent-conditioned shape templates**—in order to **generate anatomically correct heart models from patients' MRI scans**. This work was published at the International Conference on Medical Image Computing and Computer Assisted Intervention 2024 [G]. Besides showing me how integral the exchange of ideas is to the research process, the internship allowed me to see that machine learning tools were not merely academic, having real promise in improving patient outcomes.

Longer term, **I aspire to become a professor to follow my passions for both research and mentoring**. My commitment to making education more accessible has been shaped by my experiences dealing with **financial constraints as a first-generation American** of Indonesian descent—I am grateful for the full-tuition scholarship and need-based aid that made my undergraduate studies possible. To pay it forward, I have taken on teaching roles in Boston and Indonesia and I intend to continue volunteering in Seattle.

Currently, my research spans three projects: enhancing the PyTorch Connectomics framework using segmentation-guided contrastive learning foundation models, clustering neurons in fresh-water polyps [B] using translation and rotation equivariant autoencoders [A], and adapting cell tracking solutions to extract whole-brain neural dynamics in roundworms [C]. I am broadly interested in exploring the applications of deep learning in neuroscience and medicine.

In addition to my previous projects predicting anatomical structures in CT and MRI scans [G, H], my work on multi-seed tracking schemes—which adapt the Segment Anything Model (SAM) for vessel detection in volumetric images [E]—aligns with **Prof. Sheng Wang's** line of research on **biomedical** foundation models. Moreover, my extensive experience with microscopy positions me to support Prof. Wang's recent push to advance super-resolution models for chemical imaging.

On the **neuroscience** side of things, my past research has largely focused on developing segmentation models for dendrites [D], synaptic vesicles [A, B, F], and cerebral vasculature [D, E]. Last summer, I expanded on this work by developing benchmarks for neural activity trace extraction to promote progress in reverse engineering the nervous system of *C. elegans* [C]. Going forward, I hope to study how machine learning can be leveraged to better understand cognition while also investigating neuro-inspired architectures. In particular, I find **Prof. Rajesh Rao's** work on using self-supervised learning to train more effective neural decoders and **Prof. Matthew Golub's** use of brain-machine interfaces to detect memories especially compelling.

I am also applying to the NSF Graduate Research Fellowship Program, DOD National Defense Science and Engineering Graduate Fellowship Program, DOE Computational Science Graduate Fellowship, Paul & Daisy Soros Fellowships for New Americans, and Graduate Fellowships for STEM Diversity to seek additional funding.

I believe that my interdisciplinary background, spanning vision foundation models, imaging modalities, and biomedical applications, has uniquely prepared me to contribute to rigorous research at University of Washington.

References *(* indicates equal contribution)*

[A] **Jason K. Adhinarta***, Yutian Fan*, Michael Lin*, Richard Ren*, Micaela Roth*, Ayal Yakobe*, Shulin Zhang*, Rafael Yuste, Donglai Wei. **VesicleEM: A Comprehensive Vesicle Analysis Toolbox for Volumetric Electron Microscopy**. Manuscript in preparation; planned submission to PLOS Computational Biology.

[B] Shulin Zhang, Netanel Ofer, Wataru Yamomoto, Richard Schalek, Yuelong Wu, Christoph Dupre, **Jason K. Adhinarta**, Yutian Fan, Michael Lin, Micaela Roth, Ben Cox, Celina Juliano, Donglai Wei, Jeff Lichtman, Rafael Yuste. **Connectomic analysis of the *Hydra vulgaris* endoderm: cell types and vesicles**. Manuscript in preparation; planned submission to Current Biology.

[C] **Jason K. Adhinarta***, Jizheng Dong*, Tianxiao He*, Junxiang Huang*, Daniel Sprague*, Jia Wan, Hyun Jee Lee, Zikai Yu, Hang Lu, Eviatar Yemini, Saul Kato, Erdem Varol, Donglai Wei. **WormND: A Benchmark for Extracting Whole-Brain Neural Dynamics of *C. elegans* at the Neuron Resolution**. Manuscript under revision.

[D] Shixuan Gu, **Jason K. Adhinarta**, Mikhail Bessmeltsev, Jiancheng Yang, Jessica Zhang, Wenjie Yin, Daniel Berger, Jeff W. Lichtman, Hanspeter Pfister, Donglai Wei. **Frenet-Serret Frame-based Decomposition for Part Segmentation of 3D Curvilinear Structures**. Under review at IEEE Transactions on Medical Imaging. arXiv:2404.14435

[E] Jia Wan, Wanhua Li, **Jason K. Adhinarta**, Atmadeep Banerjee, Evelina Sjostedt, Jingpeng Wu, Jeff Lichtman, Hanspeter Pfister, Donglai Wei. **TriSAM: Tri-Plane SAM for zero-shot cortical blood vessel segmentation in VEM images**. Under review at IEEE Journal of Biomedical and Health Informatics. arXiv:2401.13961v4

[F] Xiaomeng Han, Xiaotang Lu, Peter H. Li, Shuohong Wang, Richard Schalek, Yaron Meirovitch, Zudi Lin, **Jason K. Adhinarta**, Daniel Berger, Yuelong Wu, Tao Fang, Elif S. Meral, Shadnan Asraf, Hidde Ploegh, Hanspeter Pfister, Donglai Wei, Viren Jain, James S. Trimmer, Jeff W. Lichtman. **Multiplexed Volumetric CLEM enabled by antibody derivatives provides new insights into the cytology of the mouse cerebellar cortex**. Nature Communications 2024. doi:10.1038/s41467-024-50411-z PMID:39103318

[G] Jiancheng Yang, Ekaterina Sedykh, **Jason K. Adhinarta**, Hieu Le, Pascal Fua. **Generating Anatomically Accurate Heart Structures via Neural Implicit Fields**. Medical Image Computing and Computer-Assisted Intervention 2024. doi:10.1007/978-3-031-72378-0_25

[H] Liang Jin, Shixuan Gu, Donglai Wei, **Jason K. Adhinarta**, Kaiming Kuang, Yongjie J. Zhang, Hanspeter Pfister, Bingbing Ni, Jiancheng Yang, Ming Li. **RibSeg v2: A Large-scale Benchmark for Rib Labeling and Anatomical Centerline Extraction**. IEEE Transactions on Medical Imaging 2023. doi:10.1109/TMI.2023.3313627 PMID:37695967