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The Emmerich Research Center was located in the same building as a tutoring center in Jakarta, Indonesia. The lab members there juggled responsibilities as both scientists and teachers; one day rigging conveyor-belt-mounted webcams to monitor larval growth and another helping kids design heat-seeking autonomous cars to extinguish candles. Who wouldn't be intrigued?

In high school, as an intern for the lab, I learned how to code by designing temperature control systems for vacuum chambers, and was introduced to computer vision while attempting to calculate reaction rates from video footage of our weighing scales. These early experiences sparked a fascination with the machine learning methods used to accelerate progress in biomedical fields. Looking ahead, I believe that pursuing a **PhD in Computer Science** will prepare me for a research career focused on developing **deep learning techniques that are widely applicable across neuroscience and medical imaging**.

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 is now a PhD student at the Harvard Visual Computing Group. 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, a top medical imaging conference.

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 have undergone significant revisions and are aiming to resubmit the work soon. 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.

I am currently working on 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 applying to multiple PhD programs, with a focus on those emphasizing multidisciplinary work at the intersection of computational methods and neuroscience. **Harvard University** is my top choice due to the collaborative opportunities offered by the Lichtman Lab and Prof. Hanspeter Pfister's Visual Computing Group—working with researchers from these groups has been instrumental in shaping my approach to **connectomics**. My projects developing segmentation models for dendrites [D], synaptic vesicles [A, B, F], and cerebral vasculature [D, E] have strengthened my ability to approach complex microscopy challenges through the lens of voxel, mesh, and point cloud representations. Furthermore, my experience with CT and MRI modalities [G, H] offers a unique perspective to contribute to Prof. Pfister's efforts in **biomedical image analysis**.

Last summer, I expanded my neuroscience research by developing benchmarks for neural activity trace extraction from calcium imaging [C], aiming to advance efforts in reverse-engineering the *C. elegans* nervous system. Going forward, I plan to explore how deep learning models can extract insights from neural activity recordings. In particular, I am eager to learn more about **Prof. Demba Ba's** work on leveraging sparse and interpretable models for **neural data analysis**, as well as **Prof. Jia Liu's** research on decoding neurons from **brain-computer interfaces**.

I believe that my interdisciplinary background, spanning diverse geometric representations, imaging modalities, and biomedical applications, has uniquely prepared me to contribute to rigorous research wherever I ultimately pursue my PhD.

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