Academic Statement of Purpose

The COVID-19 pandemic induced a significant strain between the demand for and relatively fixed supply of available physician labor, thereby threatening its ability to function properly in the future. As such, and in memory of my grandfather, who died due to insufficient medical resources, I resolved to develop intelligent healthcare solutions to help more people avoid the misery of disease and premature death. Witnessing the development of artificial intelligence has reinforced my belief that machine learning can help medical professionals better use their expertise to make decisions and mitigate the labor shortage, especially for medical imaging for screenings, precision medicine, and risk assessment. However, the community has had difficulty building unified diagnosis models for several common diseases. Therefore, I am pursuing the M.S. in Computer Science at the ETH Zürich where I will refine the skills needed to contribute to machine learning and medical imaging by developing a multi-modal multi-task unified model for diagnosing disease.

My academic trajectory is like a gradient descent algorithm $\theta_{n+1} = \theta_n - \eta \nabla F(\theta_n)$, where θ is my life goal, η is the step length, $\nabla F(\theta)$ is my research interest (descent direction), and the most important thing is my resolution to keep moving to the next point in the curve. In this regard, my undergraduate studies at Southeast University exposed me to several promising machine learning projects for medical diagnosis, including medical imaging and signal processing. Leveraging my exposure to medical imaging, I joined the University of Alberta as a Research Intern where I was tasked with designing an unsupervised model to identify and localize anomalies in retina optical coherence tomography (OCT) images. Initially, I wanted to build a hybrid architecture incorporating many models to improve detection performance, as it's the easiest way to balance respective outputs simultaneously. However, my professor proceeded to exclaim: "*What is the motivation of the method? Research is not piling others' ideas and pursuing model accuracy without a big picture. Hanshi, you should think critically about whether it makes sense and keep striving to become a scientist*." After comprehensively investigating pathological features, I discovered the uniqueness of the OCT images, different from natural images, have notable regular structure features (e.g., structured anatomy). Stimulated by this finding, I presented an architecture to integrate segmentation knowledge as privileged features, incorporating privileged features distillation and reverse distillation methods with the help of structure extraction networks. The result far exceeded my expectations, outperforming state-of-the-art methods such as STFPM by 5.76%. Ultimately, I realized that medical images have high similarity in overall structure and diversity in details; however, encoding the uniqueness of medical images precisely into models is challenging.

Currently, I am working as an R&D Intern at Apple. One of my assignments is to capture and reduce the camera noise for coexistence testing. My work and research experiences have shown it is typical to find noise in images. For some use cases, noise is not disruptive; however, for medical imaging, one small noise spot can significantly impact a diagnosis. Conscious of this issue, my time at Apple has empowered me to define my future research direction and gain a sense of image noise problems which can be challenging to research. Moreover, considering the patient privacy-preserving and the need for a unified generalized model, I plan to build a multi-modal multi-task continual learning model for diagnosing multiple diseases. With the help of a comprehensive model, doctors can make judgments more efficiently, making medical diagnoses available to more people.

I am drawn to the M.S. program at UIUC due to its leading position in machine learning and medical imaging research. I dream of joining Professor Mark Anastasio's group at Computational Imaging Science Laboratory (CISL), whose research interests in computational medical image science align perfectly with my focus. I admire Professor Mark's recent work, "Application of DatasetGAN in medical imaging: preliminary studies," which demonstrated a method to generate infinite annotated medical image datasets. I aspire to explore similar approaches to solve the issue of insufficient public datasets. I am also interested in Professor Sanmi Koyejo's FMRI data augmentation methods via synthesis. Moreover, Professor Bo Li's projects on privacy-preserving machine learning are intriguing, given the need to prevent privacy law violations and protect patients' private data, as well as Professor Svetlana Lazebnik's focus on incremental and multi-task learning. Professor Alexander Schwing's extraordinary 3D imaging research can help 3D medical imaging significantly. Beyond research, UIUC's customizable curriculum will enable me to acquire the knowledge needed to build my ideal diagnosis model, including security and networking.