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Ph.D. DISSERTATION DEFENSE

Candidate:	Xueshen Li
Degree:	Doctor of Philosophy
School/Department:	Charles V. Schaefer, Jr. School of Engineering and Science Department of Biomedical Engineering
Date:	Thursday, April 10th, 2025
Time/Location:	9AM to Noon, McLean 114
Title:	Fast, Intelligent, and Pathological Optical Coherence Tomography Scanning Using Deep Learning for Human Coronary Imaging
Chairperson:	Dr. Yu Gan, Department of Biomedical Engineering
Committee Members:	Dr. Brendan Englot, Department of Mechanical Engineering Dr. Jennifer Kang-Mieler, Department of Biomedical Engineering Dr. Shang Wang, Department of Biomedical Engineering Dr. Yue Ning, Department of Computer Science

ABSTRACT

Optical coherence tomography (OCT) is a biomedical imaging modality which offers depth-resolved, real-time, and high-resolution scanning. Optical coherence tomography systems can achieve a penetration depth of up to 10 mm, a video-rate data acquisition, and a high axial resolution at micron level. However, it is challenging to simultaneously maintain high scanning rate and image quality for OCT systems. Moreover, pathological information, which is essential for clinical decision making, can not be directly obtained during OCT imaging process.

In this dissertation, novel deep learning algorithms are developed to reconstruct OCT images, allowing OCT systems to achieve faster scanning rate, better image quality, and incorporate histology information. To improve scanning rate, an acquisition method is developed which collects and stores fewer data. Conventionally, with fewer data sampled and stored, the quality of OCT images will be compromised. To improve the quality of undersampled OCT images, deep learning reconstruction algorithms are developed, which performs non-linear forms of interpolation. In addition, super-resolution algorithms are developed for improving the quality of OCT images using cross-platform information. Histology information is crucial for diagnosis of cardiovascular artery disease (CAD). To incorporate pathology information into OCT images for assisting CAD diagnosing, deep learning virtual staining algorithm is developed to perform domain transferring and generate virtual H&E stained images from OCT images. The proposed virtual staining algorithm bypasses time-consuming chemical staining procedures and provides histology analysis in real time. To optimize the virtual staining deep learning model for human coronary samples, a dataset which contains information of layer structures of human coronary wall is generated.

The proposed implementations will enable the OCT systems to perform faster scanning while maintaining and achieving better resolving power. These improvements are particularly promising in the diagnosing of CAD, in which the fast scanning rate and good resolving power of OCT systems are both highly demanded. Moreover, the virtual H&E staining generated from OCT images could provide valuable pathological information to cardiologist and pathologist during the treatment of CAD.