Evan Harvey Thesis Abstract

Roughly a century ago the idea of using an iodine based contrast agent in synergy with an x-ray system to visualize blood vessels on x-ray images emerged into the medical imaging field. With the development of computed tomography (CT), cross-sectional anatomical images became clinically available along with larger detector coverage and faster acquisition times where by coupling iodine contrast injection techniques with the CT technology, CT-based neurovascular imaging (CTNI) was born. Two specific CTNI modalities that have gained prominence with their commercial use in the clinic due to their ability to help clinicians rapidly diagnose and treat various neurovascular diseases are known as CT angiography (CTA) and CT perfusion (CTP). However, both CTA and CTP still come with challenges. CTA (along with all other CT imaging techniques such as noncontrast head CT) is performed commercially with energy integrating scintillator based multi-detector CT (MDCT) scanning systems. Due to limitations on the MDCT detector design, MDCT based CTA still faces challenges with detecting small (less than 0.5 mm) vessels which can cause difficulties diagnosing certain diseases. However, photon counting detector based CT (PCCT) offers potential advantages with its detector design compared to MDCT such that small vessel visualization performance can be superior. While great research progress has been made on demonstrating the advantages of PCCT compared to MDCT, it remains unclear how PCCT impacts one of the most important CTA imaging packages known as maximum intensity projection (MIP) based images. This work will answer the questions of how does PCCT impact CTA MIP image quality with respect to small vessel visualization and how can the potential performance improvement be attributed to each physical property of the PCCT system? To accomplish this, an experimental comparison study of a MDCT and PCCT system was performed using an anthropomorphic phantom with challenging small vessels while concurrently a theoretical framework was developed to predict MIP SNR properties based on CT detector properties. The CTP imaging modality also faces challenges with respect to its poor image quality due to its inherent low dose constraints during its scan acquisition. This poor image quality in the resulting CTP parametric maps makes diagnosing diseases like stroke unreliable. In addition to poor image quality, another challenge is inter-observer variability due to the lack of methods to standardize the quantification and interpretation of the parametric perfusion maps. This work will develop novel postprocessing methods to improve CTP parametric map image quality and present automated region of interest (ROI) analysis algorithms to improve inter-observer variability of the parametric maps.