Radiation dose reduction and new image modalities development for interventional C-arm imaging system

Kai Niu

Under the supervision of Guang-Hong Chen

At the University of Wisconsin-Madison

Oct 20 2015

Cardiovascular disease and stroke are the leading health problems and causes of death in the US. Due to the minimally invasive nature of the evolution of image guided techniques, interventional radiological procedures are becoming more common and are preferred in treating many cardiovascular diseases and strokes. In addition, with the recent advances in hardware and device technology, the speed and efficacy of interventional treatment has significantly improved. This implies that more image modalities can be developed based on the current C-arm system and patients treated in interventional suites can potentially experience better health outcomes.

However, during the treatment patients are irradiated with substantial amounts of ionizing radiation with a high dose rate (digital subtraction angiography (DSA) with 3μGy/frame and 3D cone beam CT image with 0.36μGy/frame for a Siemens Artis Zee biplane system) and/or a long irradiation time (a roadmapping image sequence can be as long as one hour during aneurysm embolization). As a result, the patient entrance dose is extremely high. Despite the fact that the radiation dose is already substantial, image quality is not always satisfactory. By default a temporal average is used in roadmapping images to overcome poor image quality, but this technique can result in motion blurred images. Therefore, reducing radiation dose while maintaining or even improving the image quality is an important area for continued research.

This thesis is focused on improving the clinical applications of C-arm cone beam CT systems in two ways: (1) Improve the performance of current image modalities on the C-arm system. (2) Develop new image modalities based on the current system. To be more specific, the objectives are to reduce radiation dose for current modalities (e.g., DSA, fluoroscopy, roadmapping, and cone beam CT) and enable cone beam CT perfusion and time resolved cone beam CT angiography that can be used to diagnose and triage acute ischemic stroke patients more efficiently compared with the current clinical work-flow. The animal and patient cases presented in this thesis are focused towards but not limited to neurointerventional applications.