Novel methods to address data truncation artifacts and streaking artifacts in four-dimensional cone-beam computed tomography

Shuai Leng

Cone-beam computed tomography (CBCT) using an 'on-board' x-ray imaging device integrated into a radiation therapy system has recently been made available for patient positioning and target localization in image guided radiation therapy (IGRT). CBCT provides volumetric information of the patient at the treatment position just before the treatment. It has been proven to be a very powerful tool used in radiation therapy. However, there are still some issues for the CBCT system used in IGRT. In this dissertation, three methods will be presented to address these issues.

Due to the limited detector size, projection data are truncated which will generate truncation artifacts in images reconstructed with traditional algorithms like FDK. This issue will be addressed using a new image reconstruction scheme, filtering a backprojection image of differentiated projection data (FBPD). To tackle motion artifacts due to respiratory motion in lung patient scan, 4D CBCT has been proposed. While the poor image quality, strong streak artifacts and low CNR, limits its wide application in clinic. Two novel methods were proposed to reduce artifacts and improve image quality in 4D CBCT. A simple scheme will be presented to significantly reduce the streak artifacts by 60% to 70%. Another new scheme, Prior Image Constrained Compressed Sensing (PICCS), was explored to simultaneously reduce streak artifacts and increase CNR of 4D CBCT images. Using PICCS, a streak-free image can be reconstructed from no more than 20 cone-beam projections while the signal-to-noise ratio is primarily determined by the prior image, which is reconstructed using all of the acquired cone-beam projections.