X. Zhang, *Prior-Knowledge-Based Optimization Approaches for CT Metal Artifact Reduction*, Ph.D. dissertation, Dept. of Electrical Engineering, Stanford University, Stanford, CA, USA, **2013**.
http://purl.stanford.edu/ws303zb5770.

Abstract

The steak artifacts caused by metal implants have long been recognized as a problem that limits various applications of computed tomography (CT). This type of artifacts typically occurs from metallic implants like dental fillings, hip prostheses, implanted marker bins and branchy-therapy seeds. The artifacts not only blur the CT images and lead to inaccuracies in diagnosis, but also make delineation of anatomical structures intractable, which is important in image-guided intervention procedures. This dissertation focuses on utilizing prior knowledge wisely to reconstruct artifact-reduced high-quality images. Several optimization approaches that integrate prior knowledge in both image and projection spaces are proposed. First, we propose a constrained optimization model that features an anisotropically penalized smoothness objective function, subject to a data tolerance constraint and an image non-negativity constraint. Numerical examples and experimental examples are presented to demonstrate that the algorithm is capable of significantly reducing metal streak artifacts, suppressing noise and preserving edge structures. Second, a sequentially reweighted TV minimization algorithm is proposed to fully exploit the sparseness of image gradient (IG). This approach, by altering a single parameter in the weighting function, flexibly controls the sparsity of IG and reconstructs artifacts-free images in a two-stage process: binary reconstruction and background reconstruction. It is therefore a systematic approach that first identifies metal traces from projection space and then reconstructs metal-free image based on metal-trace-removed projection data. Finally, we propose a projection in-painting method that takes advantage of the piece-wise smoothness of projection data. A penalized-least-squares (PLS) model is used to obtain a smoothed projection image that realistically represents the ideal noise-free projection. Experimental phantom studies and clinical examples are presented to demonstrate the performance of the proposed in-painting algorithm.