Developments in Statistical Image Reconstruction Algorithms for Computed Tomography

Shikha Prasad* and Gaurav Pandey

University of Michigan, Ann Arbor, MI 48105
shikhap@umich.edu

Although fast and reliable, filtered back projection (FBP) algorithms are becoming challenging to use accurately with non-radon scanning geometries such as cone–beam and multi–slice helical computed tomography (CT). Statistical image reconstruction algorithms can potentially remove the artifacts in X-ray CT images as they use more accurate source–object–detector models and radiation interactions than traditional FBP algorithms. Statistical algorithms can also incorporate the effects of incomplete data sets, noise and nonlinear system behavior.

Statistical algorithms can accurately reconstruct CT images as they account for poly energetic x-rays sources and beam hardening. This is important since in reality x-ray tube emits a continuous spectrum of photons as a function of energy. It is well known that radiation attenuation is an energy dependent process, such that low energy photons are preferentially attenuated over high energy ones. The statistical algorithms can also incorporate scattered signals. Details such as detector response functions, system geometry, object constraints and any other prior knowledge can be easily incorporated using statistical algorithms. However, with increased promises statistical algorithms also have increased costs. Statistical algorithms are computationally expensive and can result in very long times to reconstruct images. Therefore, methods, such as will be discussed, are being developed to accelerate the use of statistical algorithms. Additionally, with developments in computer architecture such as GPU, it may be easier to speedup statistical algorithms to become commercially viable.

The techniques that will be discussed in this work are statistical methods which have shown promising results, for low-dose measurements, and in small simulation run times. Recently, Zhu and Milanfar have developed a locally adaptive method, GLAS, that treats image features such as blur and noise locally instead of globally (as has been done in some previous methods). Such a local treatment of blur and noise has yielded remarkably superior results. This is an example of statistical algorithms being applied to data in the image domain. In the work done by Reviére et. al. raw data from the sinogram domain has been treated (instead of the logarithms of raw data) in an approach called the penalized-likelihood approach. This approach has shown improvements for low-counts or low-dose data. Finally, a hybrid method developed by Burder et. al., termed ARI, has combined analytic and statistical algorithms. The ARI has shown promising results in reduced computation times demonstrating a way of using statistical algorithms without being computationally expensive. By analyzing these methods it can be concluded that statistical algorithms have the capability to improve existing reconstruction methods, furthermore, they can do so for low dose measurement, and in shorter simulation run times.