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The Application of the Filtered Back Projection (FBP) Algorithm to Quantitative Scatter CT Reconstruction

Introduction: Computed Tomography (CT) uses FBP to acquire Linear Attenuation Coefficient (LAC) images at a specific energy using transmitted photons. In typical CT studies a large proportion of photons are scattered and can lead to a reduction in contrast and a decrease in signal to noise ratio. However these photons carry valuable material information and this work presents a technique which uses a variant of the FBP algorithm to reconstruct images of Electron Density (ED) from scattered photons.

Methods: In the absence of attenuation the total number of scattered photons is given by the integral of ED along a narrow strip of material (eq. (1)).

$$N_s(E_0) = N_0(E_0)_e\sigma(E_0)\int \rho_e(x)\,dx \tag{1}$$

where $N_s(E_0)$ is the number of scattered photons resulting from N_0 incident photons of energy E_0, $_e\sigma(E_0)$ is the probability of scattering for a photon of energy E_0 and $\rho_e(x)$ is the electron density at point x. In conventional CT the FBP algorithm is used to reconstruct ray integrals of the LAC. Similarly, our Scatter CT system reconstructs images of ED using FBP. Our system was simulated both with and without attenuation and Attenuation Correction Factors (ACFs), which were applied iteratively, were developed to correct for the attenuation.

Results and Conclusions: Attenuation free simulations reconstructed using the FBP yielded EDs with errors ranging from -0.5% to -2.1%. Simulations which included attenuation were reconstructed using the correct ACFs and yielded EDs with errors ranging from -2.7% to 1.1% after six iterations. These results show that under appropriate attenuation corrections, Scatter CT is capable of quantifying EDs assuming mono-energetic beam conditions and an accurate rejection of multiple scatter.