Energy differentiating Micro-Computed Tomography System and Energy Axis Reconstruction Algorithms

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We developed a novel x-ray micro-computed tomography (μCT) system capable of dense energy-differentiating x-ray measurements using a photon-counting single-pixel detector. A brief overview of this system is presented, with special detail given to what is novel about the system. Reconstructed images from this system have high energy axis resolution but suffer an increase in noise resulting from the nature of photon counting. We have developed two methods to suppress the noise along the energy axis, while preserving the increased energy resolution: a Penalized Weighted Least Squares Algorithm (PWLS) for iterative reconstruction along the energy axis, and an Eigenvector Filtering Algorithm (EIGEN) for noise suppression in the energy domain using a set of basis functions. These two algorithms are reviewed with a focus on specific the underlying assumptions justifying the noise suppression. Once the noise suppression methods have been applied, we demonstrate that the increased energy resolution makes it possible to identify imaged elements based on the specific way each element's attenuation relates to x-ray energy. We show that this identification allows us to separated two metallic contrast agents imaged at the same time. Using the increased energy resolution, we demonstrate it is possible to accurately estimate the concentration of metallic contrast agents in an imaged object. This justifies further x-ray energy resolving detector research; accuracy is shown to increase significantly from six to ten energy samples. This work will lead to increased sensitivity in high-resolution molecular-targeted X-ray imaging of biological subjects.