Scatter Estimation for PET Reconstruction

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This paper presents a Monte Carlo scatter estimation algorithm for Positron Emission Tomography (PET) where positron-electron annihilations induce photon-pairs that fly independently in the medium and eventually get absorbed in the detector grid. The path of the photon pair will be a *polyline* defined by the detector hits and scattering points where one of the photons changed its direction. This polyline contains the emission point somewhere inside one of its line segments. The values measured by detector pairs will then be the total contribution, i.e. the integral of such polyline paths of arbitrary length. These high dimensional integrals need to be estimated for all detector pairs with similar relative error, thus the classical approach that would sample the source and follow photons in their natural direction is not appropriate. Instead, we should solve the adjoint problem that starts building paths at the detector pairs. We consider the contribution of photon paths to each pair of detectors as an integral over the Cartesian product set of the volume.

This integration domain is sampled globally, i.e. a single polyline will represent all annihilation events occurred in any of its points. Furthermore, line segments containing scattering points will be reused for all detector pairs. Sampling parts of photon paths globally and *reusing* a partial path for all detector pairs allow us to significantly reduce the number of samples and consequently the computation time.

The scatter estimation is incorporated into a PET reconstruction algorithm where the scattered term is subtracted from the measurements. We also show that with this correction, the noise of the reconstructed data can be greatly reduced.