Recovery of Multi-interaction Photon Events to Improve the Performance of PET Scanners

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Multi-interaction photon (MIP) coincidences are events coming from a positron-electron annihilation in which more than two γ-rays are detected simultaneously because at least one of the two original photons deposited its entire energy in more than one detector element. These coincidences are usually discarded in PET scanners as it is not possible to assign them to a unique line-of-response (LOR). Existing methods to recover MIP events are mainly based on Compton scatter kinematics. We propose a methodology which uses the measured double-coincidence distribution to sort MIP coincidences into LORs. The PET component of a preclinical PET/CT scanner (Argus/CT, SEDECAL S.A., Spain) was adapted to enable the detection and acquisition of MIP coincidences. The effect of including MIP events recovered using several methods was studied in terms of image quality and noise equivalent count (NEC) rate following the guidelines described in the NEMA NU-4 protocol. Recovery of the MIP coincidences using the proposed methodology increased the peak NEC rates by 15.25% and 17.23% when imaging ^{18}F for mouse- and rat-sized objects respectively. Furthermore, this method is capable of simultaneously providing better SNR and contrast for hot lesions than those achieved using standard coincidences, while preserving recovery coefficients and contrast in cold lesions. Since the proposed approach can be easily implemented in block-detector and high-granularity detector-based scanners, this work provides a means to effectively increase the photon sensitivity of new or existing preclinical and clinical PET scanners.

Key Words: PET, Multi-interaction photon, sensitivity, NEC.