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Regularized Richardson-Lucy deconvolution of positron range effects in micro-PET studies

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Positron range effects in positron emission tomography (PET) studies have a negative impact in both spatial resolution and activity concentration quantification, particularly when high energy positron emitters travel in low density tissues. Several methods have been proposed to recover spatial resolution in PET with the aim of improving image quality. In this work, we propose a regularized Richardson-Lucy deconvolution algorithm using synthetic and experimental data. The method was initially optimized using synthetic-blurred transaxial images of the NEMA NU 4-2008 phantom (with and without noise) using the reported Point Spread Functions of the small-animal microPET Focus 120 scanner for F-18 and Ga-68. Experimental studies of the NEMA NU 4-2008 image quality phantom and a new conical-helix phantom filled with F-18 and Ga-68 were also carried out. Finally, a brain scan of a rat injected with C-11-Raclopride was performed. All images were reconstructed using OSEM-2D. A regularized Richardson-Lucy (RRL) algorithm using bilateral filtering (BLF) was implemented to obtain deblurred images, recovering the spatial resolution while maintaining the noise at reasonable levels. The NEMA NU 4-2008 protocol was followed to quantify recovery coefficients (RC) and spill-over-ratios (SOR) of the image quality phantom. The results indicate that the RCs for F-18 increased when using the RRL algorithm from 0.26, 0.47, 0.56, 0.66, 0.81 to 0.64, 0.85, 0.86, 0.88, 1.0 for the 1, 2, 3, 4 and 5 mm hot rods, respectively. SOR values decreased from 0.04 (water) and 0.19 (air) to 0.03 and 0.018. These values changed more drastically for Ga-68, as expected. The proposed method based on a regularized Richardson-Lucy deconvolution also provided a drastic improvement in the image quality for the conical-helix phantom and the rat cerebral PET scan. We acknowledge the support from PAPIIT-UNAM IN110616 and IN108615, Conacyt Problemas Nacionales 2015-612, PAEP-UNAM and Conacyt MSc scholarship.

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