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Statistical Properties of the Positronium Lifetime Image Reconstruction

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Abstract

Positronium Lifetime Image (PLI) reconstruction is a technique used in time-of-flight (TOF) Positron emission tomography (PET) imaging that involves measuring the lifespan of positronium, which is a metastable electron-positron pair that arises when a PET molecule releases a positron, prior to its annihilation. In our previous work, we demonstrated that our proposed maximum likelihood (ML) algorithm for PLI reconstruction can generate quantitatively accurate lifetime images for a 570 ps TOF PET system. In this study, we conducted further investigations into the statistical properties of the algorithm, including the variability of the reconstruction results, the sensitivity of the algorithm to the number of acquired PLI events and its robustness to hyperparameter choices. Our findings indicate that the proposed ML method produces sufficiently stable lifetime images to enable reliable distinction of regions of interest and the number of PLI events required to produce quantitatively accurate lifetime images is computationally plausible. These results demonstrate the potential of our ML algorithm for advancing the capabilities of TOF PET imaging.

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