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AI-supported ROI list-mode reconstruction for improved lesion detectability in large-FOV PET

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The extended number of detectors in large-field-of-view (LFOV) PET provides the possibility to increase the number of lines-of-response (LORs), as axial acceptance angles (α) become significantly larger when compared with conventional PET. Considering a small region inside the LFOV, however, its corresponding LORs become a very small fraction of the total detected signal and, hence, their weight within the image reconstruction (IR) strategy decreases. The dependence of signal-to-noise (SNR) and lesion detectability as a function of α are well known. This study investigates the problem further by extending a (multimodal) simulation & reconstruction management tool, named Musiré, to fully support LFOV-PET geometries and to incorporate artificial intelligence (AI)-supported methodology. Based on Monte Carlo (Gate) simulated LFOV-PET list-mode data, it was investigated whether lesion detectability can be improved by taking into account only those LORs for image reconstruction (Castor), which intersect the manually selected vicinity of a lesion within the LFOV. Having clearly observed differences in lesion contrast between global and local IR, the obvious task becomes to develop a procedure for automatic lesion classification. This has been accomplished by means of a supervised learning strategy through a convolutional neural network (U-Net/nnU-Net). Simulation design, AI-supported local lesion detection, as well as global/local list-mode reconstruction results are presented for LFOV-PET simulations. Said simulations involved anthropomorphic phantom geometries incorporating highly diverse tumor point-cloud representations. Spatial resolution and lesion-to-background contrast improved with local list-mode IR.

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