Title: Deep Learning-Based PET Image Correction Toward Quantitative Imaging

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Introduction:

Recent advancements in Deep learning (DL) have significantly impacted PET imaging. exploring CT-free methods. has significant advantages not only for attenuation scatter correction (ASC) but also in artifact correction. However, practical applicability is challenging due to differences in scanners and radiotracer distribution.

Objective: By developing an Integrated multi-center U-Net deep neural network model (IMCM), we addressed ASC, and assessed several case studies on image artifact correction, focusing on mismatch and halo artifacts in 68Ga PET imaging.

Methods: 270 images were selected from a collection of over 1000 patients undergoing 68Ga and 18F-FDG PET/CT scans across seven centers. Three cneters are set aside as external test sets (Ex-center) , while the training, validation and internal testing was conducted on the remaining data. A dedicated 3D-DynUnet which employs a deep supervision strategy, was used.

Results: For internal centers, the model achieved Mean Error (ME) of -0.56±0.74, Mean Absolute Error (MAE) of 1.28±0.37, Relative Error (RE) of -1.15±18.77, Root Mean Squared Error (RMSE) of 2.90±0.58, Peak Signal-to-Noise Ratio (PSNR) of 37.66±2.67, and Structural Similarity Index (SSIM) of 0.93±0.03.

For the Ex-center, IMCM model yielded an ME of -1.92±0.58, an MAE of 2.38±0.76, an RE of -19.87±19.58, an RMSE of 5.41±3.05, a PSNR of 32.25±3.04, and an SSIM of 0.89±0.03.

For cross-tracer centers, the model showed an ME of -0.54±0.13, an MAE of 0.69±0.12, an RE of -39.52±7.62, an RMSE of 1.17±0.52, a PSNR of 35.39±5.84, and an SSIM of 0.78±0.10.

Analysis of joint histograms revealed that the IMCM model had a regression slope of 0.65±0.02 with an R-value of 0.949 at the Ex-center, indicating a systematic underestimation of SUV values. At internal centers, the IMCM model showed closer to ideal predictions of 0.87±0.01 and an R-value of 0.988.

Discussion: The developed model addressed variations in scanner types and radiotracers, demonstrating its adaptability and effectiveness in different clinical environments for the same study. Untuned IMCM struggled with cross radiotracers but showed strong performance after fine-tuning.

Conclusion: The study highlighted the potential of DL to provide accurate, artifact-free PET images, this method offers a promising alternative to CT-based ASC, reducing radiation exposure and artifacts.

Keywords: Deep learning, attenuation scatter correction, CT-free imaging.

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| A diagram of a mean error  Description automatically generated | A chart with different colored boxes  Description automatically generated with medium confidence |
| A diagram of a number of colored boxes  Description automatically generated with medium confidence | A diagram of a root mean squared error  Description automatically generated |
| A chart with different colored boxes  Description automatically generated | A diagram of a number of different colored boxes  Description automatically generated with medium confidence |

The Ex-center had an RE 1,63% worse than the internal centers' RE, while the cross-tracer centers had 3,338.26% higher RE. Regarding RMSE, 5.41 and 1.17, repectively. The PSNR for the external center is 32.25, 14.37% lower than the internal centers' 37.66, while the cross-tracer centers' PSNR of 35.39 is 6.03% lower. The SSIM for the external center is 0.89, 4.30% lower than the internal centers' 0.93, while the cross-tracer centers' SSIM of 0.78 is 16.13% lower.