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NEUROIMAGING

End-to-End 3D CycleGAN Model for Amyloid PET Harmonization

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Abstract

Background: Amyloid PET (Positron Emission Tomography) is crucial in detecting amyloid burden within the brain. However, the diversity of amyloid tracers and the scarcity of paired data significantly challenge the collaboration between cross-center studies. In this research, we introduce a novel patch-based 3D end-to-end image transformation model. This model works as a harmonization strategy, transferring the amyloid PET images from one tracer type to another.

Method: 51 florbetapir (FBP) and 604 PiB images from the Australian Imaging, Biomarkers and Lifestyle Study of Ageing (AIBL) were processed using established pipelines to extract regional standard uptake value ratios (SUVRs), mean cortical SUVRs (mcSUVRs), and SUVR images. 3D Cycle-Consistent Generative Adversarial Networks (CycleGAN) was used to learn the end-to-end 3D image transformation using adversarial training strategies in conjunction with Resnet generators and multilayer discriminators within different tracer domains. Data augmentation techniques were applied to process the FBP images to balance the training samples and patch-based learning was used throughout the experiment. The trained CycleGAN model was then applied to an independent dataset with 46 paired images from www.gaain.org/centiloid-project for performance evaluation. Correlation analyses were conducted voxel-wise and on mcSUVR, comparing the FBP/synthetic PiB to the true PiB data. The Structural Similarity Index Measure (SSIM) and Peak Signal-to-Noise Ratio (PSNR) were also evaluated between the synthetic and real PiB SUVR images.

Result: The synthetic PiB SUVR images were visually more similar to real PiB SUVR images than FBP. Voxel-wise correlation improved from 0.942 between FBP and real PiB to 0.958 between the virtual and real PiB SUVR image ($p < 0.0001$). The agreement of mcSUVR improved from $r = 0.909$ to $r = 0.954$ ($p<0.001$) in the independent test

dataset. The SSIM and PSNR between synthetic and real PiB are 0.762 and 25.370 in the independent dataset.

Conclusion: We proposed a novel end-to-end image transformation model for 3D PET image synthesis. The model finds the nonlinear mapping between different tracers and eliminates the requirement for paired training images. The result was confirmed using an independent dataset to demonstrate its effectiveness.

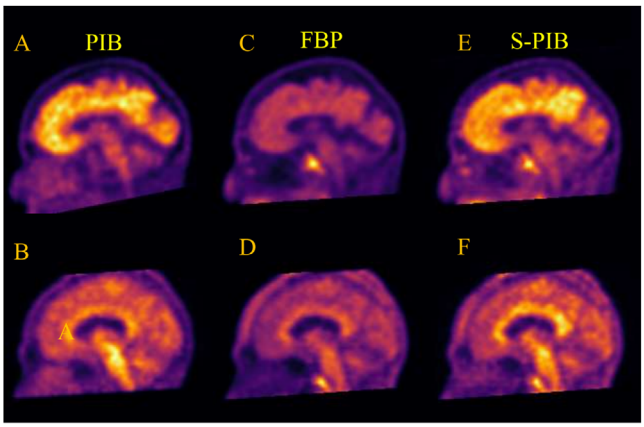

Figure 1. Example images for an amyloid negative participant (B, D, F) and an amyloid positive participant (A, C, E) from the independent testing dataset. The difference between florbetapir (FBP) and PIB images can easily be observed and the synthetic PIB (S-PIB) images from FBP demonstrated substantially improved similarity with true PIB image.

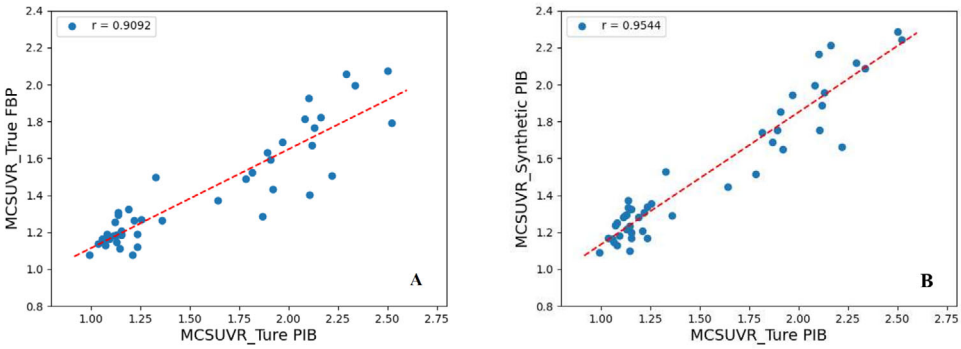

Figure 2. Comparison between FBP and PIB mean cortical SUVR (mcSUVR) measurements in the independent test dataset (A), and between synthetic PIB mcSUVR estimated from 3D CycleGAN model using FBP data and true PIB mcSUVR in the same set (B). Significantly improved correlation was observed ($p < 0.001$).