Comparative Evaluation of 2D and 2.5D U-Net and cGAN for qMRI to [18F]UCB-H PET Image synthesis

Authorship: Meyer F[1, †], Huang J[1,†], Ruymaekers A[1,2], Jacquemin A[1], Dauby S[1], Salmon E[1,3], Bastin C[1], Phillips C[1], Zubkov M[1], Bahri MA[1]*

1. GIGA-Institute, CRC-Human Imaging, University of Liège, Belgium

2. Department of Sciences and Technology, Haute Ecole de la Province de Liège, Belgium

3. Department of Neurology, University of Liège, Liège, Belgium

†Equal contribution

*Correspondence author

Abstract:

Positron Emission Tomography (PET) using the SV2A radioligand [18F]UCB-H is currently one of the most direct and validated methods to quantify synaptic density *in vivo*. However, the use of radioactive tracers limits repeated acquisitions and long-term follow-up. In contrast, quantitative MRI (qMRI) including magnetization transfer saturation, proton density (PD), R1, R2* mapping, provides non-invasive information on tissue composition and microstructural integrity, thus supporting PET prediction from qMRI. In this study, 74 participants (14 healthy controls, 40 and 20 patients with subjective cognitive decline and Alzheimer's disease, resp.) were scanned. We implemented anatomical atlas informed 2D and 2.5D U-Net and cGAN models to compare their performance in PET image synthesis from qMRI and to further investigate the importance of qMRI parameters. The models were evaluated using mean squared error (MSE) and structural similarity index measure (SSIM), while the contribution of each parametric images was assessed using mean gradient magnitude (MGM). Among all neural networks, 2D U-net achieved the best overall performance in term of MSE and SSIM, with 2.5D U-Net yielding similar results. Although cGAN-based methods generated images that appeared visually closer to PET, their quantitative performance was less stable than Unet-based methods. Across all reconstruction model, *PD and R2** maps showed the strongest contributions to PET synthesis.

These preliminary results support the feasibility of synthesizing PET-like images from qMRI parameters. However, noticeable artificial intelligent–related hallucination remains in the synthesized PET images, indicating that the stronger bio-physical priors should be incorporated to further improve reconstruction reliability and biological interpretability.