MRI-less Anatomically-Guided PET Reconstruction Using Unrolled Deep Neural Networks

Seung Kwan Kang and Jae Sung Lee

Department of Nuclear Medicine, Seoul National University, Korea

Abstract

The image quality of PET is degraded by its limited spatial resolution and high noise in acquisition in comparison with other anatomical imaging modalities, such as magnetic resonance imaging. Accordingly, there have been many efforts to improve image quality and quantitative accuracy by incorporating anatomical imaging into the iterative imaging reconstruction process with various priors (e.g. Bowsher prior). Most of these methods assumed the simultaneous acquisition or existence of MRI, however, it is not always available. In this study, we proposed an unrolled deep neural network for PET image reconstruction that can generate anatomically-guided PET images without the use of corresponding MRI input.

Our proposed neural network consisting of eight blocks took two inputs, initial image and sinogram. In each block, ordinary ML-EM updates image passed from the previous block with a given sinogram followed by resNet sub-blocks containing the attention layer. The L1 loss combined with multi-scale structural similarity loss was minimized between the network output and reference Bowsher prior results. We also constructed standard U-Net with the same loss to compare the performance. We used 39 FDG brain PET scans which were divided into training (n=29) and test (n=10) sets. Visual comparison and statistical analysis were performed. We calculated the error between the output of neural networks and the ground truth (Bowsher prior).

As a result, our proposed network produced clearer and quantitative accurate results compared to the U-Net. More detailed uptakes in gray matter and separated anatomical structures could be found in the proposed network. Moreover, the U-Net yielded quantification issues, even if it restored the anatomical structures better than conventional OS-EM. This result can be found in statistical analysis, where the proposed network produced less biased and deviated outcomes.

We proposed a deep neural network generating anatomically-guide PET image without MR image input. The proposed network yielded better performances than U-Net.

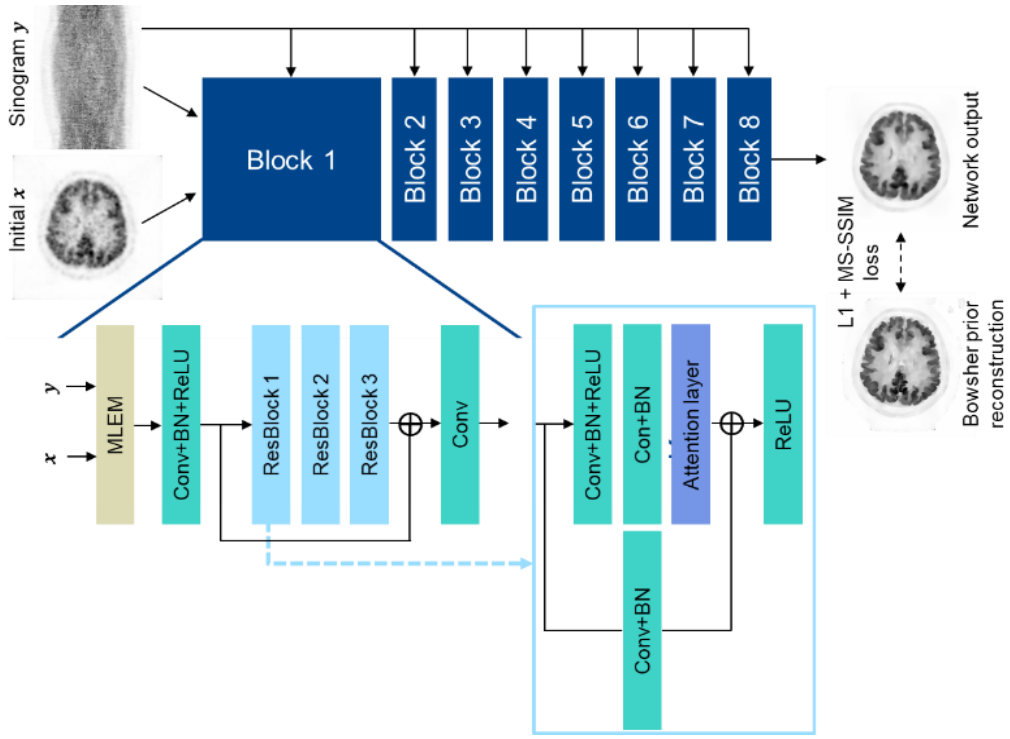

Fig. 1. Schematic of the enrolled deep neural network for the MRI-less anatomically-guided PET image reconstruction.

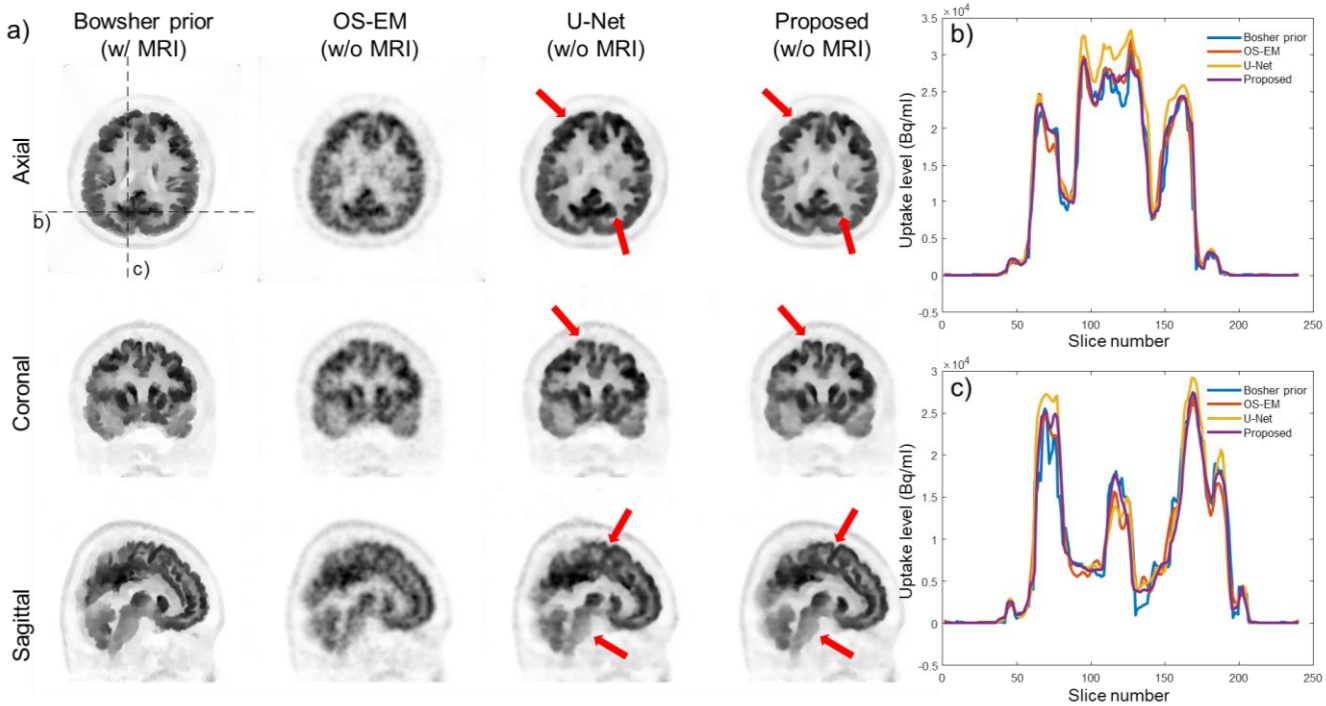

Fig. 2. Reconstructed PET images of a representative case. (a) From left to right, Bowsher prior (reference), OSEM, U-net, and proposed unrolled deep neural network. (b) Vertical and (c) horizontal profiles on axial slices.