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Image Reconstruction Network with Sinogram-to-Image Transform Layer for Projection Data

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• Abstract

Image reconstruction from projection domain data in nuclear imaging has recently been adopting deep learning (DL) technology instead of conventional analytical and iterative methods. In this paper, we proposed a novel neural network including pre-convolutional layers, sinogram-to-image transform layer (SITL) and post convolutional layers. The SITL included the rearrangement operation of the sinogram data to the image pixel followed by point-wise convolution layer. It enabled to reduce unnecessary parameters effectively from the fully connected layer, and thereby the model could process the conventional medical images with large matrix size of 256, which was not available for previous approaches with the conventional computing resources. The sinogram obtained from the conventional PET/CT data was successfully reconstructed using the network, which was trained by the generic image of MS COCO (Microsoft Common Objects in Context) 2017 and the corresponding sinogram data.

• Method

By the nature of the back-projection algorithm, each pixel of the reconstructed image should use the data from all views of the sinogram. Therefore, the FC layer could be suitable for image reconstruction, since it connects all input nodes to an output node. Nonetheless, the FC layer could not be applied to the real PET images because the number of parameters increases in proportion to the input size. The motivation for SITL comes from these disadvantages of using the FC layer during the domain transform process.

For each pixel of an image domain, a *pixel-wise sinogram* is generated by applying the Radon transform to a single point of the image. (Fig. 1). SITL is proposed to replace the FC layer for mapping from the sinogram to the image domain. (Fig. 2)

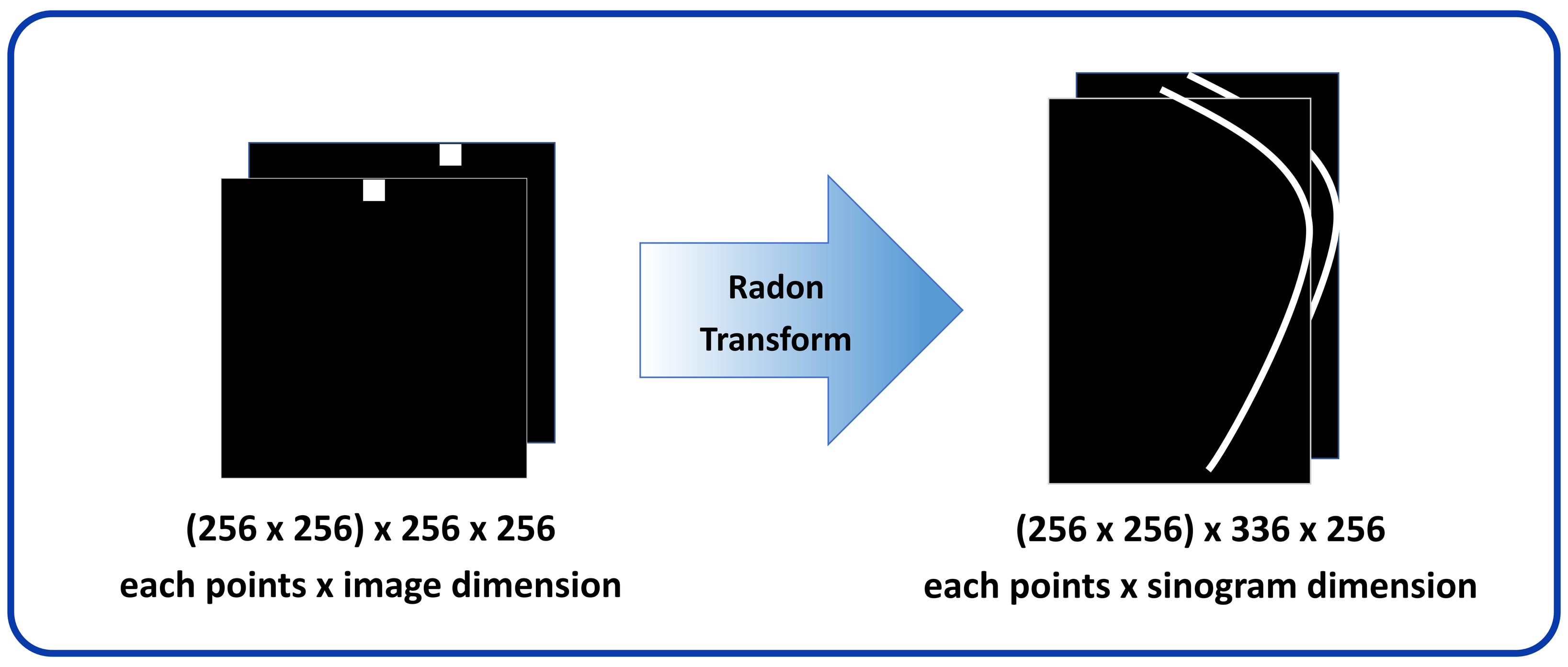


Fig. 1 Data generation process of pixel-wise sinograms

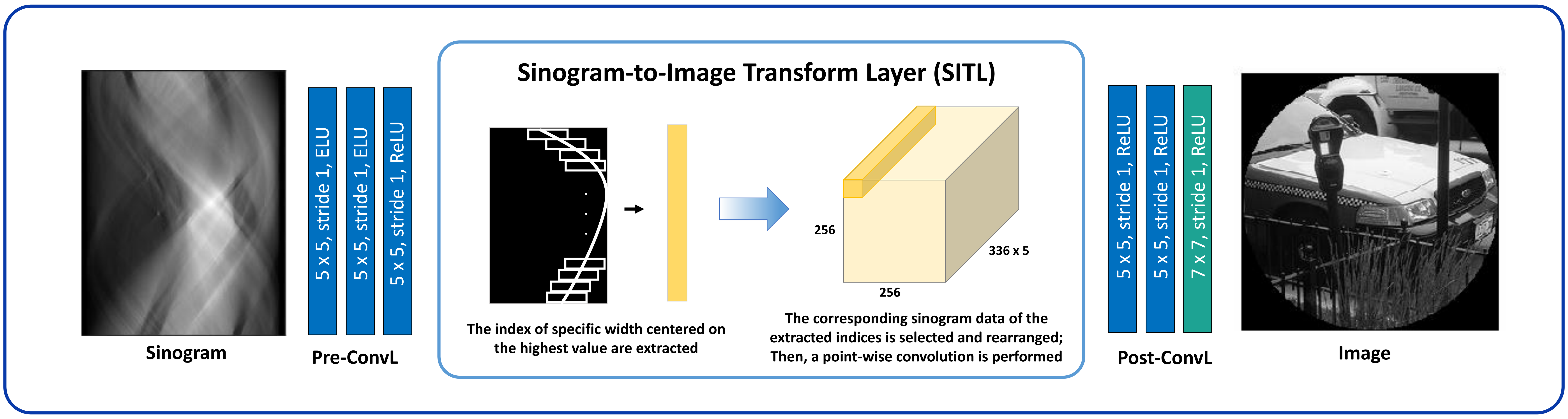
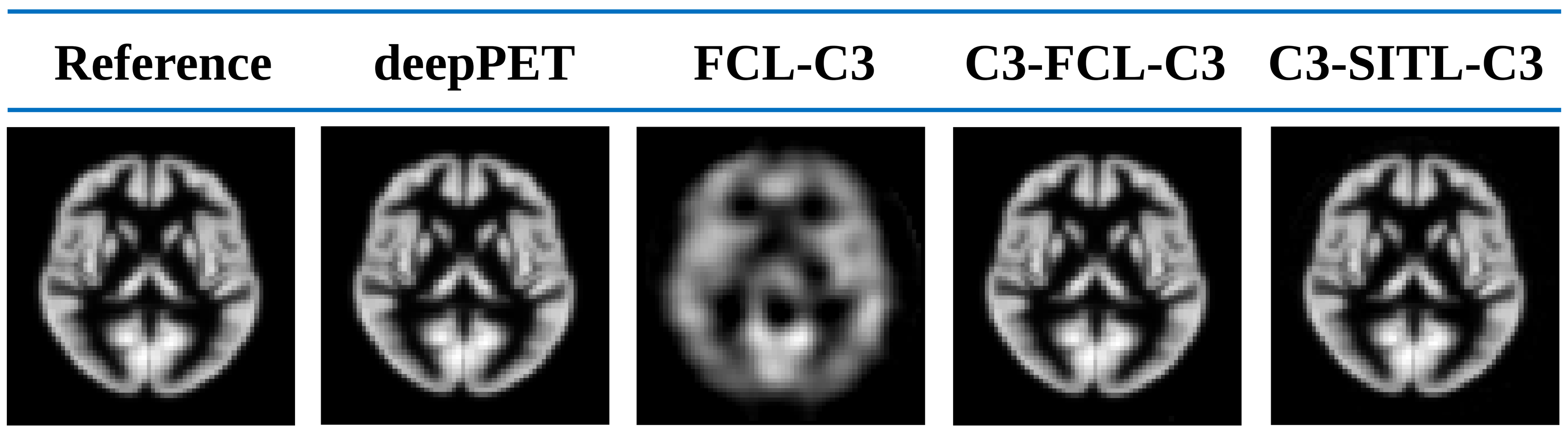
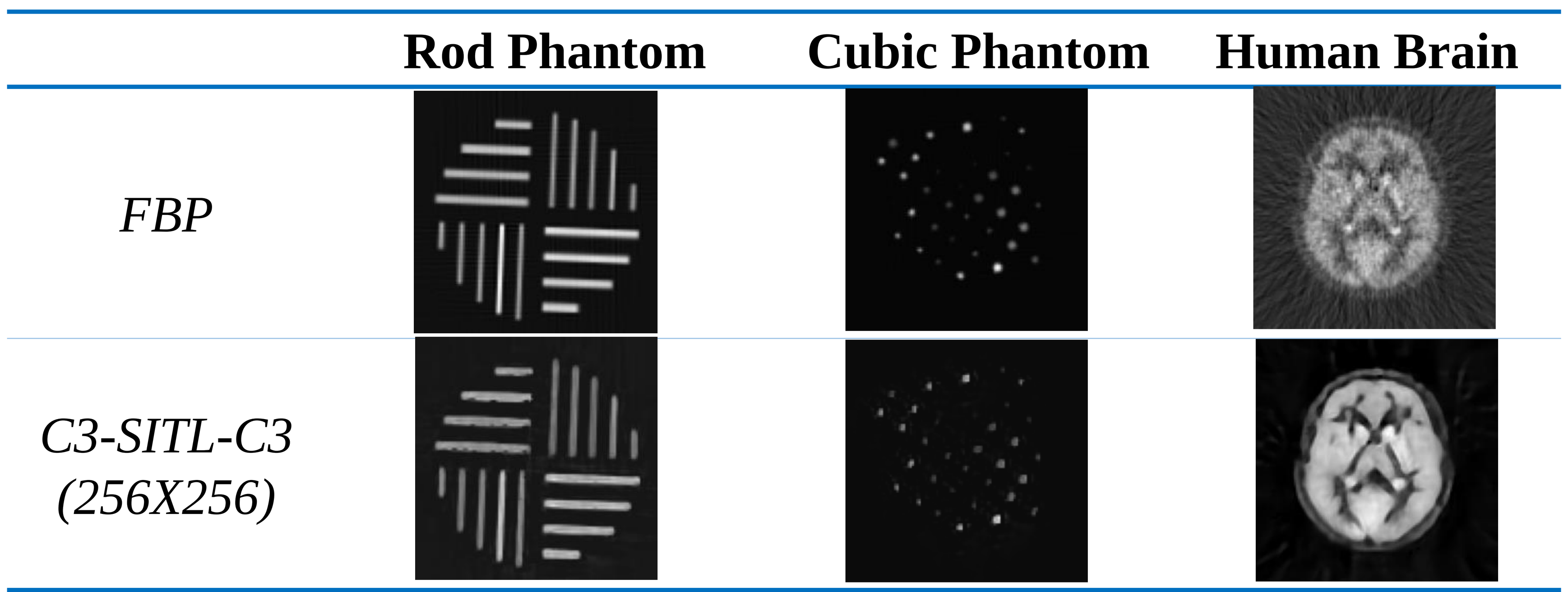


Fig. 2 Schematic of the proposed reconstruction network; pre-convolutional layer, sinogram-to-image transform layer (SITL), and post-convolutional layer

• Results

model	parameters	RMSE	SSIM	PSNR
DeepPET (64x64)	63,639,329	2.360% ± 0.010	0.968 ± 0.020	33.206 dB ± 3.407
FCL-C3 (64x64)	50,447,105	7.790% ± 0.023	0.711 ± 0.074	22.580 dB ± 2.802
C3-FCL-C3 (64x64)	50,485,250	**0.052% ± 0.001**	**1.000 ± 0.000**	**68.369 dB ± 6.528**
C3-SITL-C3 (64x64)	**247,250**	1.556% ± 0.005	0.983 ± 0.008	36.601 dB ± 2.783





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• Reference

[1] P. E. Kinahan and J. G. Rogers, "Analytic 3D image reconstruction using all detected events," IEEE Trans. Nucl. Sci., vol. 36, no. 1, pp. 964–968, Feb. 1989, doi:10.1109/23.34585.
[2] L. A. Shepp and Y. Vardi, "Maximum Likelihood Reconstruction for Emission Tomography," IEEE Trans. Med. Imaging, vol. 1, no. 2, pp. 113–122, Oct. 1982, doi:10.1109/TMI.1982.4307558.
[3] B. Zhu, J. Z. Liu, S. F. Cauley, B. R. Rosen, and M. S. Rosen, "Image reconstruction by domain-transform manifold learning," Nature, vol. 555, no. 7697, pp.487–492, Mar. 2018, doi:10.1038/nature25988.
[4] I. Häggström, C. R. Schmidtlein, G. Campanella, and T. J. Fuchs, "DeepPET: A deep encoder–decoder network for directly solving the PET image reconstruction inverse problem," Med. Image Anal., vol. 54, pp. 253–262, May 2019, doi:10.1016/j.media.2019.03.013