Experimental Plan and Literature Review: Impact of Network Architecture on Noise2Inverse

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1 Research Question

Does the choice of CNN architecture—U-Net vs. DnCNN—significantly affect denoising quality in the Noise2Inverse self-supervised CT framework, under fixed noise and geometry settings? Subquestion: Are there differences in convergence speed?

2 Experimental Plan

We simulate a 3D human-like phantom composed of geometric primitives (spheres, ellipsoids, cuboids) representing head, torso, limbs, and embedded internal structures. The phantom is randomly generated with anatomically plausible proportions and fine-scale internal variation to test denoising and feature preservation. Using `scikit-image`, we simulate 360-view projections with moderate Gaussian or Poisson noise, followed by Filtered Backprojection (FBP) reconstruction.

In PyTorch, we implement the Noise2Inverse training pipeline. We compare U-Net and DnCNN architectures, keeping all other parameters fixed (loss, learning rate, epochs, etc.). Evaluation includes PSNR, SSIM, and visual inspection of denoised outputs and residuals.

3 Related Work

- **Zhang et al. (2017)[3]:** Introduced DnCNN with residual learning and batch norm; performs well across noise levels using a single model.
- **Ronneberger et al. (2015)[2]:** Proposed U-Net with encoder-decoder and skip connections; effective in preserving fine details in biomedical images.
- **Geng et al. (2021)[1]:** Compared U-Net and DnCNN in medical GAN denoising; both performed competitively, with differing strengths depending on modality and noise type.

References

[1] Geng, M., Meng, X., Yu, J., Zhu, L., Lujia, J., Jiang, Z., Qiu, B., Li, H., Kong, H., Yuan, J., Yang, K., Shan, H., Han, H., Yang, Z., Ren, Q., Lu, Y.: Content-noise complementary learning for medical image denoising. IEEE Transactions on Medical Imaging **PP**, 1–1 (09 2021). https://doi.org/10.1109/TMI.2021.3113365

[2] Ronneberger, O., Fischer, P., Brox, T.: U-net: Convolutional networks for biomedical image segmentation. In: Navab, N., Hornegger, J., Wells, W.M., Frangi, A.F. (eds.) Medical Image Computing and Computer-Assisted Intervention – MICCAI 2015. pp. 234–241. Springer International Publishing, Cham (2015)

[3] Zhang, K., Zuo, W., Chen, Y., Meng, D., Zhang, L.: Beyond a gaussian denoiser: Residual learning of deep cnn for image denoising. IEEE Transactions on Image Processing **26**(7), 3142–3155 (2017). https://doi.org/10.1109/TIP.2017.2662206