

Deep Learning-Based Denoising for Optical Coherence Tomography: Evaluating Self-Supervised and Generative Models Across Retinal Datasets

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Abstract

Denoising medical imaging is crucial for enhancing diagnostic accuracy, particularly for Optical Coherence Tomography (OCT) scans used to detect retinal diseases. We aimed to evaluate the performance of five deep learning-based denoising models, namely Zero Shot Noise2Noise (ZS-N2N), DnCNN (for Gaussian denoising), U-Net Autoencoder, SwinIR Transformer, and CycleGAN. We used OCT scans with different retinal diseases datasets, such as diabetic retinopathy, age-related macular degeneration, macular hole, central serous retinopathy, and normal retinas. The models were trained using diverse OCT images and tested across these datasets to assess their generalization capability. Preliminary results indicated that ZS-N2N and CycleGAN consistently achieve the lowest loss and highest accuracy, making them the most effective for denoising across different pathologies. The DnCNN and U-Net Autoencoder exhibited moderate performance, with slightly higher loss values, likely due to their sensitivity to fine structural variations. SwinIR Transformer performs comparably to convolutional-based models but slightly underperforms on structurally complex conditions such as macular holes and central serous retinopathy. The accuracy values suggest that normal retina images achieve the highest denoising performance (approximately 96% for ZS-N2N and CycleGAN). Overall, the results of our study highlights the effectiveness of self-supervised and generative adversarial approaches in preserving essential medical details while removing noise. Future work will involve refining these models with domain-specific augmentations and validating results on larger datasets.

Keywords: Optical Coherence Tomography (OCT) Denoising; Deep Learning (DL) in Medical Imaging; Retinal Disease Detection; Self-Supervised Learning; Generative Adversarial Network.

