FD-GAN: A Dual-Domain Approach with Fourier Domain Discriminators for Denoising Low-Dose CT Images

Mi Yixuan, Li Jiashu, Chen Moyang, Dr. Gaurav Gupta, Dr. Tong Guanchao

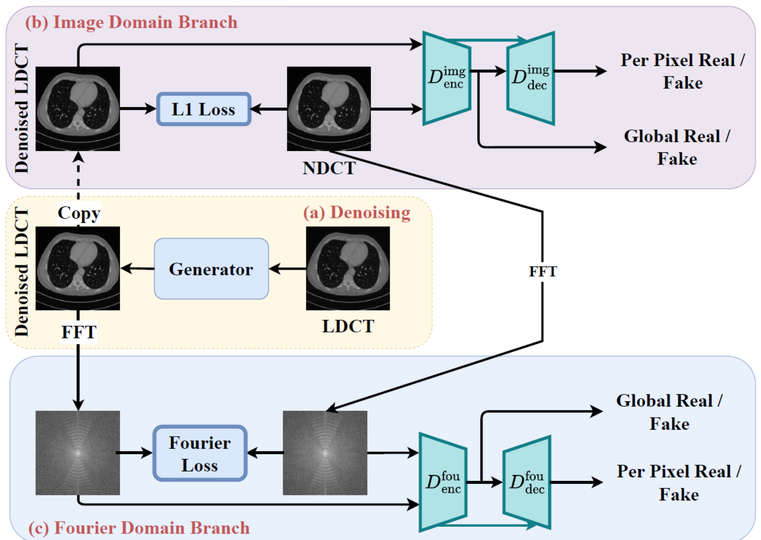
Department of Mathematical Sciences, CSMT, miy@kean.edu

Introduction

- Low-Dose CT (LDCT) reduces radiation exposure for patients but introduces significant noise, affecting diagnostic accuracy.
- Traditional denoising methods, such as total variation minimization and MSE-trained CNNs, often lead to excessive smoothing and loss of structural details.
- GAN-based methods improve image quality but suffer from artifacts and training instability.
- We propose **FD-GAN**, a **dual-domain GAN framework** that integrates both **image domain and Fourier domain discriminators** to effectively suppress noise while preserving high-frequency details.

Methods and Materials

➢ **Model Architecture:**



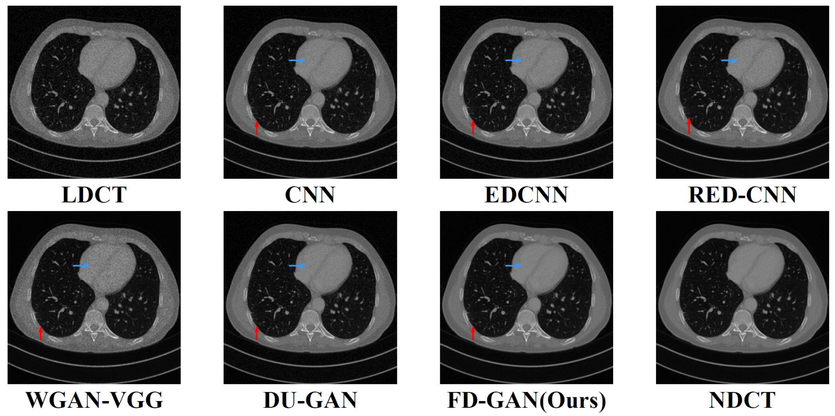
➢ **Experimental Setup:**

- Dataset: NIHAAPM-Mayo Clinic LDCT dataset.
- Training & Testing: Experiments conducted on **chest 10% dose** and **head 25% dose** subsets.

➢ **Evaluation Metrics:** PSNR, SSIM, RMSE.

Results

➢ **Visual Results:**



➢ **Quantitative Evaluations:**

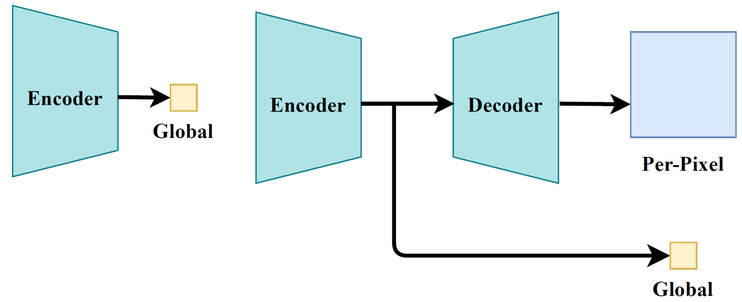
	Method	Chest-10%		
		PSNR↑	RMSE↓	SSIM↑
	LDCT	16.4251	0.1884	0.6479
MSE-based	CNN	19.6382	0.1954	0.6871
	EDCNN	23.2639	0.0834	0.7012
	RED-CNN	**23.4328**	**0.0712**	**0.7195**
SDGAN-based	GAN	21.2731	0.0987	0.7214
	WGAN-VGG	**22.1457**	**0.0801**	**0.7324**
DDGAN-based	DU-GAN	24.2422	**0.0721**	0.7389
	FD-GAN (ours)	**24.3089**	0.0783	**0.7489**

➢ **Ablation Study Results:**

Method	PSNR↑	RMSE↓	SSIM↑
Baseline	20.1468	0.0851	0.7197
DU-GAN(without gradient domain)	21.1415	0.0839	0.7327
DU-GAN	**21.5291**	**0.0813**	**0.7393**
Ours (+ Dual-Domain)	**21.7376**	**0.0798**	**0.7484**

Conclusions

- **FD-GAN outperforms traditional denoising methods** by achieving better noise suppression while preserving image structures.
- It surpasses conventional CNNs and single-domain GAN methods on the **NIHAAPM-Mayo Clinic LDCT dataset**.
- This approach has potential for **clinical applications in low-dose imaging**, with future extensions to **various dose levels and imaging modalities**.
- Our work **has been accepted** to the International Joint Conference on Neural Networks (IJCNN) 2025 and will be published in the **IEEE proceedings.**



References

[1] H. Chen et al., "Low-dose CT denoising with convolutional neural network," Proc. IEEE ISBI, pp. 143-146, 2017. DOI: 10.1109/ISBI.2017.7950488

[2] Z. Huang et al., "DU-GAN: Generative adversarial networks with dual-domain U-Net-based discriminators for low-dose CT denoising," IEEE Trans. Instrum. Meas., vol. 71, pp. 1-12, 2022. DOI: 10.1109/TIM.2021.3128703

[3] Q. Yang et al., "Low-dose CT image denoising using a GAN with Wasserstein distance and perceptual loss," IEEE Trans. Med. Imaging, vol. 37, no. 6, pp. 1348–1357, 2018. DOI: 10.1109/TMI.2018.2827462