COMP576: Image Denoising using Convolutional Neural Network

Dongwei Li (dl82), Iris Wu (yw110), Danyu Wang (dw65), Kunhua Lei (kl61)

Introduction and Motivation

- Taking photos with smartphones has become a popular way for people to record their lives. However, image denoising still remains one of the most challenging tasks when it comes to processing smartphone images.
- Deep learning techniques have received much attention in the area of smartphone image denoising.

Goal

Developing and training a CNN-based model that can demonstrate better performances of image denoising by comparing results of different network structures.

Dataset

- Smartphone Image Denoising Dataset (SIDD)[1][2]
- Captured under different lighting conditions using five representative smartphone cameras
- Generated ground truth images
- 160 image pairs (noisy and ground-truth), 160 scene instances

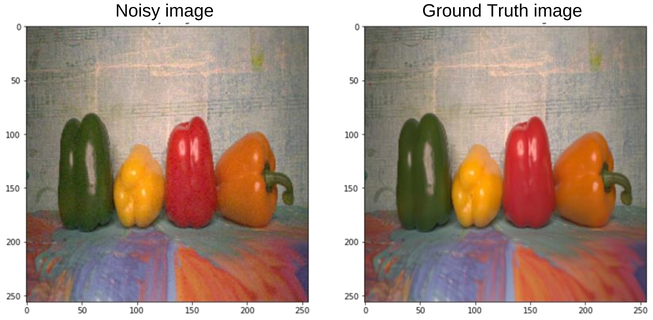

Figure 1. A pair of sample dataset

Our Model

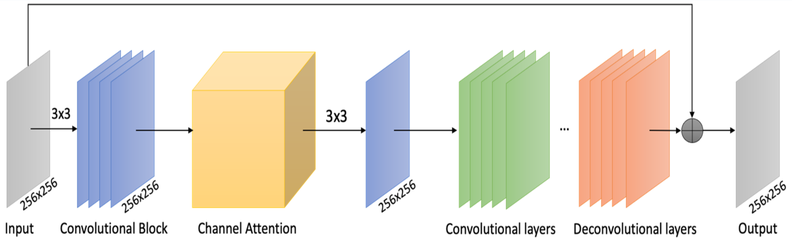

Figure 2. Architecture of the Model

- Build a new CNN-based image denoising model which contains channel attention and a REDNet (Residual Encoder-Decoder Networks).
- Compare our model with previous methods, REDNet[3] , and PRIDNet[4].
- Vary convolution and deconvolution layers in our model and REDNet.

Experiments

We test our trained model on noisy images to visualize denoising performance. The eye-closeup and rail train image were from Online Dataset. We can see that noise in predicted images is much less than original images.

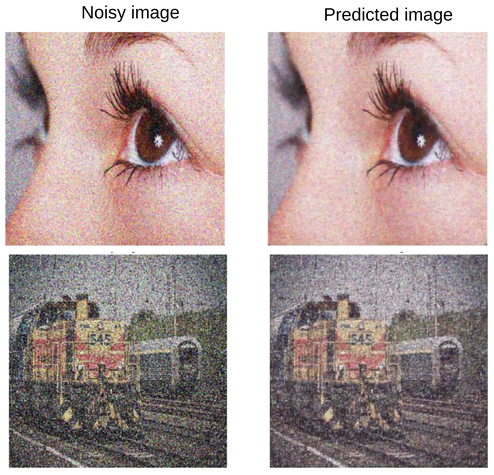

Figure 3. Test images

Results & Discussion

Model	PSNR	SSIM	PSNR Improvement	SSIM improvement
Original X-y pairs (No Model)	26.3779	0.6000	-	-
REDNet_5layers	32.1988	0.7725	5.8209	0.1725
REDNet_9layers	32.7721	0.7728	6.3942	0.1728
REDNet_15layers	33.1718	0.7738	6.7939	0.1738
REDNet_5layers (using Attention)	33.5744	0.7785	7.1965	0.1785
PRIDNet (using Attention)	33.3105	0.8049	6.9326	0.2049

Table 1. Result of different CNN based image denoising methods

- Our model (REDNet_5layers (using Attention)) has about 7.2 increase in PSNR and 0.18 increase in SSIM from original pairs, which means predicted image using our model can have a “closer” quality and structural similarity to the ground truth image.
- Adding layers will increase the quality of image by denoising

Conclusion & Further Work

- We proposed a new CNN-based image denoising model by combing channel attention and a REDNet.
- The new model demonstrated higher performance with its better metrics (PSNR, SSIM) and structural simplicity (compared to PRIDNet).
- Potential improvements/considerations include:
  - Training on larger dataset (SIDD-Full Dataset)
  - Using larger number of epochs
  - Using K-Fold Cross Validation, if possible

References

[1] Abdelrahman Abdelhamed, Lin S., Brown M. S. "A High-Quality Denoising Dataset for Smartphone Cameras", IEEE Computer Vision and Pattern Recognition **(CVPR)**, June 2018.

[2] Abdelrahman Abdelhamed, Timofte R., Brown M. S., et al. "NTIRE 2019 Challenge on Real Image Denoising: Methods and Results", IEEE Computer Vision and Pattern Recognition Workshops **(CVPRW)**, June 2019.

[3] Mao, Xiao-Jiao, et al. Image Restoration Using Convolutional Auto-Encoders with Symmetric Skip Connections. 30 Aug. 2016, doi:10.48550/arXiv.1606.08921.

[4] Y. Zhao, Z. Jiang, A. Men and G. Ju, "Pyramid Real Image Denoising Network," *2019 IEEE Visual Communications and Image Processing (VCIP)*, 2019, pp. 1-4, doi: 10.1109/VCIP47243.2019.8965754.