# Image Denoising using Deep Residual Blocks with Fourier Transform

Xiaoran Liu, Wenzhe Xu, Ruijie Hou

Department of Computer Science, University of Toronto

Motivation

- **Image Denoising** is critical in image processing pipeline and computer vision tasks.
- Existing developed methods are mainly traditional spatial filtering algorithms and real-valued deep learning methods.
- The **spectrums** of the clean and noisy images are quite different.
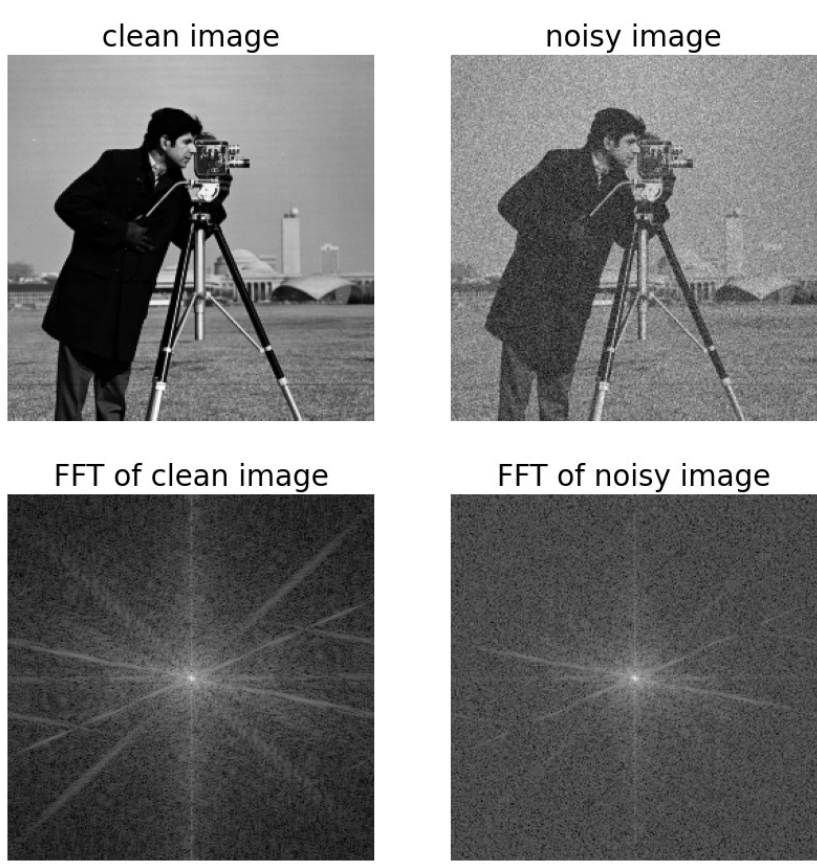
- This study aims to propose an innovative neural network model that filters out noise in **both the time and frequency domain**, along with the use of **residual blocks**.

Related Work

- **Complex-valued CNN** offers another promising deep-learning method for image denoising[1].
  - ➤ Frequency domain is disregarded.
- The model performs better when **complex filters** are applied to noisy images after **Fourier transform**[2].
  - ➤ Relatively complicated approach, and difficult to generalize.
- Adding Fourier transforms to **inner network structures** helps improve image deblurring models[3].

References

[1] Quan et al., Image denoising using complex-valued deep cnn, *Pattern Recognition*, 2021

[2] Pham et al., Efficient complex valued neural network with fourier transform on image denoising, 2021

[3] Mao et al.,, Deep residual fourier transformation for single image deblurring, *arXiv preprint arXiv*, 2021

Methods

- **Blind Training**: BSDS400 (#=20,000), **Testing**: SET12 & BSD68
- Proposed structures (**ResDnCNN**, **FFTResCNN**):
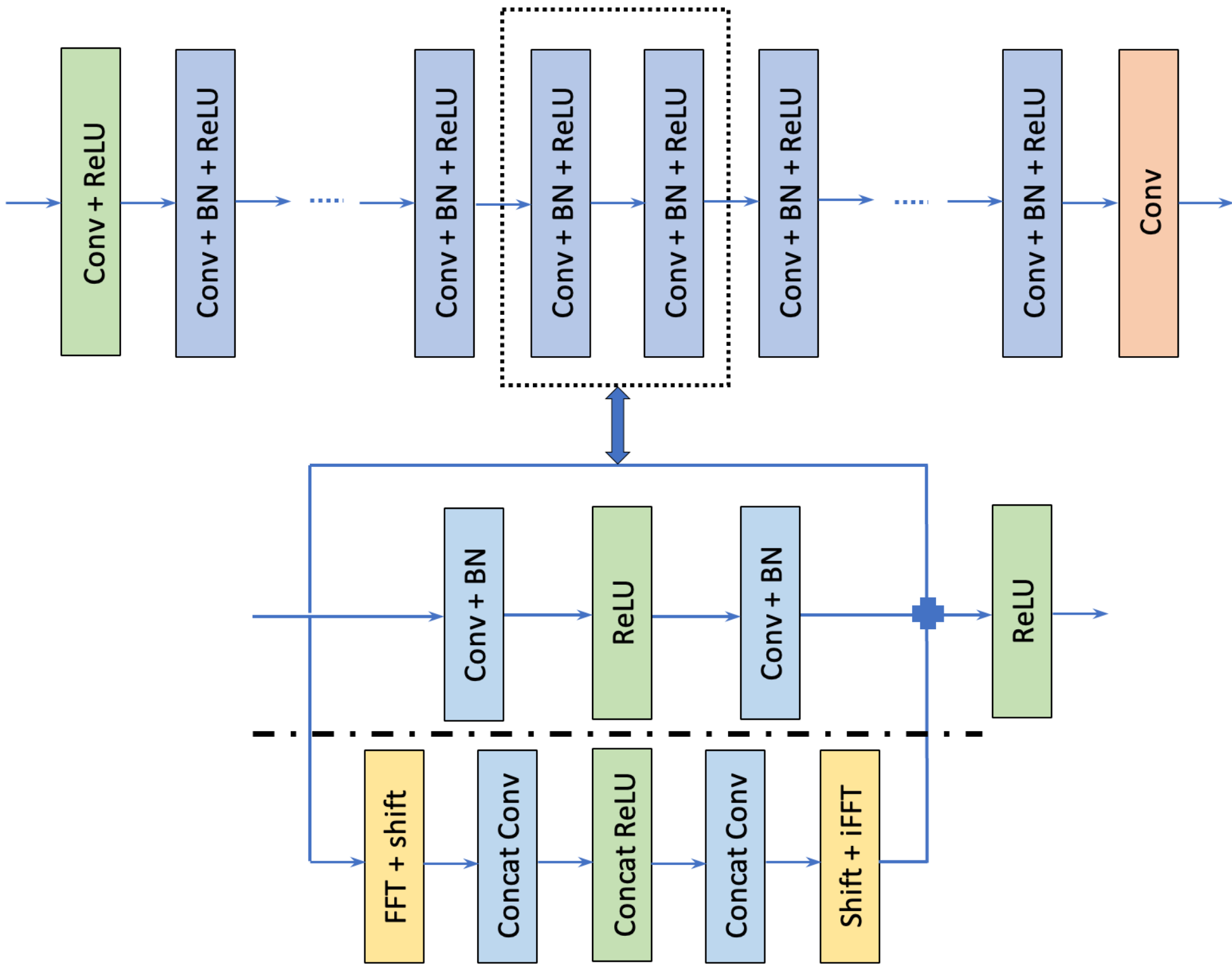
- Also implemented **BM3D** and **DnCNN**, and compared average PSNR on testing data

Experimental Results

- Results (measured in average PSNRs):

Noise Level	BM3D	DnCNN	ResDnCNN	FFTResCNN
15	26.184	32.342	32.411	**32.527**
25	25.451	30.027	30.089	**30.139**
50	23.172	26.739	26.855	**26.876**

Table 1. Comparisons on SET12 Average PSNR (in dB)

Noise Level	BM3D	DnCNN	ResDnCNN	FFTResCNN
15	24.461	31.322	31.390	**31.466**
25	23.805	28.883	28.953	**28.992**
50	22.297	25.908	**26.027**	25.982

Table 2. Comparisons on BSD68 Average PSNR (in dB)

- Denoising examples:

BM3D, 25.44dB   DnCNN, 29.42dB   FFTResCNN, 29.77dB

- Limited number of training data (20,000 vs. 226,800)
- Future work & Implications