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].

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):

<table>
<thead>
<tr>
<th>Noise Level</th>
<th>BM3D</th>
<th>DnCNN</th>
<th>ResDnCNN</th>
<th>FFTResCNN</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>26.184</td>
<td>32.342</td>
<td>32.411</td>
<td>32.527</td>
</tr>
<tr>
<td>25</td>
<td>25.451</td>
<td>30.027</td>
<td>30.089</td>
<td>30.139</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Noise Level</th>
<th>BM3D</th>
<th>DnCNN</th>
<th>ResDnCNN</th>
<th>FFTResCNN</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>24.461</td>
<td>31.322</td>
<td>31.390</td>
<td>31.466</td>
</tr>
<tr>
<td>50</td>
<td>22.297</td>
<td>25.908</td>
<td>26.027</td>
<td>25.982</td>
</tr>
</tbody>
</table>

  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

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