

Neumann Network with Recursive Kernels for Single Image Defocus Deblurring (Supplementary Materials)

1. Visual Comparison of SIDD Results of LFDOF-Trained Models on CUHK-BD Dataset

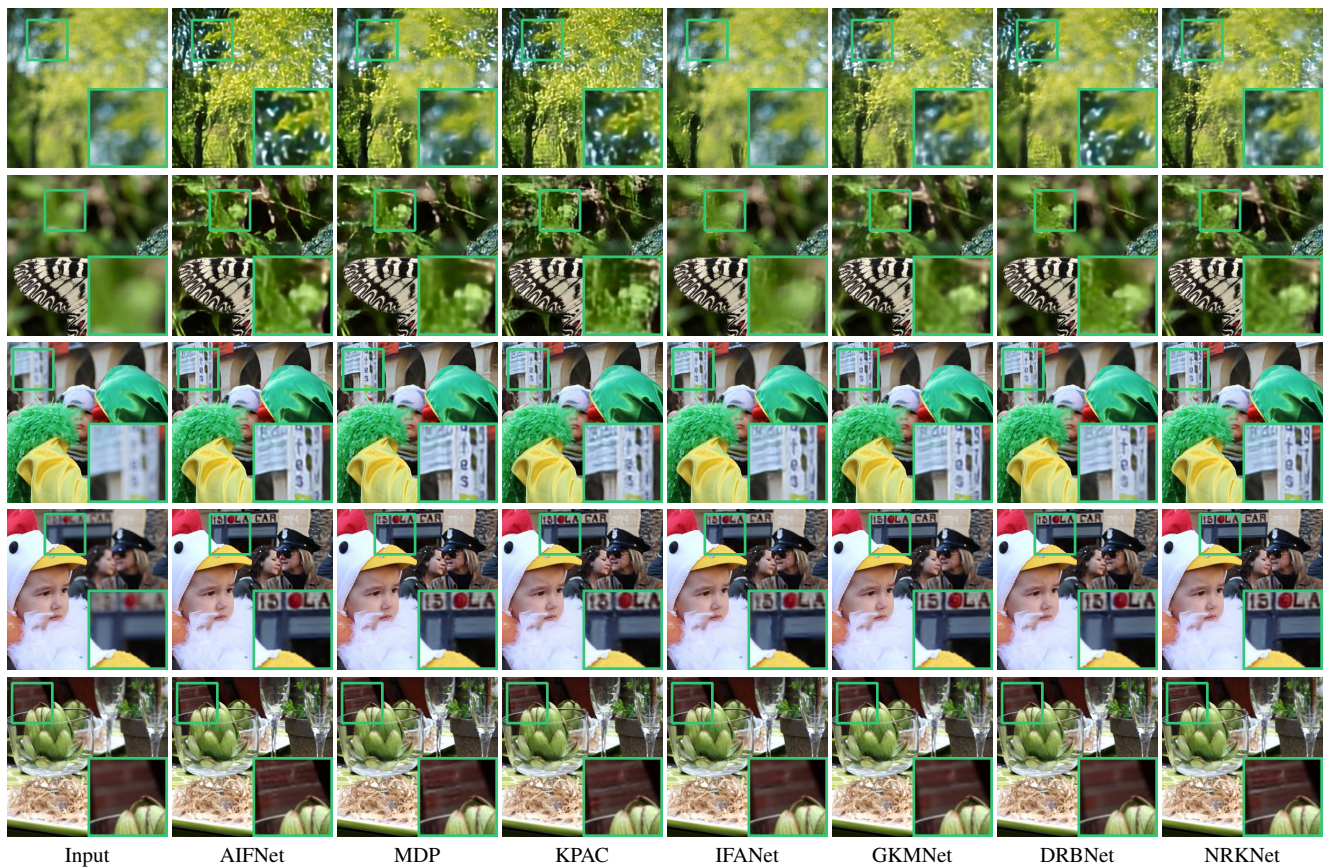


Figure 1. SIDD results from LFDOF-trained models on selected images from CUHK-BD dataset.

2. Code Link and Animated Versions of Visual Results

Our code is also published via the link <https://github.com/csZcWu/NRKNet>. We also supply animated versions of the visual results via this link for clarity and convenient sake.

3. Results of Ablation Studies on Other Datasets

| Method | RealDOF | | | RTF | | | LFDOF | | | RTF | | |
|--------------|---------------|--------------|--------------|---------------|--------------|--------------|---------------|--------------|--------------|---------------|--------------|--------------|
| | PSNR | SSIM | LPIPS | PSNR | SSIM | LPIPS | PSNR | SSIM | LPIPS | PSNR | SSIM | LPIPS |
| Input | 23.890 | 0.725 | 0.349 | 24.200 | 0.717 | 0.248 | 25.874 | 0.777 | 0.320 | 24.200 | 0.717 | 0.248 |
| NonAdaptive | 24.501 | 0.756 | 0.372 | 24.738 | 0.807 | 0.246 | 30.360 | 0.881 | 0.154 | 27.753 | 0.883 | 0.166 |
| NonRecursive | 25.148 | 0.768 | 0.342 | 25.346 | 0.817 | 0.241 | 30.475 | 0.883 | 0.148 | 27.814 | 0.885 | 0.150 |
| NonSeparable | 25.150 | 0.769 | 0.339 | 25.538 | 0.825 | 0.231 | 30.450 | 0.883 | 0.150 | 27.968 | 0.888 | 0.149 |
| FullRKR | 25.148 | 0.768 | 0.340 | 25.931 | 0.829 | 0.215 | 30.537 | 0.884 | 0.147 | 28.047 | 0.889 | 0.145 |

Table 1. Results of ablation study on RKR using DPDD-trained models (left part) and LFDOF-trained models (right part).

| Method | RealDOF | | | RTF | | | LFDOF | | | RTF | | |
|----------|---------------|--------------|--------------|---------------|--------------|--------------|---------------|--------------|--------------|---------------|--------------|--------------|
| | PSNR | SSIM | LPIPS | PSNR | SSIM | LPIPS | PSNR | SSIM | LPIPS | PSNR | SSIM | LPIPS |
| Input | 22.333 | 0.633 | 0.524 | 24.200 | 0.717 | 0.248 | 25.874 | 0.777 | 0.320 | 24.200 | 0.717 | 0.248 |
| FullExp | 25.149 | 0.768 | 0.340 | 25.569 | 0.813 | 0.225 | 30.517 | 0.883 | 0.149 | 28.028 | 0.891 | 0.147 |
| 2Scales | 24.914 | 0.755 | 0.356 | 25.561 | 0.812 | 0.248 | 29.497 | 0.864 | 0.180 | 26.975 | 0.848 | 0.235 |
| 4Scales | 25.146 | 0.769 | 0.361 | 25.728 | 0.814 | 0.247 | 30.470 | 0.883 | 0.149 | 27.904 | 0.887 | 0.149 |
| w/o LSTM | 24.679 | 0.747 | 0.361 | 24.725 | 0.787 | 0.323 | 29.053 | 0.860 | 0.174 | 25.223 | 0.844 | 0.178 |
| Original | 25.148 | 0.768 | 0.340 | 25.931 | 0.829 | 0.215 | 30.537 | 0.884 | 0.147 | 28.047 | 0.889 | 0.145 |

Table 2. Results of ablation study on DNN pipeline using DPDD-trained models (left part) and LFDOF-trained models (right part).

| Method | RealDOF | | | RTF | | | LFDOF | | | RTF | | |
|----------------------------|---------------|--------------|--------------|---------------|--------------|--------------|---------------|--------------|--------------|---------------|--------------|--------------|
| | PSNR | SSIM | LPIPS | PSNR | SSIM | LPIPS | PSNR | SSIM | LPIPS | PSNR | SSIM | LPIPS |
| Input | 22.333 | 0.633 | 0.524 | 24.200 | 0.717 | 0.248 | 25.874 | 0.777 | 0.320 | 24.200 | 0.717 | 0.248 |
| w/o \mathcal{L}_{reblur} | 25.009 | 0.758 | 0.352 | 25.052 | 0.812 | 0.233 | 30.006 | 0.880 | 0.156 | 27.674 | 0.885 | 0.163 |
| w/o FDR Loss | 24.972 | 0.764 | 0.349 | 25.275 | 0.819 | 0.249 | 30.280 | 0.873 | 0.165 | 27.689 | 0.875 | 0.188 |
| Single-scale Loss | 24.785 | 0.749 | 0.363 | 25.173 | 0.797 | 0.278 | 29.296 | 0.861 | 0.185 | 26.487 | 0.832 | 0.275 |
| Full Loss | 25.148 | 0.768 | 0.340 | 25.931 | 0.829 | 0.215 | 30.537 | 0.884 | 0.147 | 28.047 | 0.889 | 0.145 |

Table 3. Results of ablation study on loss functions using DPDD-trained models (left part) and LFDOF-trained models (right part).

4. Visualization of Learned Atoms Kernels in RKR

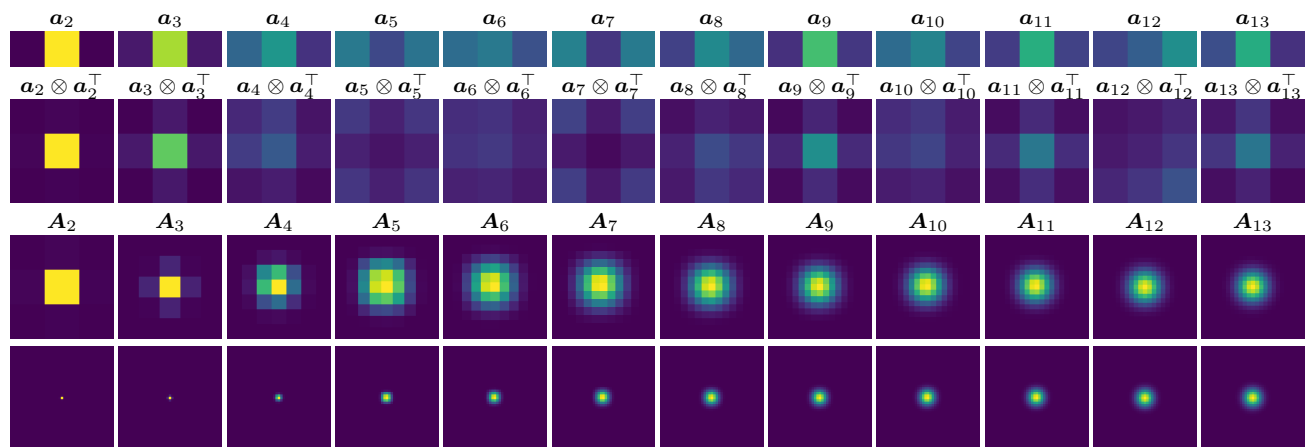


Figure 2. Visualization of learned adaptive kernels in our DPDD-trained NRKNet. The kernels shown in the 4th row are the ones of the 3rd row padded with zeros to have the same size.

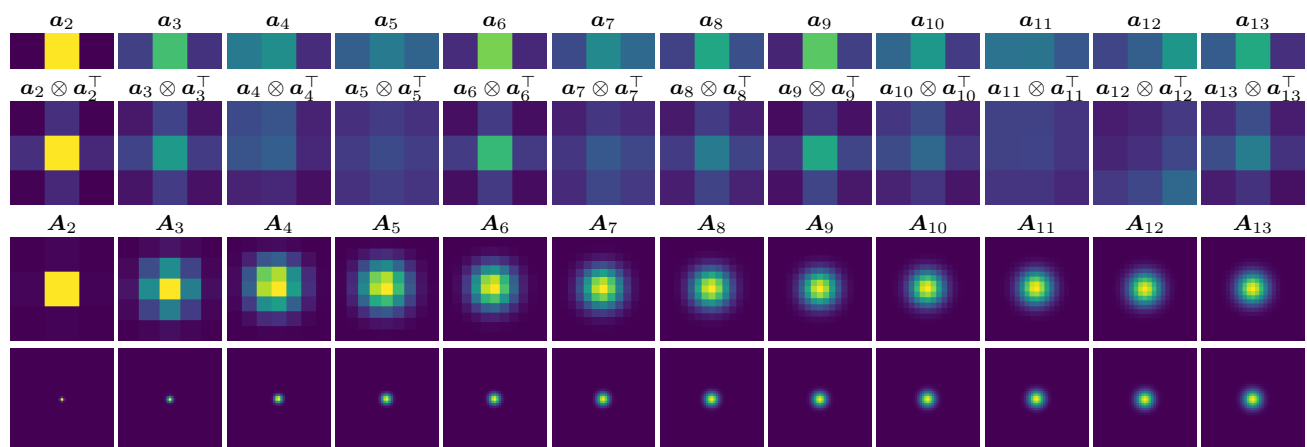


Figure 3. Visualization of learned adaptive kernels in our LFDOF-trained NRKNet. The kernels shown in the 4th row are the ones of the 3rd row padded with zeros to have the same size.

5. Visualization of Coefficient Maps

See Fig. ?? for the visualization of some coefficient maps at the original image scale. We can observe that the regions with larger blur amount tend to have larger coefficients on large-size kernels, and vice versa.

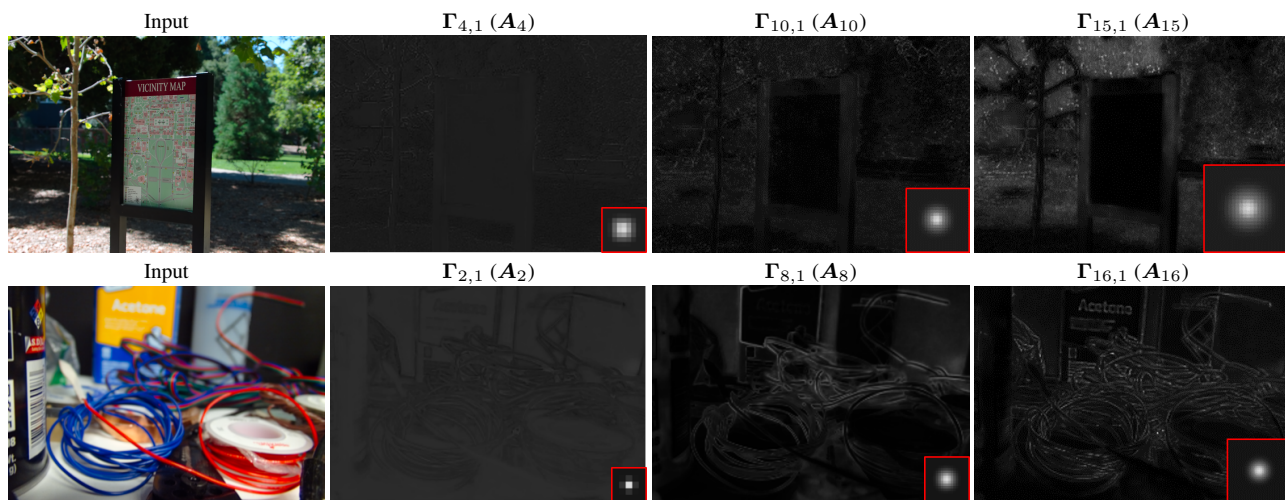


Figure 4. Visualization of coefficient maps and learned kernels.