Supplementary File to “External Prior Guided Internal Prior Learning for Real-World Noisy Image Denoising”

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In this supplementary file, we provide:
1) More results on the 15 cropped real-world noisy images in dataset [1];
2) More results on the 60 cropped real-world noisy images in dataset [1];
3) More results on the 1000 cropped real-world noisy images in dataset [2];
4) More results on the 100 cropped real-world noisy images in our new dataset.

I. MORE RESULTS ON THE 15 CROPPED REAL-WORLD NOISY IMAGES IN DATASET [1]

In this section, we provide more comparisons of the proposed method with the state-of-the-art denoising methods on the 15 cropped real-world noisy images used in [1]. In this dataset, each scene was shot 500 times under the same camera and camera setting. The mean image of the 500 shots is roughly taken as the “ground truth”, with which the PSNR and SSIM [3] can be computed. The average SSIM results of GAT-BM3D [4], CBM3D [5], WNNM [6], TID [7], MLP [8], CSF [9], TNRD [10], DnCNN [11], NI [12], NC [13], [14], CC [1], and the proposed method are listed in Table I. As can be seen from Figures 1-2, our proposed method achieves visually more pleasing results than the competing methods.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|}
\hline
Setting & GAT-BM3D & CBM3D & WNNM & TID & MLP & CSF & TNRD & DnCNN & NI & NC & CC & Ours \\
\hline
Canon 5D Mark III ISO = 3200 & 0.9126 & 0.9778 & 0.9673 & 0.9515 & 0.9695 & 0.9434 & 0.9742 & 0.9389 & 0.9600 & 0.9689 & 0.9678 & 0.9813 \\
Nikon D600 ISO = 3200 & 0.9245 & 0.9130 & 0.9321 & 0.8915 & 0.9481 & 0.8792 & 0.9494 & 0.9123 & 0.9411 & 0.9497 & 0.9484 & 0.9535 \\
Nikon D800 ISO = 3200 & 0.9554 & 0.9385 & 0.9727 & 0.9514 & 0.9647 & 0.9747 & 0.9375 & 0.9171 & 0.9438 & 0.9461 & 0.9473 & 0.9535 \\
Nikon D800 ISO = 1600 & 0.9085 & 0.9277 & 0.9317 & 0.8935 & 0.9437 & 0.9497 & 0.9115 & 0.8935 & 0.9215 & 0.9315 & 0.9351 & 0.9513 \\
Nikon D800 ISO = 6400 & 0.9193 & 0.8935 & 0.9656 & 0.8935 & 0.9777 & 0.9617 & 0.9377 & 0.9011 & 0.8966 & 0.9391 & 0.9296 & 0.9318 \\
Nikon D800 ISO = 12800 & 0.9017 & 0.8935 & 0.9354 & 0.8935 & 0.9745 & 0.9617 & 0.9377 & 0.9011 & 0.8966 & 0.9391 & 0.9296 & 0.9318 \\
Average & 0.8846 & 0.9063 & 0.9381 & 0.8463 & 0.9436 & 0.9250 & 0.9465 & 0.8635 & 0.9126 & 0.9364 & 0.9481 & 0.9505
\end{tabular}
\caption{Average SSIM [3] results of different methods on 15 cropped real-world noisy images used in [1].}
\end{table}

II. MORE RESULTS ON THE 60 CROPPED REAL-WORLD NOISY IMAGES IN DATASET [1]

In this section, we provide more comparisons of the proposed method with the state-of-the-art denoising methods on the 60 real-world noisy images cropped from [1]. In this dataset, each scene was shot 500 times under the same camera and camera setting. The mean image of the 500 shots is roughly taken as the “ground truth”, with which the PSNR and SSIM [3] can be computed. The average SSIM results of GAT-BM3D [4], CBM3D [5], WNNM [6], TID [7], MLP [8], CSF [9], TNRD [10], DnCNN [11], NI [12], NC [13], [14], CC [1], and the proposed method are listed in Table II (CC is not compared since the code of [1] is not available). As can be seen from Figures 3-4, our proposed method achieves visually more pleasing results than the competing methods.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|c|}
\hline
Methods & GAT-BM3D & CBM3D & WNNM & MLP & CSF & TNRD & DnCNN & NI & NC & Ours \\
\hline
SSIM & 0.9331 & 0.9251 & 0.9633 & 0.9653 & 0.9598 & 0.9670 & 0.8873 & 0.9241 & 0.9514 & 0.9691 \\
\end{tabular}
\caption{Average SSIM [3] results of different methods on 60 real-world noisy images cropped from [1].}
\end{table}

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III. MORE RESULTS ON THE 1000 CROPPED REAL-WORLD NOISY IMAGES IN DATASET [2]

In this section, we give more visual comparisons of the competing methods on the 1000 cropped real-world noisy images in [2]. In this dataset, each scene was shot twice, one at a high ISO value and the other at a low ISO value. The image captured at low ISO value (usually 100 or 125) is roughly taken as the “ground truth”, with which the PSNR and SSIM [3] can be computed. The average SSIM results of GAT-BM3D [4], CBM3D [5], WNNM [6], MLP [8], CSF [9], TNRD [10], DnCNN [11], NI [12], NC [13], [14], and the proposed method are listed in Table III (CC is not compared since the code of [1] is not available). As can be seen from Figures 5-10, our proposed method achieves visually more pleasing results than the competing methods.

### Table III: Average SSIM [3] results of different methods on 1000 real-world noisy images cropped from the dataset [2].

<table>
<thead>
<tr>
<th>Methods</th>
<th>GAT-BM3D</th>
<th>CBM3D</th>
<th>WNNM</th>
<th>MLP</th>
<th>CSF</th>
<th>TNRD</th>
<th>DnCNN</th>
<th>NI</th>
<th>NC</th>
<th>Ours</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSIM</td>
<td>0.7564</td>
<td>0.7773</td>
<td>0.8012</td>
<td>0.8201</td>
<td>0.8128</td>
<td>0.8271</td>
<td>0.7897</td>
<td>0.8778</td>
<td>0.9013</td>
<td>0.9101</td>
</tr>
</tbody>
</table>

IV. MORE RESULTS ON THE 100 CROPPED REAL-WORLD NOISY IMAGES IN OUR NEW DATASET

In this section, we provide more comparisons of the proposed method with the state-of-the-art denoising methods on the 100 real-world noisy images cropped from the new dataset we constructed. In this dataset, each scene was shot 500 times under the same camera and camera setting. The mean image of the 500 shots is roughly taken as the “ground truth”, with which the PSNR and SSIM can be computed. The average SSIM results of GAT-BM3D [4], CBM3D [5], WNNM [6], MLP [8], CSF [9], TNRD [10], DnCNN [11], NI [12], NC [13], [14], and the proposed method are listed in Table IV (CC is not compared since the code of [1] is not available). As can be seen from Figures 9-10, our proposed method achieves visually more pleasing results than the competing methods.

### Table IV: Average SSIM [3] results of different methods on 100 real-world noisy images cropped from our new dataset.

<table>
<thead>
<tr>
<th>Methods</th>
<th>GAT-BM3D</th>
<th>CBM3D</th>
<th>WNNM</th>
<th>MLP</th>
<th>CSF</th>
<th>TNRD</th>
<th>DnCNN</th>
<th>NI</th>
<th>NC</th>
<th>Ours</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSIM</td>
<td>0.8881</td>
<td>0.9494</td>
<td>0.9290</td>
<td>0.9453</td>
<td>0.9398</td>
<td>0.9486</td>
<td>0.8852</td>
<td>0.9190</td>
<td>0.9356</td>
<td>0.9529</td>
</tr>
</tbody>
</table>

REFERENCES

[12] Neatlab ABSOft. Neat Image. https://ni.neatvideo.com/home. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
Fig. 1: Denoised images of a region cropped from the real-world noisy image “Canon 5D Mark 3 ISO 3200 2” [1] by different methods. The images are better to be zoomed-in on screen.
(a) Noisy [1]: 33.77dB
(b) Mean Image [1]

(c) CBM3D [15]: 35.07dB
(d) WNNM [6]: 36.09dB
(e) TNRD [10]: 36.37dB
(f) DnCNN [11]: 34.48dB

(g) NI [12]: 35.36dB
(h) NC [13], [14]: 36.70dB
(i) CC [1]: 35.95dB
(j) Ours: 36.31dB

Fig. 2: Denoised images of a region cropped from the real-world noisy image “Nikon D600 ISO 3200 2” [1] by different methods. The images are better to be zoomed-in on screen.
Fig. 3: Denoised images of a region cropped from the real-world noisy image “Nikon D800 ISO 1600 B2” [1] by different methods. The images are better viewed by zooming in on screen.
Fig. 4: Denoised images of a region cropped from the real-world noisy image “Nikon D800 ISO 3200 A1” [1] by different methods. The images are better viewed by zooming in on screen.
Fig. 5: Denoised images by different methods of the real-world noisy image “0002_10” captured by a Huawei Nexus 6P phone [2]. Note that the ground-truth clean image of the noisy input is not publicly released yet.
Fig. 6: Denoised images by different methods of the real-world noisy image “0003_5” captured by a Huawei Nexus 6P phone [2]. Note that the ground-truth clean image of the noisy input is not publicly released yet.
(a) Noisy [14]

(b) CBM3D [15]

(c) WNNM [6]

(d) MLP [8]

(e) CSF [9]

(f) TNRD [10]

(g) DnCNN [11]

(h) NI [12]

(i) NC [13], [14]

(j) Ours

Fig. 7: Denoised images by different methods of the real-world noisy image “0006_18” captured by a Sony A7R camera [2]. Note that the ground-truth clean image of the noisy input is not publicly released yet.
Fig. 8: Denoised images by different methods of the real-world noisy image “0049_4” captured by a Huawei Nexus 6P phone [2]. Note that the ground-truth clean image of the noisy input is not publicly released yet.
Fig. 9: Denoised images of a region cropped from the real-world noisy image “Canon 80D ISO 12800 IMG2360” in our new dataset by different methods. The images are better viewed by zooming in on screen.
Fig. 10: Denoised images of a region cropped from the real-world noisy image “SONY A7II ISO 6400 DSC03017” in our new dataset by different methods. The images are better viewed by zooming in on screen.