Image Noise and Filtering (II)

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Bilateral Filter [2]

- Bilateral filtering smoothes images while preserving edges, by means of a **nonlinear combination** of nearby image values.

new

not new

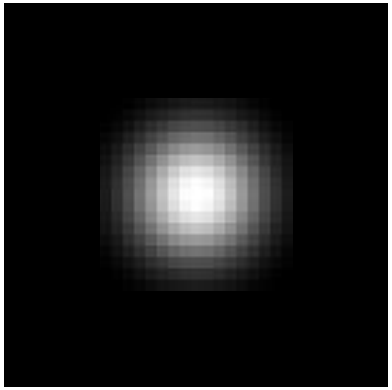
new

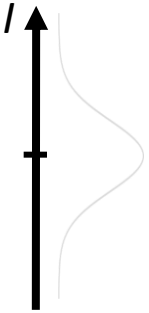
$$BF[I]_{\mathbf{p}} = \frac{1}{W_{\mathbf{p}}} \sum_{\mathbf{q} \in S} G_{\sigma_s}(\|\mathbf{p}-\mathbf{q}\|)\, G_{\sigma_r}(|I_{\mathbf{p}}-I_{\mathbf{q}}|)\, I_{\mathbf{q}}$$

normalization factor

space weight

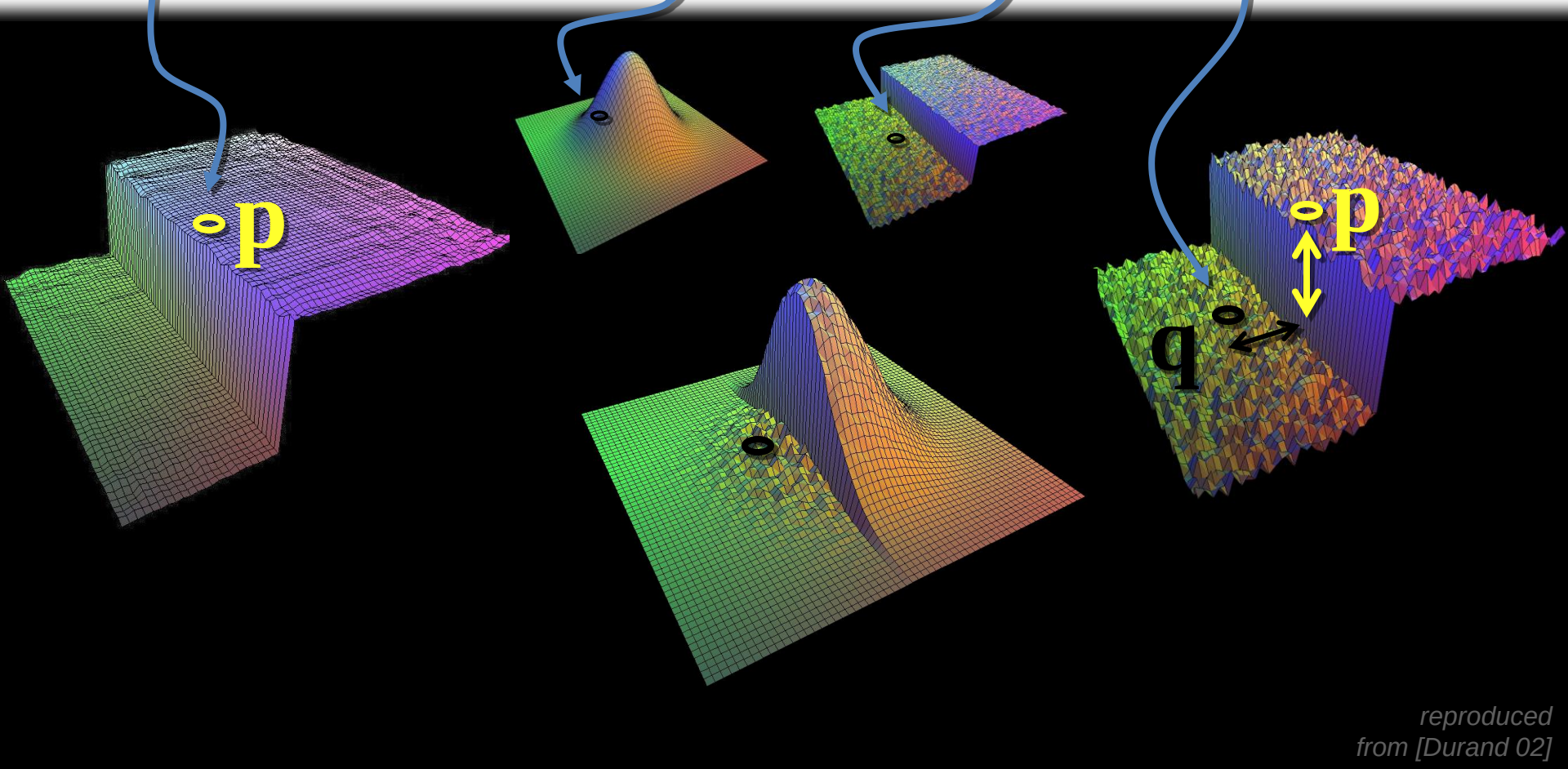
range weight





Bilateral Filter on a Height Field

$$BF[I]_{\mathbf{p}} = \frac{1}{W_{\mathbf{p}}} \sum_{\mathbf{q} \in S} G_{\sigma_s}(\|\mathbf{p}-\mathbf{q}\|)\, G_{\sigma_r}(|I_{\mathbf{p}}-I_{\mathbf{q}}|)\, I_{\mathbf{q}}$$



reproduced from [Durand 02]

Bilateral Filter for Gray Image

Noise image (Gaussian Noise, mean =0, std = 5)

Bilateral Filtering (ISNR= 1.4211 dB, 9×9, $\sigma_s = 5$, $\sigma_r = 10$, Time = 1.1909s)

Failed Example

Noise image (Gaussian Noise, mean = 0, std = 20)

Bilateral Filtering (ISNR= 1.0637 dB, 9×9, $\sigma_s = 5$, $\sigma_r = 10$, Time = 1.2673s)

Failed Example

Noise image (Gaussian Noise, mean = 0, std = 20)

Bilateral Filtering (ISNR= 4.0883 dB, 9×9, $\sigma_s = 5$, $\sigma_r = 50$, Time = 1.0722s)

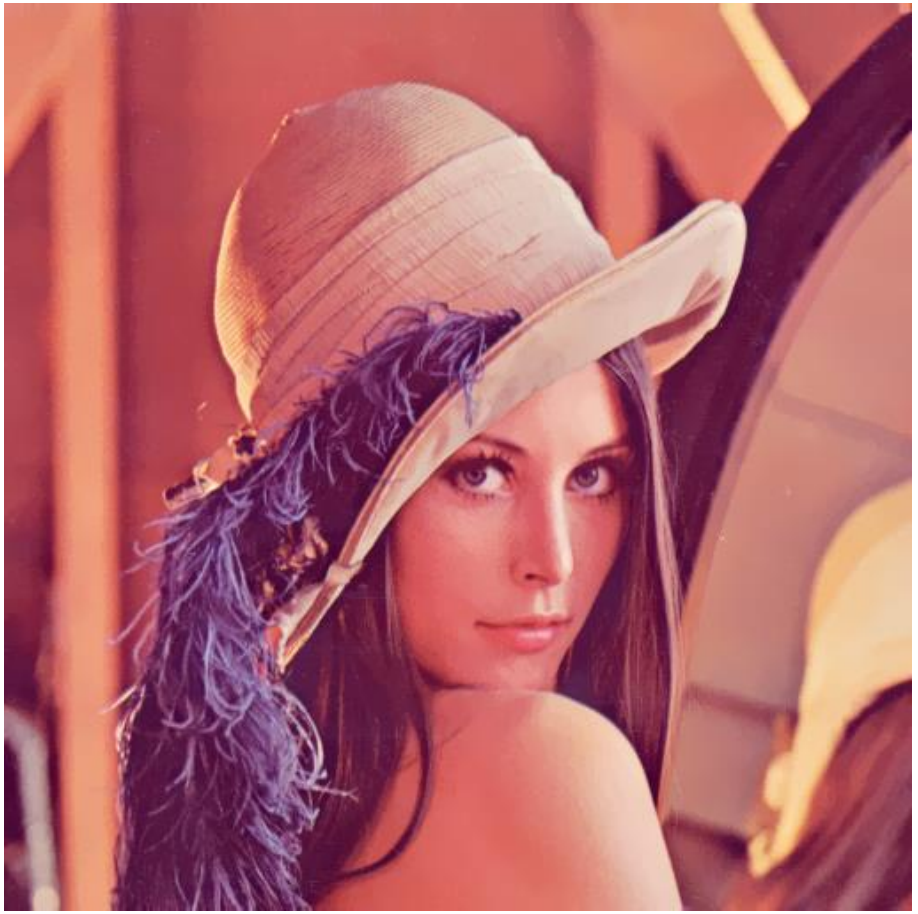
Bilateral Filter for Color Image

Noise image (Gaussian Noise, mean =0, std = 10)

Bilateral Filtering (ISNR= 3.8447 dB, 9×9, $\sigma_s = 5$, $\sigma_r = 10$, Time = 3.2966s)

More Examples for Color Images

(a) Input Image



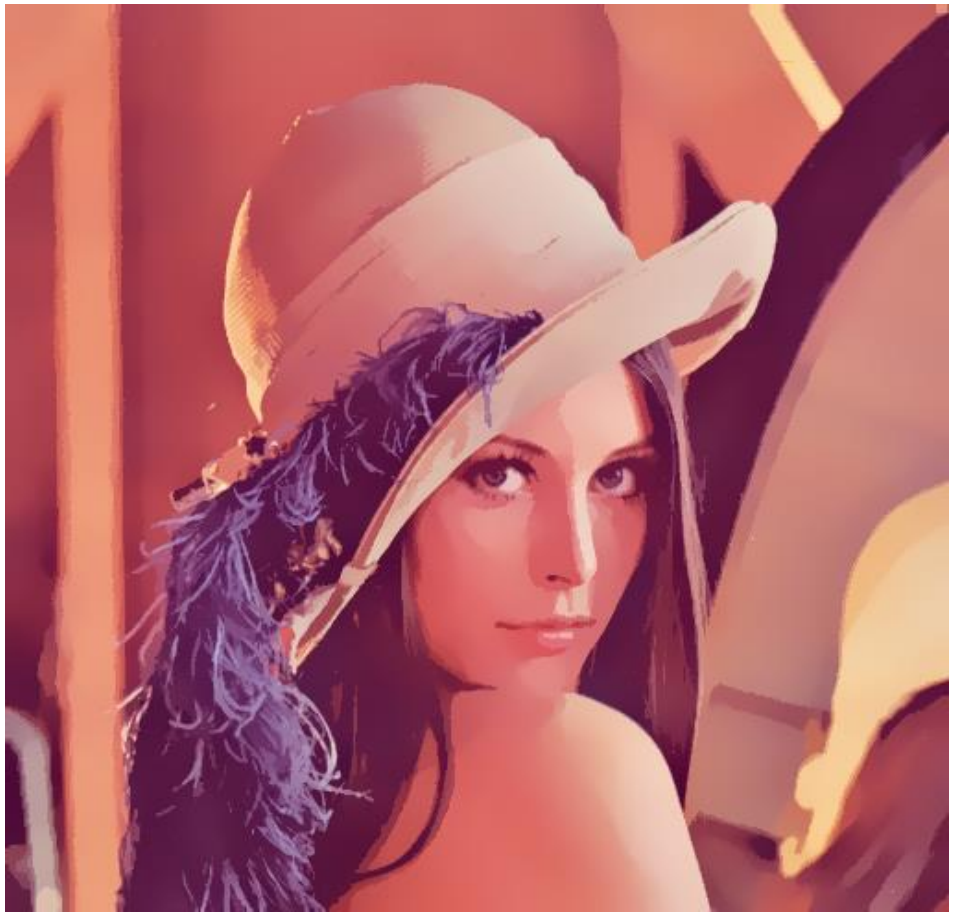
(b) Bilateral Filtered Image (iter = 5, w = 5, σ_s = 5, σ_r = 3)

More Examples for Color Images

(b) Bilateral Filtered Image (iter = 5, w = 5, σ_s = 5, σ_r = 3)

(c) Bilateral Filtered Image (iter = 5, w = 5, σ_s = 5, σ_r = 10)

More Examples for Color Images



(c) Bilateral Filtered Image (iter = 5, w = 5, σ_s = 5, σ_r = 10)

(d) Bilateral Filtered Image (iter = 10, w = 5, σ_s = 5, σ_r = 3)

Failed Example for Texture Noise

(a) Input Image

(b) Bilateral Filtered Image (iter = 5, w = 5, σ_s = 5, σ_r = 3)

References

- [1] X.-Q. Lu and H. Sakaino, “A spatial adaptive filter for smoothing of non-Gaussian texture noise” in Proc. of ICASSP, 2009.
- [2] C. Tomasi and R. Manduchi, “Bilateral filtering for gray and color images,” in Proc. Of the IEEE International Conference on Computer Vision, pp.839-846, 1998.

Thank You!

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