Blind Deconvolution with Richardson-Lucy Algorithm

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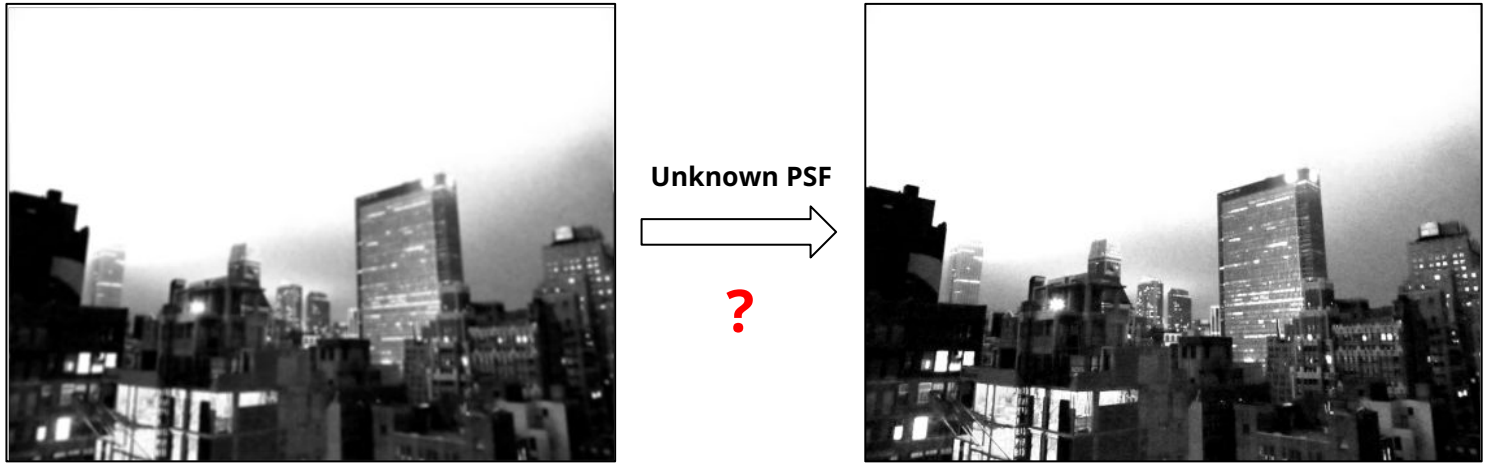
Background



Blind Deconvolution!

However…

- Complicated optimization problems
- Signal processing
- Fourier transformation
- Even deep neural networks

Is there an easy method?

Richardson-Lucy Algorithm

- An **iterative procedure** for recovering a latent image that has been blurred by a **known point spread function**
- $$\hat{I}^{(t+1)} = \hat{I}^{(t)} \cdot \left(\frac{B}{\hat{I}^{(t)} \otimes K} \otimes K^{*} \right)$$
- Simple iterations!
- Provably converge to the **maximum likelihood solution** for the latent image

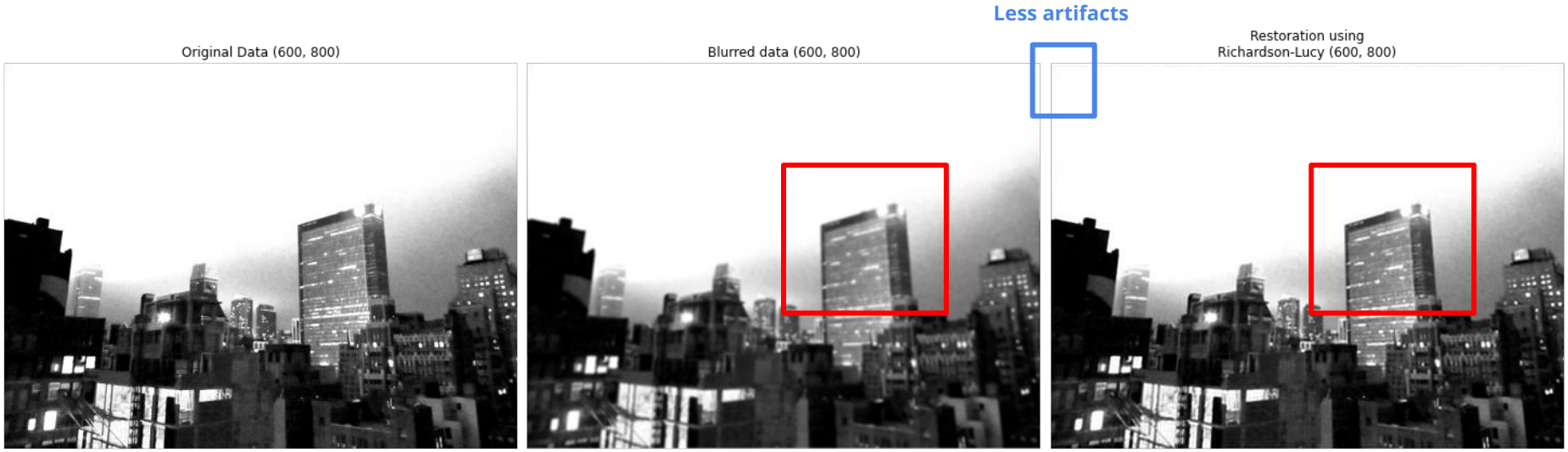
R-L Algorithm Results

Artifacts at boundaries

PSNR: 24.86

PSNR: 21.30

R-L Algorithm Results with Boundary Wrapping



PSNR: 24.94

PSNR: 29.73
Only after 25 iterations!

Goal – Blind Deconvolution

- $B = I \otimes K + N$

- ***I*** and ***K*** are **both** unknown!

- Can we estimate PSF similar as we estimate latent image?

R-L Algorithm for Blind Deconvolution [1]

- $$\hat{I}(t+1) = \hat{I}(t) \cdot \left(\frac{B}{\hat{I}(t) \otimes \hat{K}(t)} \otimes \hat{K}(t)^{*} \right)$$

  $$\hat{K}(t+1) = \hat{K}(t) \cdot \left(\frac{B}{\hat{I}(t+1) \otimes \hat{K}(t)} \otimes \hat{I}(t+1)^{*} \right)$$

- Still simple iterations but no guarantee on good convergence
- Results may **heavily depend on PSF initialization** (mainly on the ***kernel size*** instead of the kernel values)

[1] Lanteri, Henri, et al. "Blind deconvolution using the Richardson-Lucy algorithm." *Optics in Atmospheric Propagation and Random Phenomena*. Vol. 2312. SPIE, 1994.

Sample Results

blurred by a random **5*5** PSF
PSNR: 25.69

5*5

Only after 10 iterations!

9*9

restored from a full **5*5** PSF
PSNR: 26.28

restored from a full **9*9** PSF
PSNR: 23.39

Limitations

- Blind deconvolution heavily depends on size of initial kernel estimation
- Improvement is not significant in the “blind” setting

References

- Wikimedia Foundation. (2022, November 6). Richardson–Lucy Deconvolution. Wikipedia. Retrieved December 19, 2022, from https://en.wikipedia.org/wiki/Richardson%E2%80%93Lucy_deconvolution
- Lanteri, H., Aime, C., Beaumont, H., & Gaucherel, P. (1994, December). Blind deconvolution using the Richardson-Lucy algorithm. In Optics in Atmospheric Propagation and Random Phenomena (Vol. 2312, pp. 182-192). SPIE.
- Biggs, D. S., & Andrews, M. (1997). Acceleration of iterative image restoration algorithms. Applied optics, 36(8), 1766-1775.

Thank You!