DEEP-URL: A MODEL-AWARE APPROACH TO BLIND DECONVOLUTION BASED ON DEEP UNFOLDED RICHARDSON-LUCY NETWORK

CHIRAG AGARWAL, SHAHIN KHOBAHI, ARINDAM BOSE,
MOJTABA SOLTANALIAN, DAN SCHONFELD

Agarwal et al. “Deep-URL: A Model-aware Approach To Blind Deconvolution Based On Deep Unfolded Richardson-Lucy Network”. IEEE International Conference on Image Processing (ICIP). 2020.

Challenges with current DNN?

- Lack of interpretability
- Gap between classical estimation technique and deep neural network

Vs.

Problem formulation

$$\min_{x,\,H} \|y - H \circledast x\|_2^2 + \lambda\, TV(x)$$

RL algorithm

$$H^{k+1} = \left(\left[\frac{y}{x^k \circledast H^k}\right] \circledast x^{k\dagger}\right) \odot H^k$$

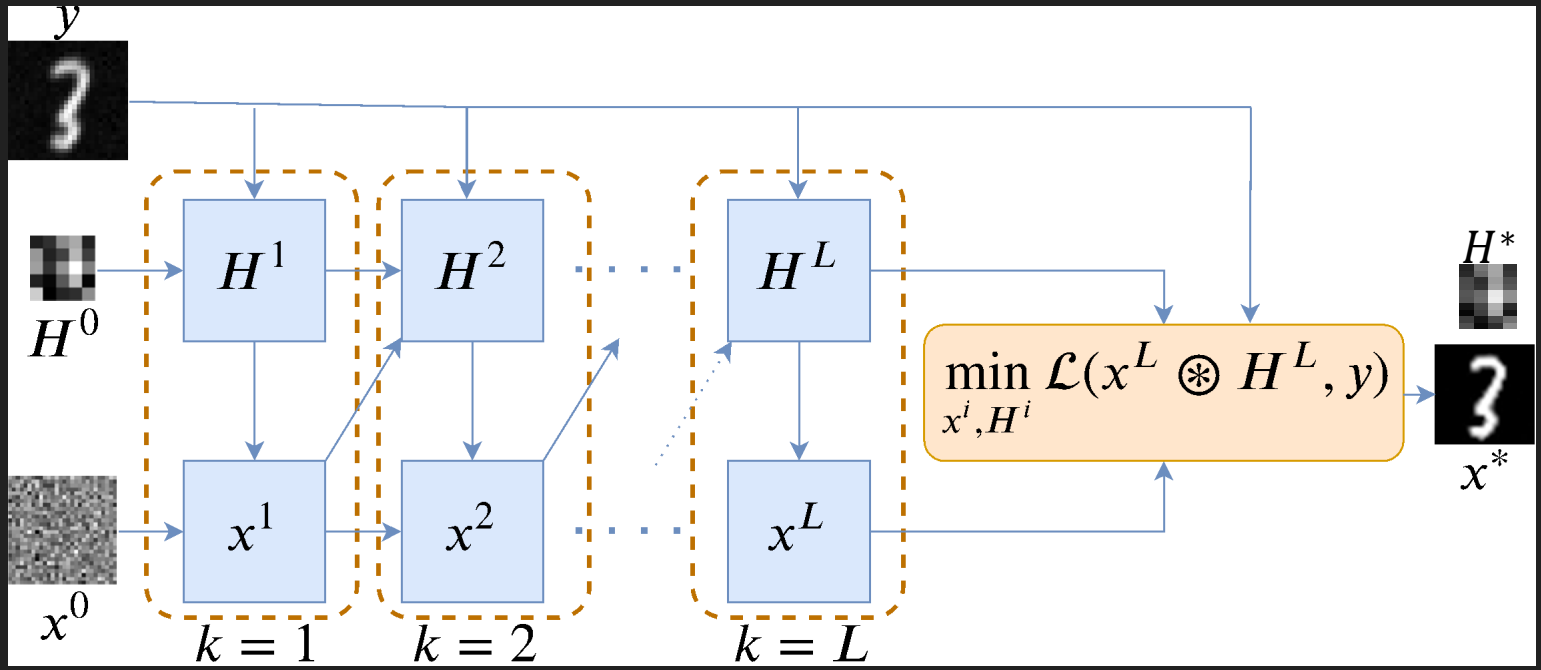
$$x^{k+1} = \left(\left[\frac{y}{x^k \circledast H^{k+1}}\right] \circledast H^{(k+1)\dagger}\right) \odot x^k$$

Deep-URL algorithm

$$H^{k+1} = \sigma\left(ReLU\left(\left[\frac{y}{ReLU(x^k \circledast W_H^k)}\right] \circledast x^{k\dagger}\right) \odot W_H^k\right)$$

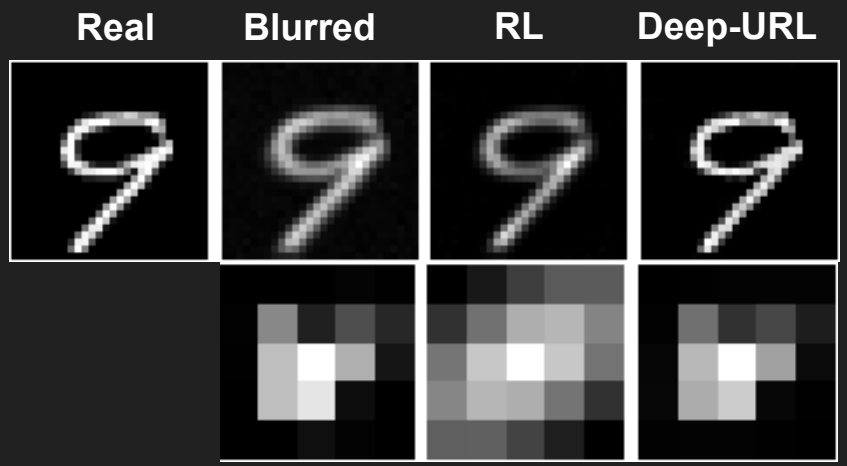
$$x^{k+1} = \sigma\left(ReLU\left(\left[\frac{y}{ReLU(W_x^k \circledast H^{k+1})}\right] \circledast H^{k+1\dagger}\right) \odot W_x^k\right)$$

Deep-URL


y
H^0
x^0
H^1
H^2
H^L
x^1
x^2
x^L
$k=1$
$k=2$
$k=L$
$\min_{x^i,H^i} \mathcal{L}(x^L \circledast H^L, y)$
H^*
x^*

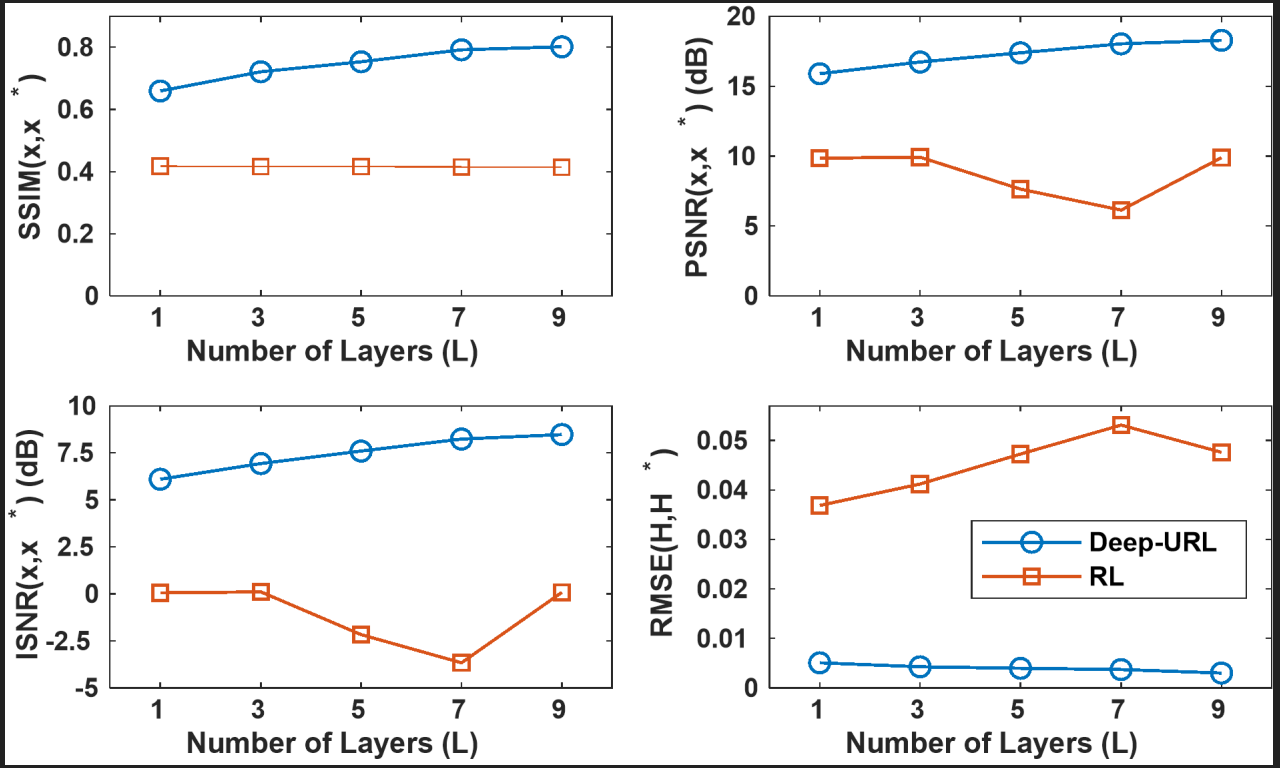
Deep-URL outperforms RL

Better reconstruction of both Image and Blurring kernel



Metrics	L=2		L=5	
	RL	Deep-URL	RL	Deep-URL
PSNR (dB)	10.392	**18.282**	10.474	**19.071**
ISNR (dB)	0.065	**7.955**	0.076	**9.310**
SSIM	0.445	**0.767**	0.448	**0.821**
RMSE (x 1e-3)	38.54	**4.396**	38.07	**4.399**

Increase in performance with additional layers



Results (Levin dataset)

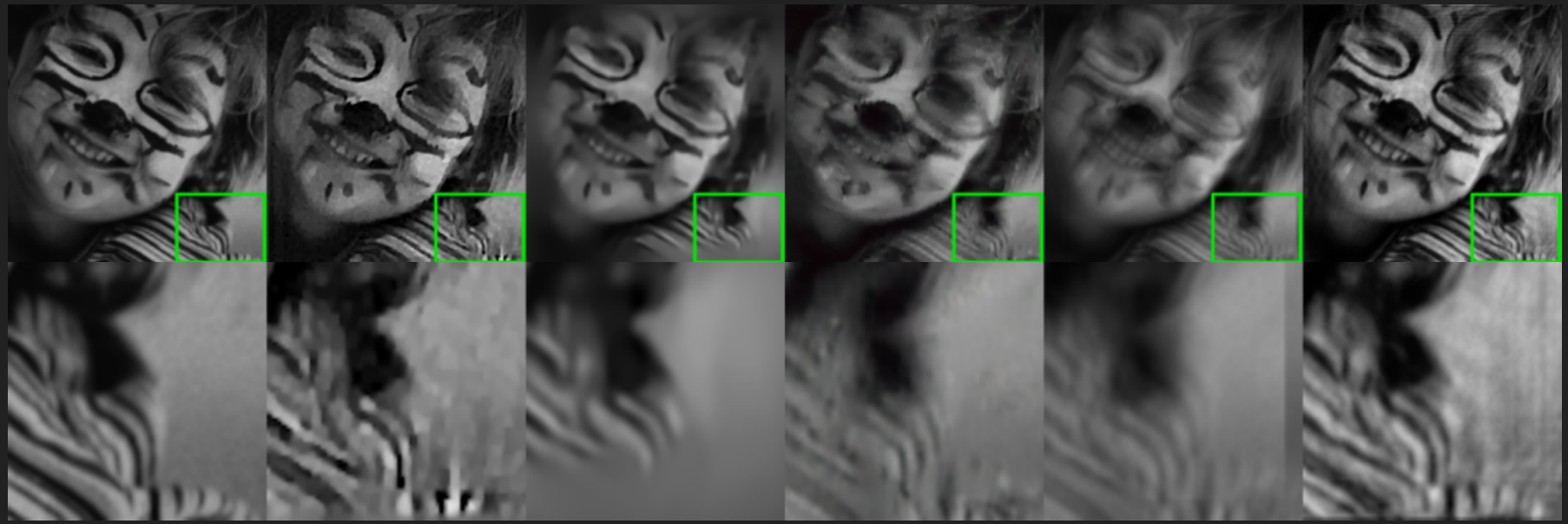
Deep-URL does not converge to trivial kernel solutions

Metrics	Li et al.	Nah et al.	Ayan et al.	RL	Deep -URL
PSNR (dB)	27.15	24.51	23.18	19.42	27.12
ISNR (dB)	3.79	1.35	0.02	-2.98	**6.95**
SSIM	0.88	0.81	0.81	0.53	**0.91**
RMSE (x 1e-3)	**3.87**	-	-	10.10	7.10

Levin et al. “Understanding and evaluating blind deconvolution algorithms,” in 2009 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), June 2009.

Results (Levin dataset)

Deep-URL performs on par or better than existing deblurring methods



Final takeaways

- A model-aware deep blind deconvolution architecture
- Non-trivial solution

Questions?

chiragagarwall12@gmail.com
@_cagarwal