Explore Image Deblurring via Blur Kernel Space

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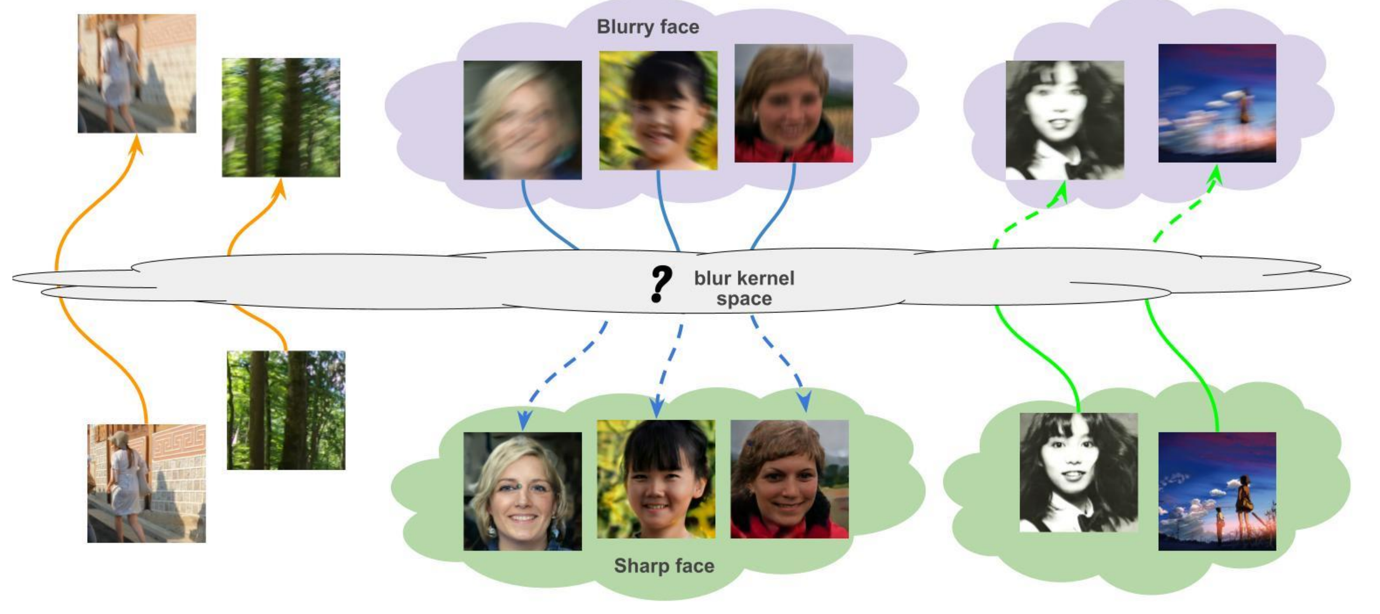
1. Introduction

- We propose a method to model the **blur kernel space** of a given dataset.
- Using this blur kernel space, we can perform **image deblurring** and **blur synthesis**.



2. Limitation of existing methods

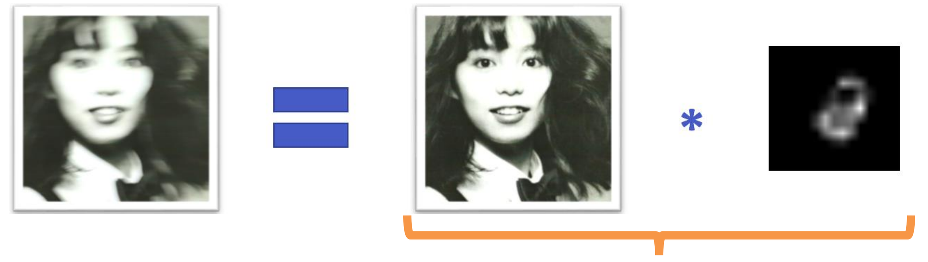
Blur model:

$$y = \hat{\mathcal{F}}(x, k) + \eta \approx \hat{\mathcal{F}}(x, k)$$

Noise

Blur img. Blur func. Sharp img. Blur kernel

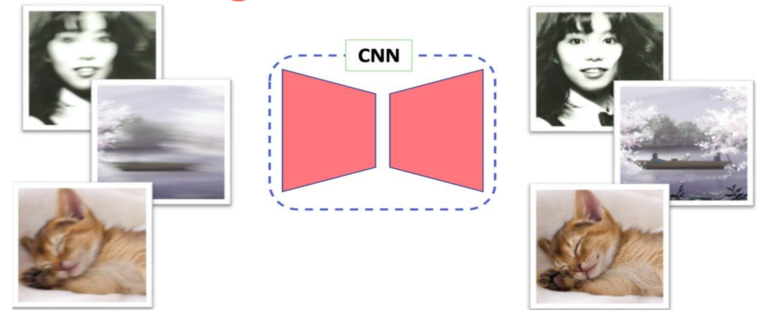
○ **Classical methods**:



Linear convolution

Linear and uniform → too simple

○ **Deep learning methods:**



Overfit to the training set

3. Blur kernel encoding

- Find two functions F and G such that:

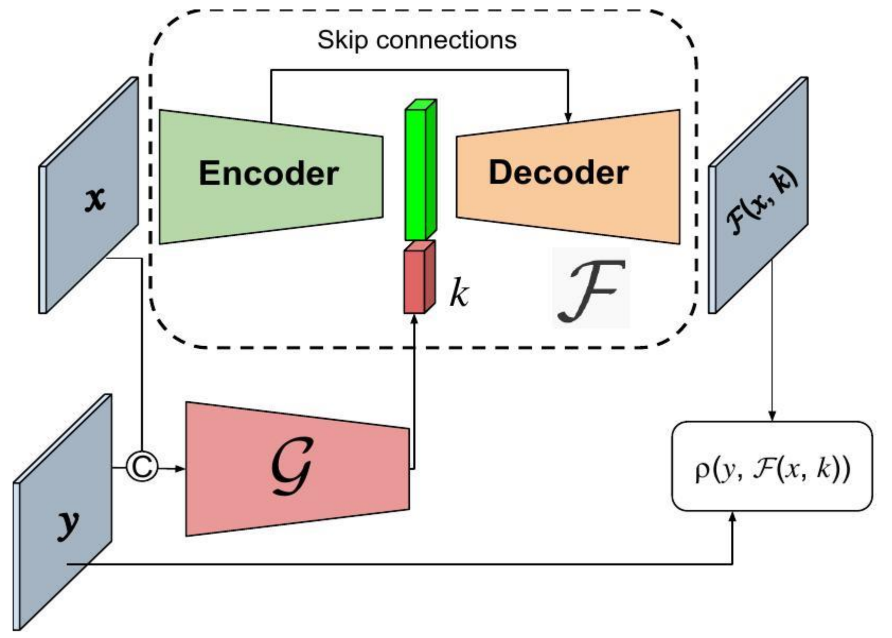
$$y = \mathcal{F}(x, k) \quad \text{and} \quad k = \mathcal{G}(x, y)$$

- Learn F and G by optimizing the objective function, given training data $\{(x_i\ y_i)\}$

$$\sum_{i=1}^{n} \rho(y_i, \mathcal{F}(x_i, \mathcal{G}(x_i, y_i)))$$

Charbonnier loss

- F and G are implemented by two neural networks.



4. Image Deblurring

○ **General Image Deblurring**

Given F, a blurry image y, we can **alternatively** search for **x** and **k** via an objective function:

$$\rho(y, \mathcal{F}(x, k)) + \lambda ||k||_2 + \gamma(g_u^2(x) + g_v^2(x))^{\alpha/2}$$

Kernel norm reg Gradient penalty

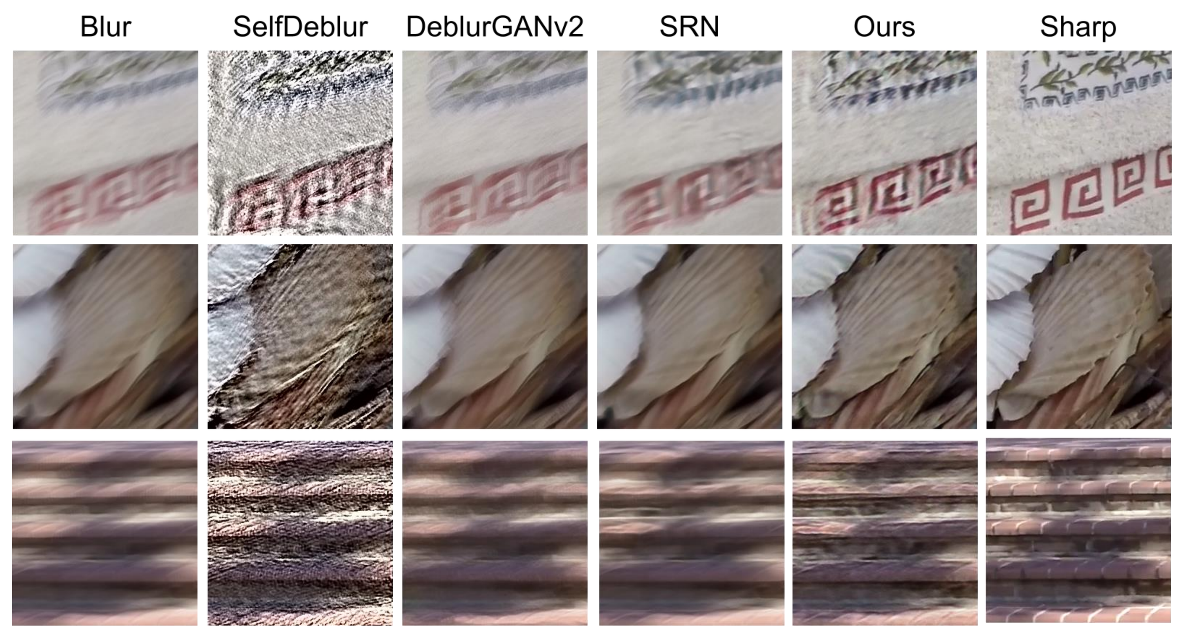
- To stabilize the optimization, we reparameterize x and k by Deep Image Prior (DIP)[1]

○ **Domain-specific Deblurring**

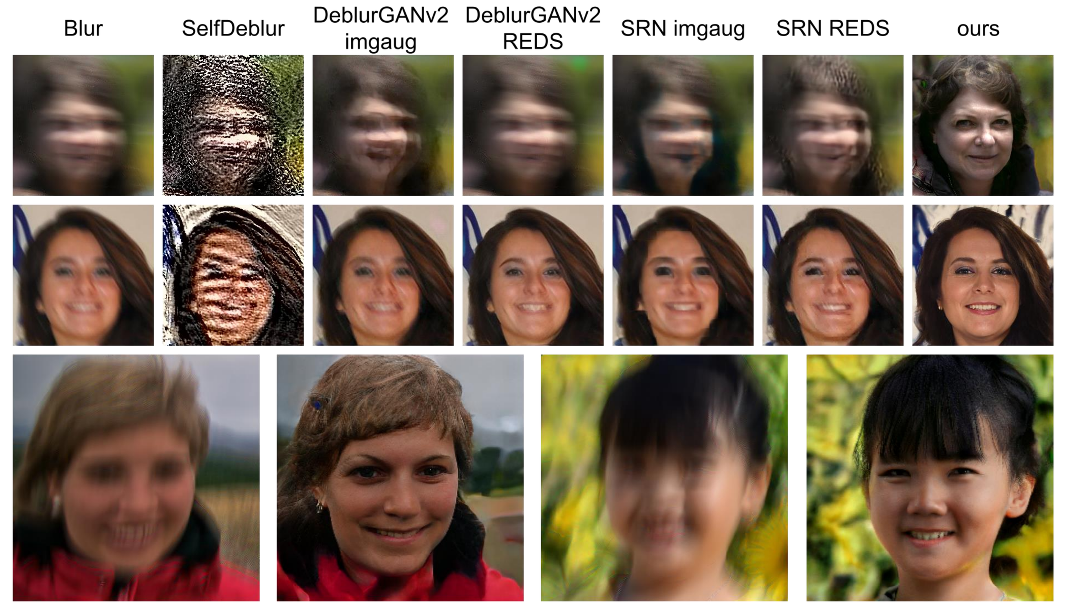
- Replace DIP of x with $G_{style}(z)$ in which G_{style} is the pretrained StyleGAN.

5. Experiments

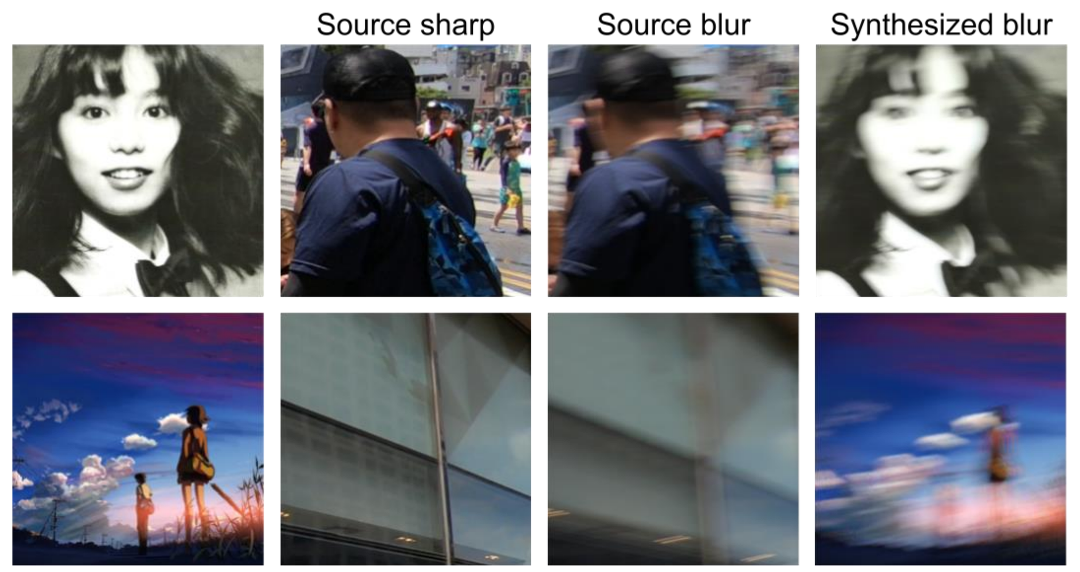
Image Deblurring



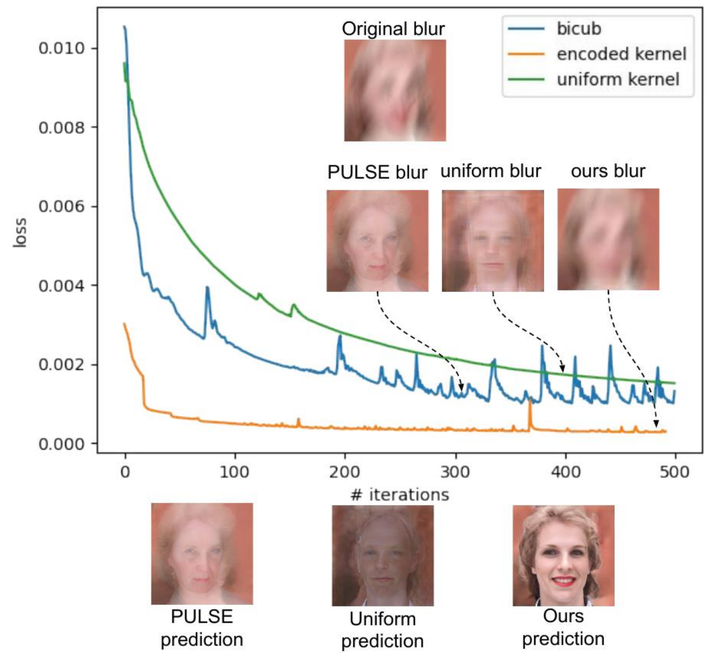
Face Deblurring



Blur Swapping



Loss Convergence



6. Data augmentation

- Apply blurs learned from a reference sharp-blur dataset
- Improve SRN-Deblur performance

	Test kernels		
Tranining kernels	imgaug	REDS	GOPRO
imgaug	**28.64**	24.22	22.96
comb.	28.30	**28.37**	**23.92**

7. Conclusion

- Propose a method to **encode the blur kernel** space of a deblurring dataset.
- Propose some **applications** of the blur kernel space.

[1]. Menon, Sachit, et al. "PULSE: Self-supervised photo upsampling via latent space exploration of generative models." *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*. 2020.

https://github.com/VinAIResearch/blur-kernel-space-exploring