Denoising Adversarial Networks for Rain Removal and Reflection Removal

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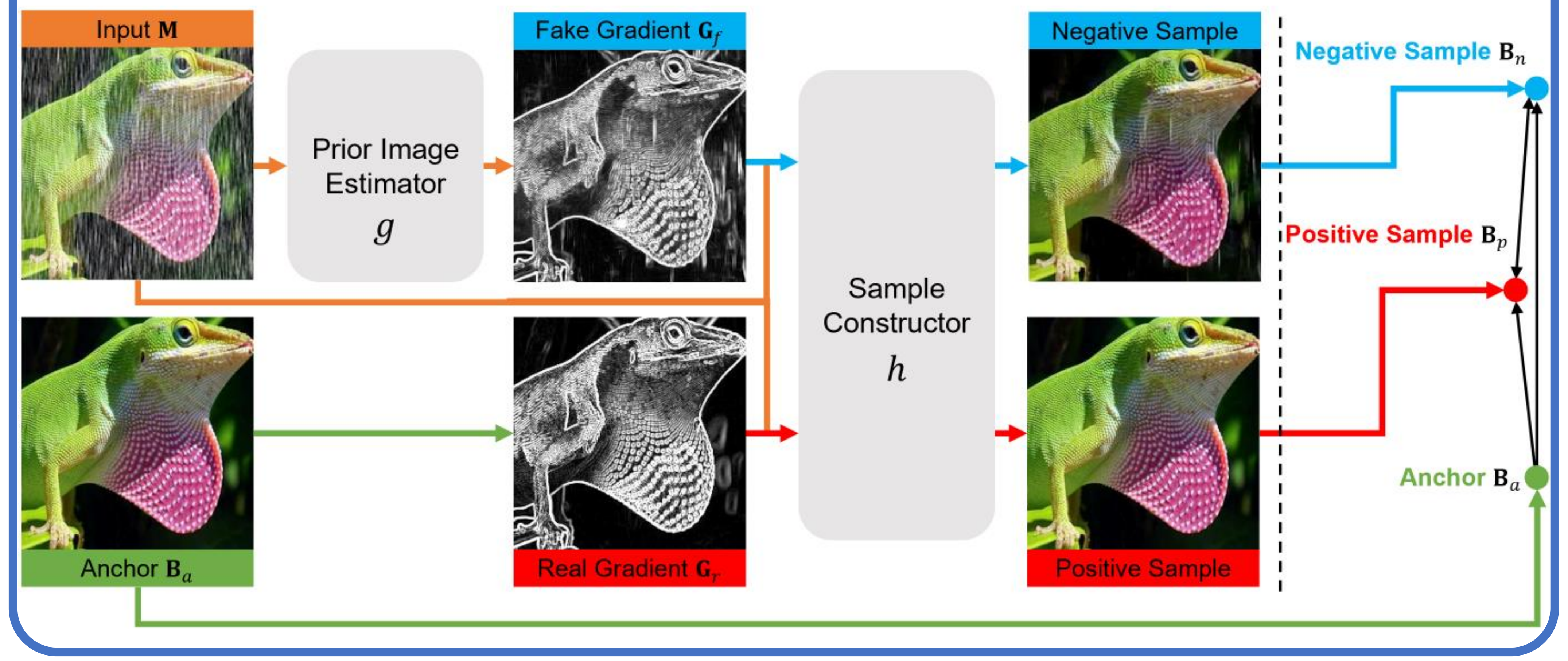
Overview

This paper presents a novel adversarial scheme to perform image denoising for the tasks of rain streak removal and re-flection removal, *i.e.*, jointly learn the prior/gradient image and noise-free image based on an adversarial scheme. More specifically, the inferred noise-free image guided by an estimated gradient **(fake gradient)** is regarded as a **negative sample**, while the noise-free image guided by the ground truth of a gradient **(real gradient)** is taken as a **positive sample**. With the **anchor** defined by the ground truth of noise-free image, we play a min-max game to jointly train two optimizers for the estimation of the gradient and the inference of noise-free images. State-of-the-art performance is achieved on two public benchmark datasets.

Framework



Objective Function

$$\min_g \max_h d(\mathbf{B}_a, \mathbf{B}_n) - d(\mathbf{B}_a, \mathbf{B}_p), \qquad \text{s.t.} \quad d(\mathbf{B}_a, \mathbf{B}_p) < \delta$$

$$\mathbf{B}_n = h(\mathbf{M}, \mathbf{G}_f) = h(\mathbf{M}, g(\mathbf{M})), \ \ \mathbf{B}_p = h(\mathbf{M}, \mathbf{G}_r)$$

Min-Max Optimization

Optimize an h to distinguish whether a sample is inferred guiding by a **fake** or **real** gradient. Optimize a g to fool the h.

Differences from GAN:

1. Focus on the output of h ***vs.*** focus on the output of g
2. Minimize the difference between $\mathbf{G}_f$ and $\mathbf{G}_r$ ***vs.*** minimize KL-divergence

$$\min_g \max_h d(\mathbf{B}_a, \mathbf{B}_n) - d(\mathbf{B}_a, \mathbf{B}_p)$$

$$\approx \min_g d(\mathbf{B}_p, \mathbf{B}_n) = \min_g d\left(h(\mathbf{M}, \mathbf{G}_r), h(\mathbf{M}, \mathbf{G}_f)\right)$$

Implementation Details

Loose constraint $d(\mathbf{B}_a, \mathbf{B}_p) < \delta$ and reformulate objective function as

$$\min_g \max_h d(\mathbf{B}_a, \mathbf{B}_n) - \alpha d(\mathbf{B}_a, \mathbf{B}_p)$$

Algorithm:

for number of training iterations **do**

  for 5 steps **do**

    sample minibatch of m data pairs from training data:

    $$\left\{\left(\mathbf{M}^{(1)}, \mathbf{B}_a^{(1)}\right), \dots, \left(\mathbf{M}^{(m)}, \mathbf{B}_a^{(m)}\right)\right\}$$

    update h by ascending its stochastic gradient:

    $$\nabla_{\theta_h} \frac{1}{m} \sum_{i=1}^{m} \left(d(\mathbf{B}_a, \mathbf{B}_n) - \alpha d(\mathbf{B}_a, \mathbf{B}_p)\right)$$

  end for

  update g by descending its stochastic gradient:

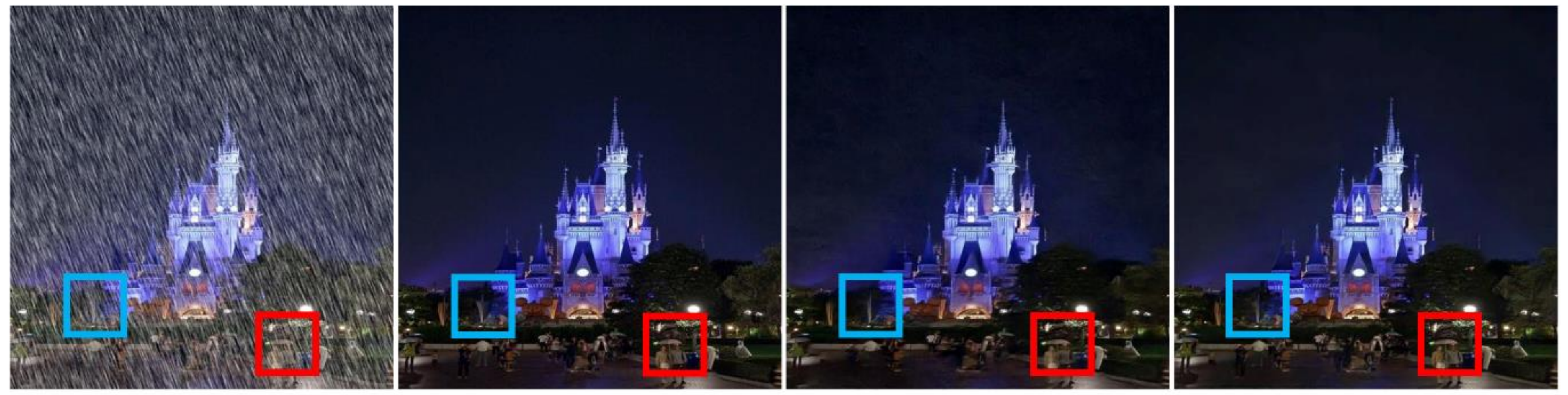
  $$\nabla_{\theta_g} \frac{1}{m} \sum_{i=1}^{m} d(\mathbf{B}_a, \mathbf{B}_n)$$

end for

Performance

Results of rain removal on DIDMDN-DATA [ZP18]

Metric	FH17	YT17	ZP18	LH18	Ours
SSIM	0.7057	0.8763	0.8707	0.9192	**0.9331**
PSNR	23.53	30.35	28.30	33.16	**33.43**



Input Ground truth LH18 (SSIM:0.9443) Ours (SSIM:0.9637)

Results of reflection removal on SIR[2] [WS17]

Metric	AA17	FY17	WS18	ZN18	Ours
SSIM	0.8614	0.8649	0.8907	0.8981	**0.9022**
SI	0.8979	0.8896	0.9160	0.9150	**0.9229**

Input Ground truth ZN18 (SSIM:0.8957) Ours (SSIM:0.9275)

References

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