Study of SinGAN: Learning a Generative Model from a Single Natural Image

KILANI Al Houceine, NAOUMI Salmane

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Study of the SinGAN architecture

Properties :

- An unconditional generative model that can be learned from a single natural image.
- Hypothesis: Internal statistics of patches within a single natural image carry enough information for learning generative models
- Captures the internal distribution of patches within an image:
  - Pyramid of fully convolutionnal GANs and Residual learning
  - Markovian discriminators.
- Training (WGAN-GP loss and a reconstruction loss):

$$\min_{G_n} \max_{D_n} \mathcal{L}_{\text{adv}}\left(G_n, D_n\right) + \alpha \mathcal{L}_{\text{rec}}\left(G_n\right) \tag{1}$$

$$\mathcal{L}_{\text{rec}} = \left\| G_n\left(0, \left(\tilde{x}_{n+1}^{\text{rec}}\right) \uparrow^r\right) - x_n \right\|^2 \tag{2}$$

Sanity Check on the **Colusseum** image:

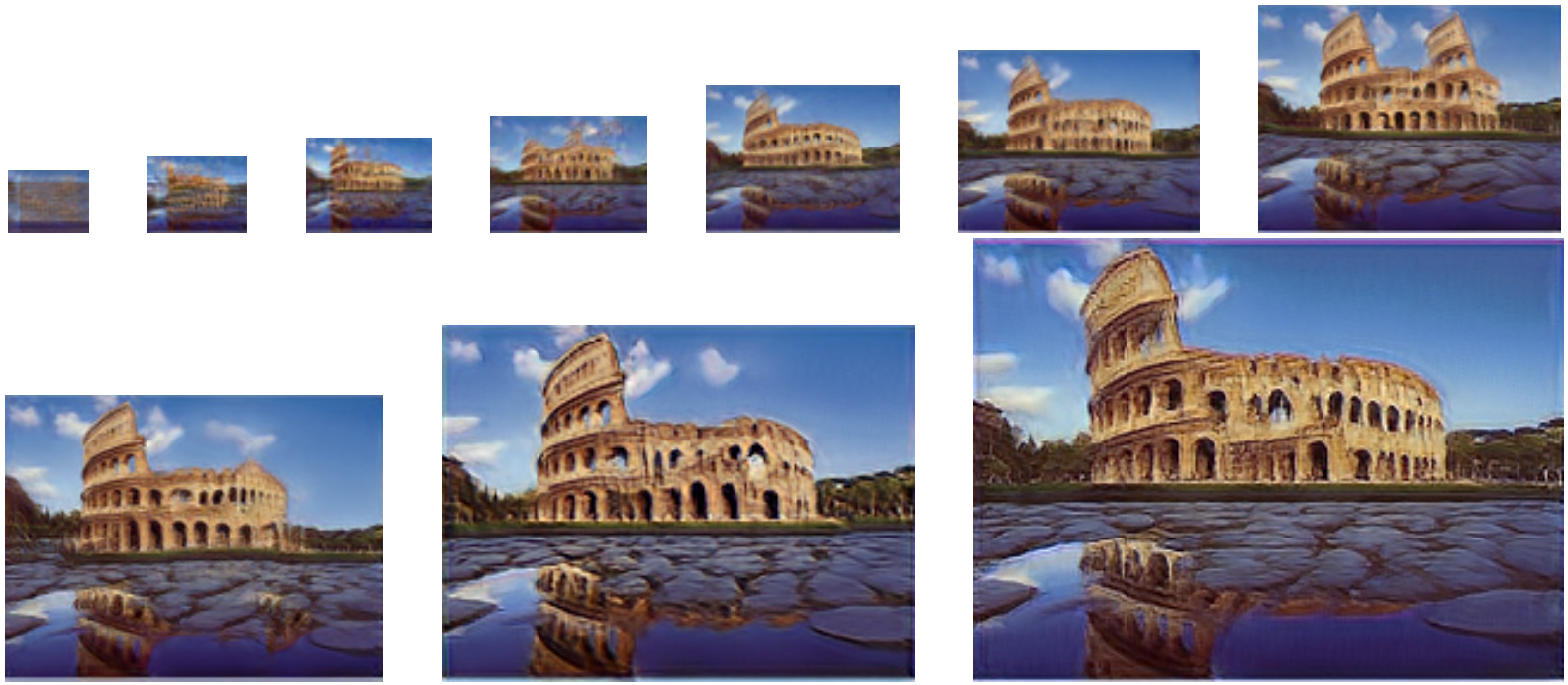

Figure: 10 levels generation - The generation process at level n involves all generators $G_N, ..., G_n$ and all noise maps $z_N, ..., z_n$ up to this level

Application of SinGAN for denoising

- There are numerous applications of the SinGAN architecture including Editing, Harmonization and other tasks.
- Our work is to check if SinGAN can be used efficiently for image denoising.
- We consider two cases:
  - Case 1: Train on good picture - Treat bad picture
  - Case 2: Train on bad picture - Treat bad picture

Figure: Good image and darker (noisy) image used

- Two strategies : Random sampling with noisy image injection and Super Resolution

Case 1:

We add a SP noise on the original image.

- Proposed method:


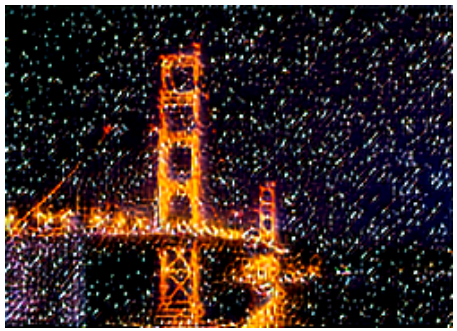
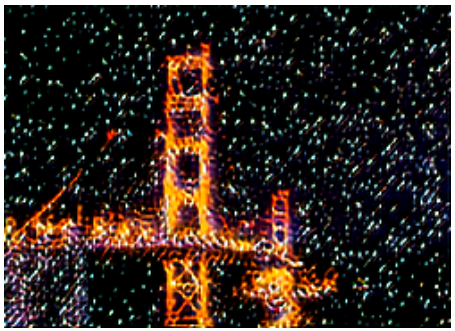

Figure: 3 successive injections in the G_0

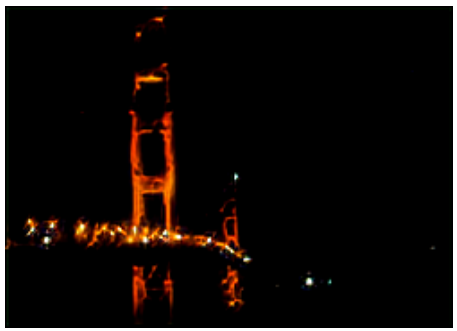

Figure: Denoising darker image

Case 1:

- Super resolution method:

Figure: Denoising using super resolution

Case 2:

Only Super Resolution method:

Figure: Output of SR SinGAN trained on SP noise

Comparison and Metrics :

Metric	noisy image	Proposed method	SR case 1	SR case 2
PSNR	12.15	12.51	22.28	13.47
SSIM	0.147	0.126	0.794	0.169

Comparison with the original image

Potential improvements

- Injecting down-scaled versions of the noisy image in the intermediate levels of the pyramidal structure.
- Apply Super Resolution on small parts by subdividing the image and constitute a denoised overall image.
- ...

The End