Challenge: Others … … …

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Challenge: Others

- Internal Distribution Modelling
  - InGAN
  - SinGAN
- What is in the Frequency Domain
  - CNN-generated images
  - Learning in the frequency domain
- What It Learns
  - GAN Dissection
  - Mode Collapse

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InGAN

- InGAN: Capturing and Remapping the "**DNA**" of **a** Natural Image

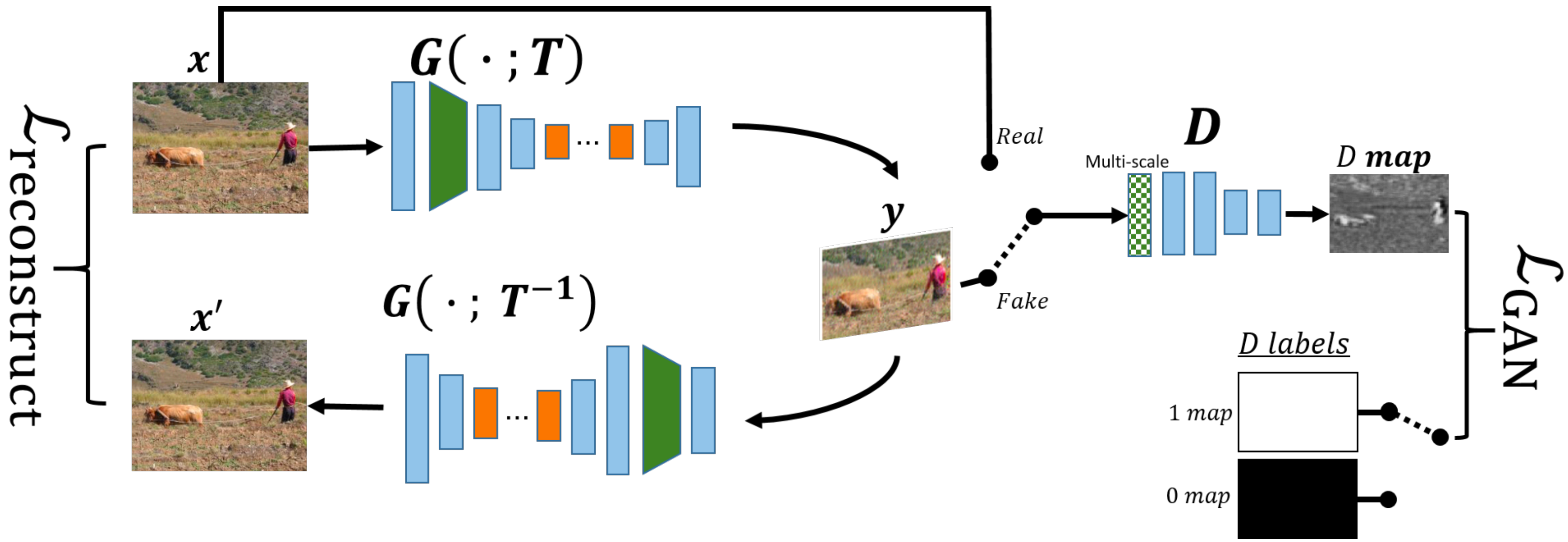
Conditional generative model

InGAN

- Architecture

$$\mathcal{L}_{\texttt{InGAN}} = \mathcal{L}_{\texttt{GAN}} + \lambda \cdot \mathcal{L}_{\texttt{reconst}}$$

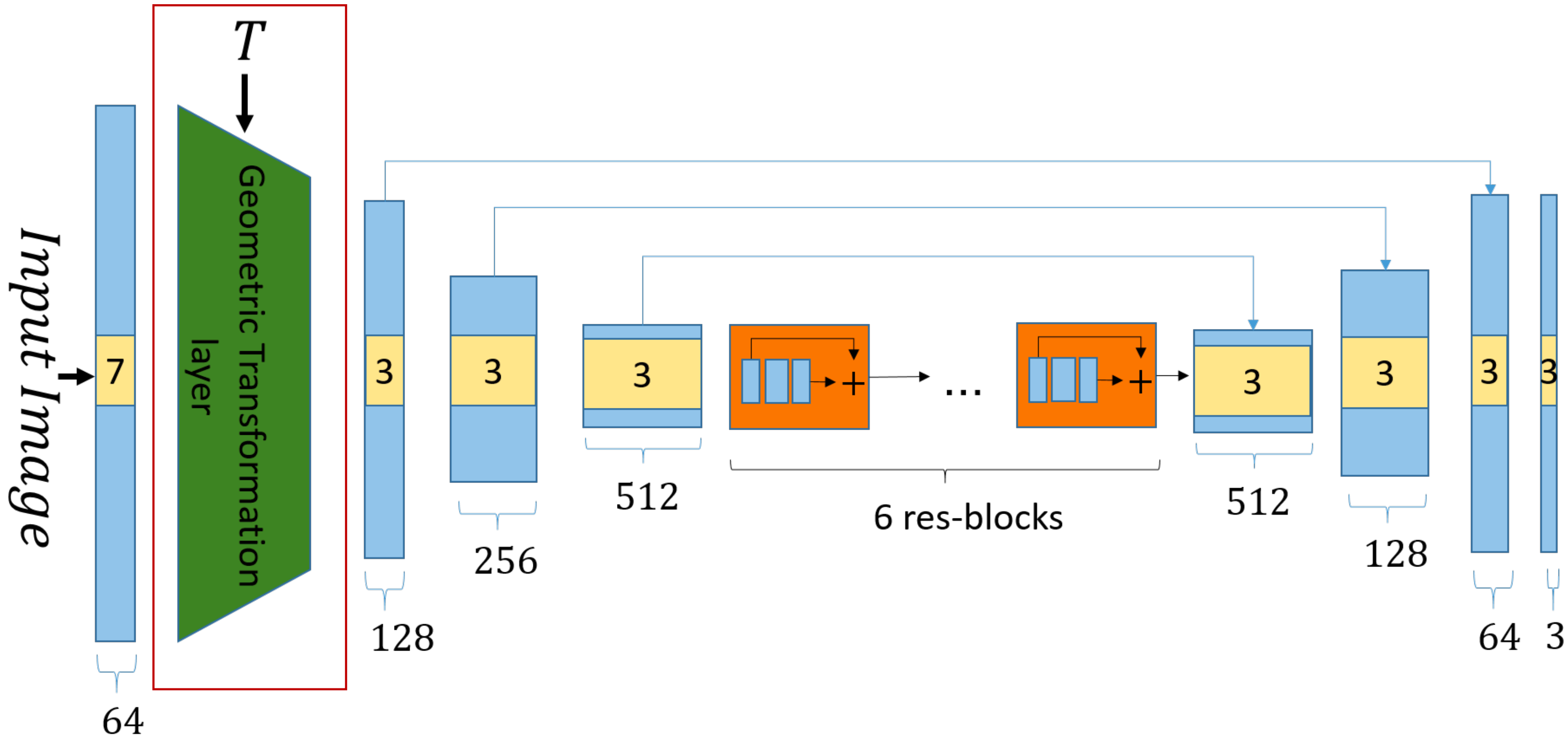
$$\mathcal{L}_{\text{GAN}}(G, D) = \mathbb{E}_{y\sim p_{\text{data}}(x)}[(D(x)-1)^2] + \mathbb{E}_{x\sim p_{\text{data}}(x)}[D(G(x))^2]$$



$$\mathcal{L}_{\texttt{reconst}} = \left\| G\left(G\left(x;T\right);T^{-1}\right) - x \right\|_1$$

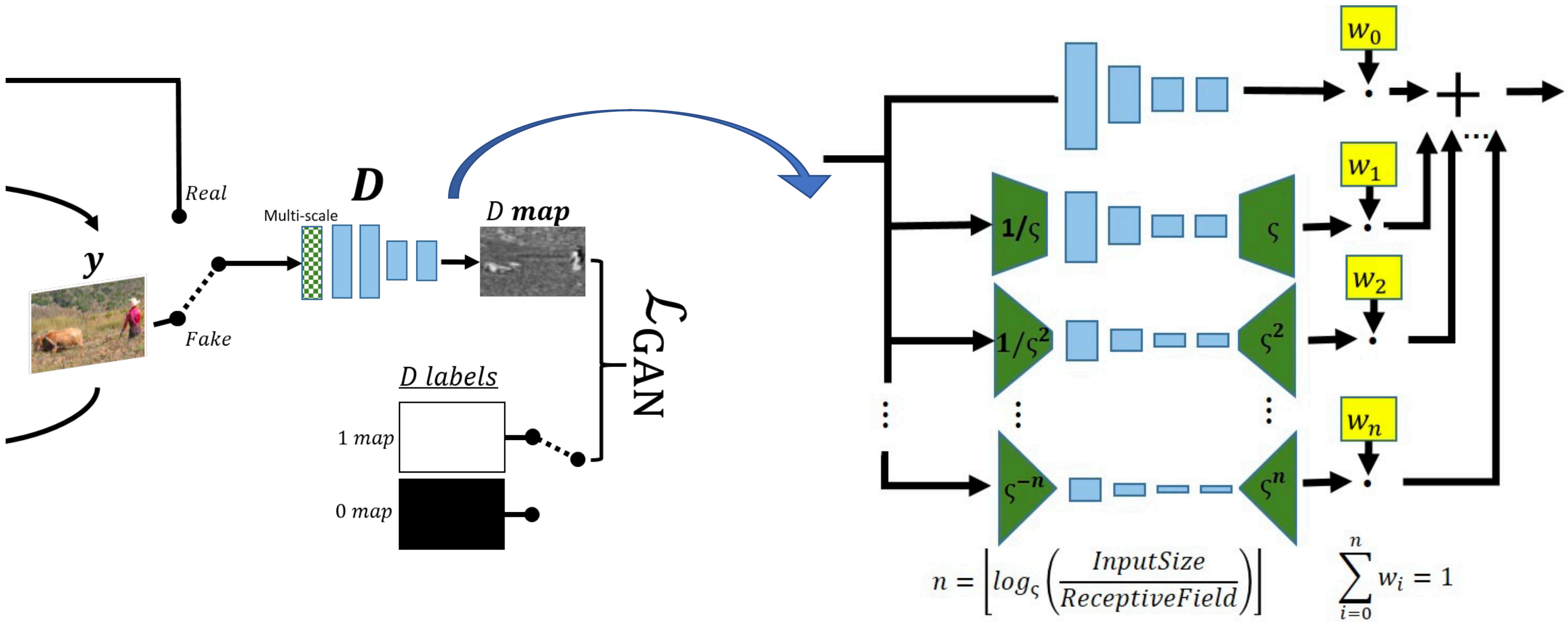
InGAN

- Generator architecture



InGAN

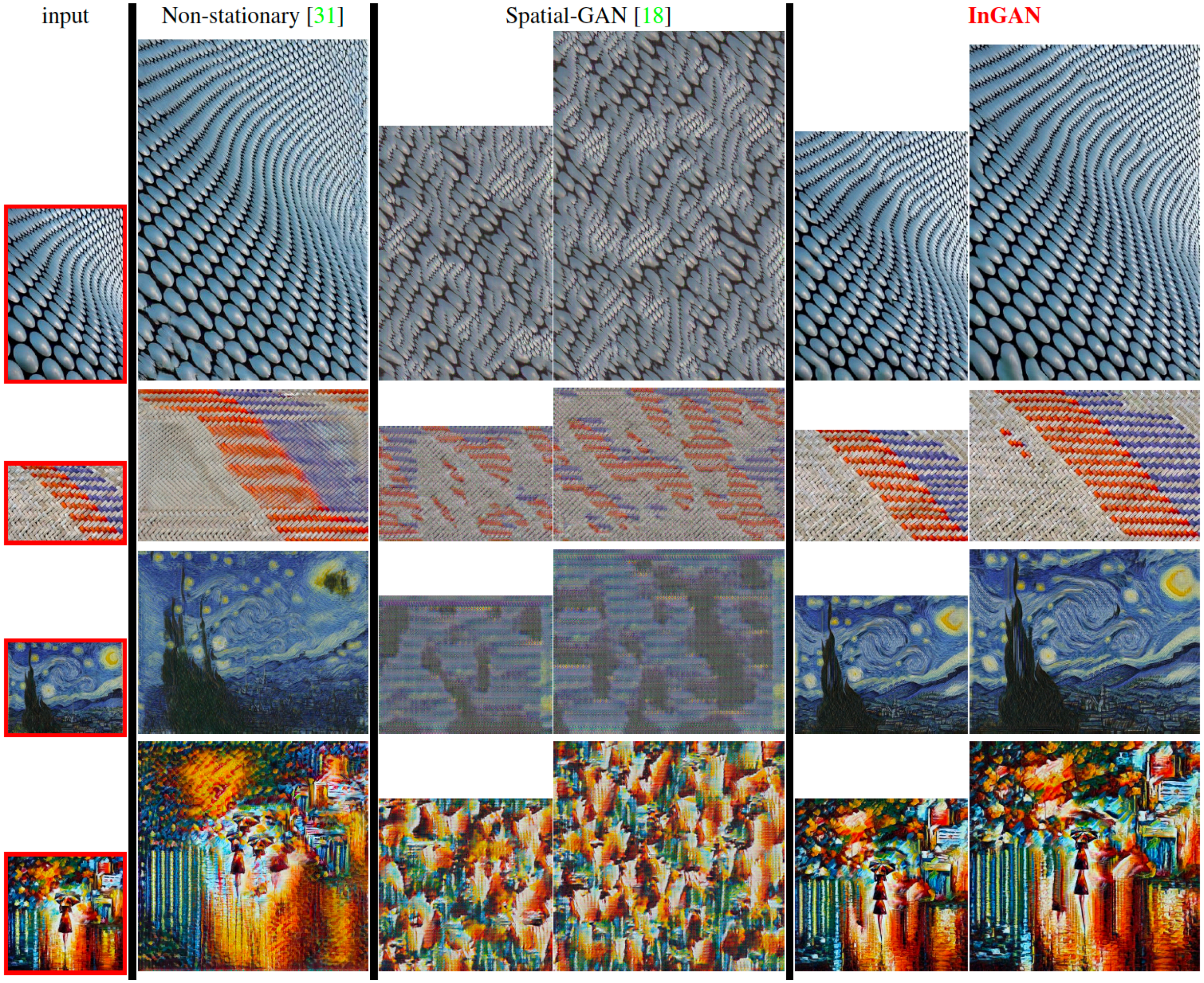
- Adaptive Multi-Scale Patch Discriminator



InGAN

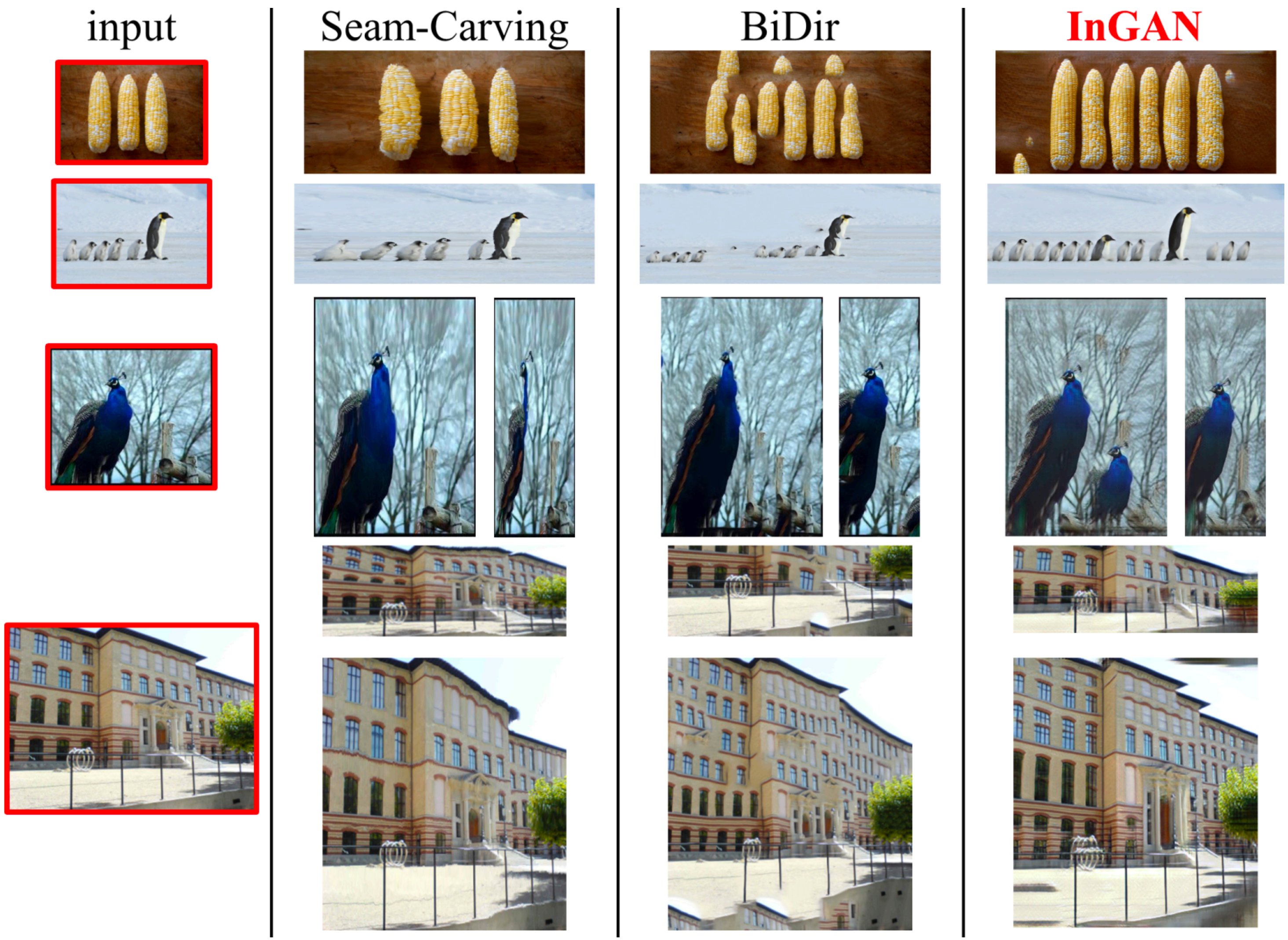
Multiple Tasks:

- Texture synthesis



InGAN

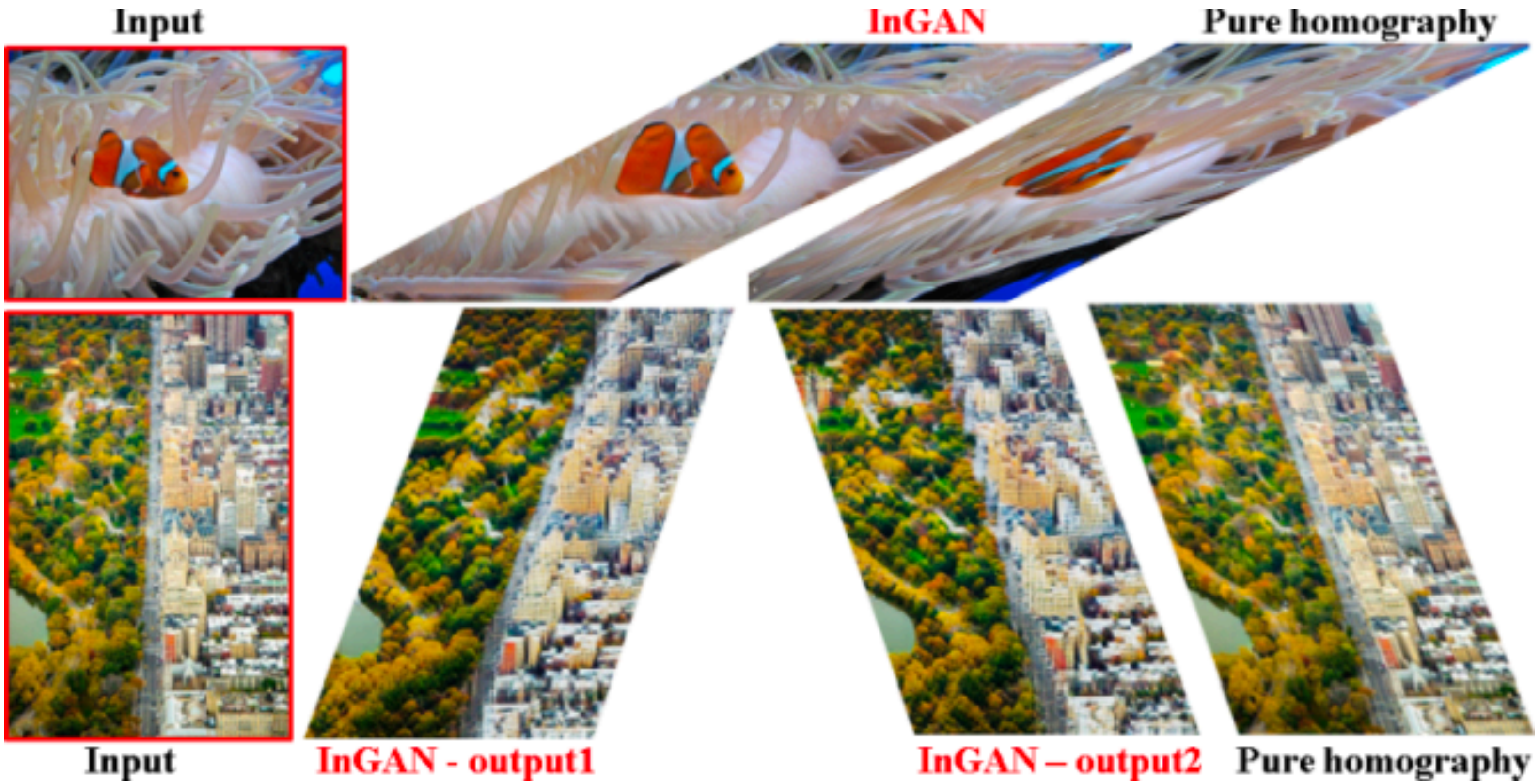
Multiple Tasks:
- Natural image retargeting



InGAN

Multiple Tasks:

- Retargeting to Non-Rectangular Outputs



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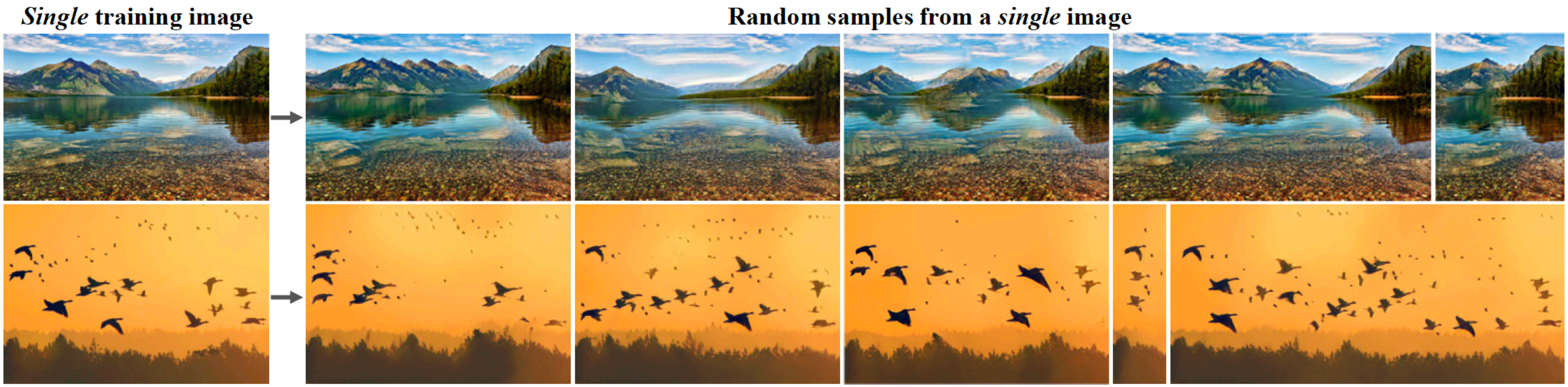
SinGAN

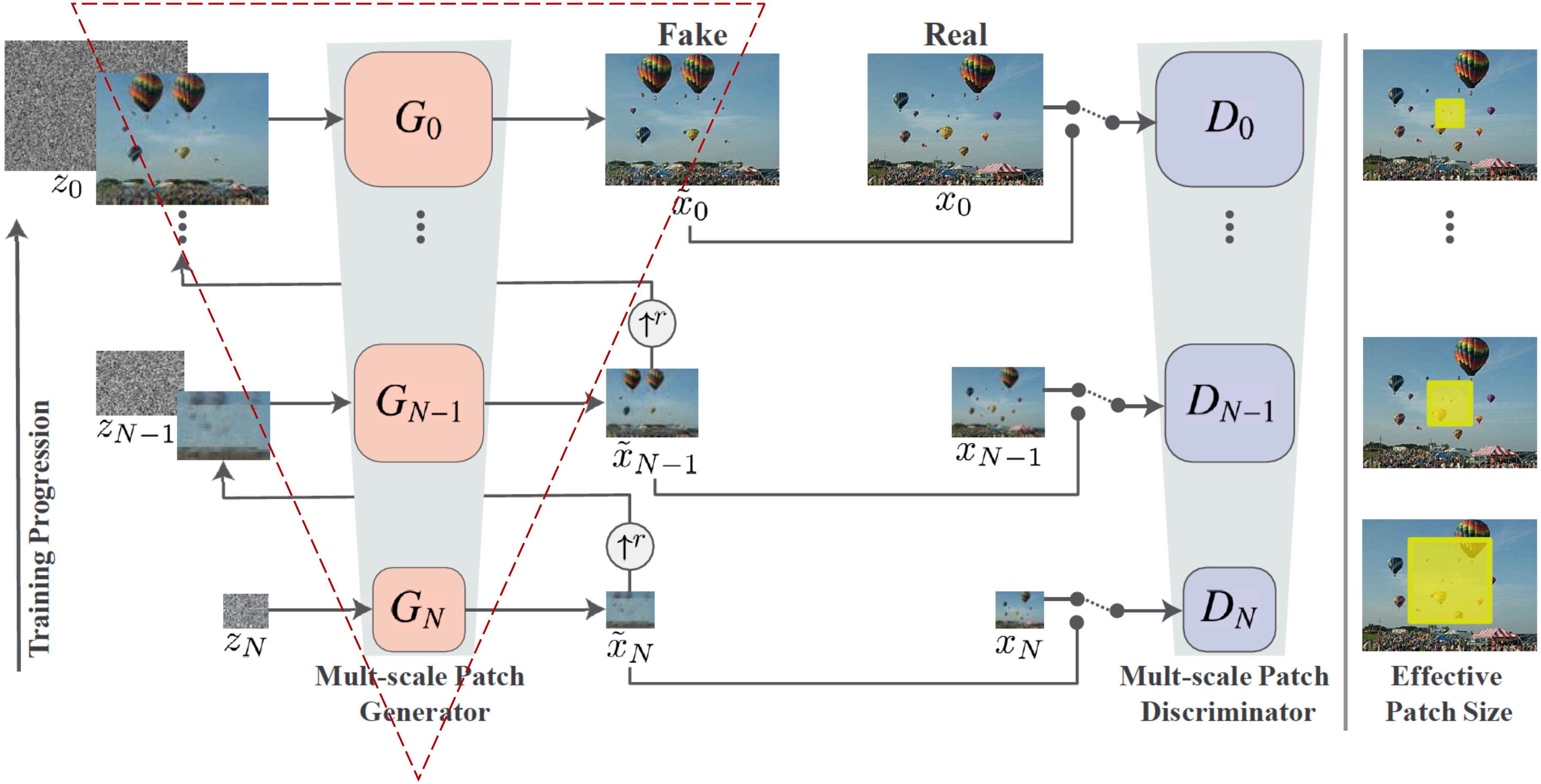
- SinGAN：Learning a Generative Model from a Single Natural Image



SinGAN: Unconditional VS. InGAN: Conditional

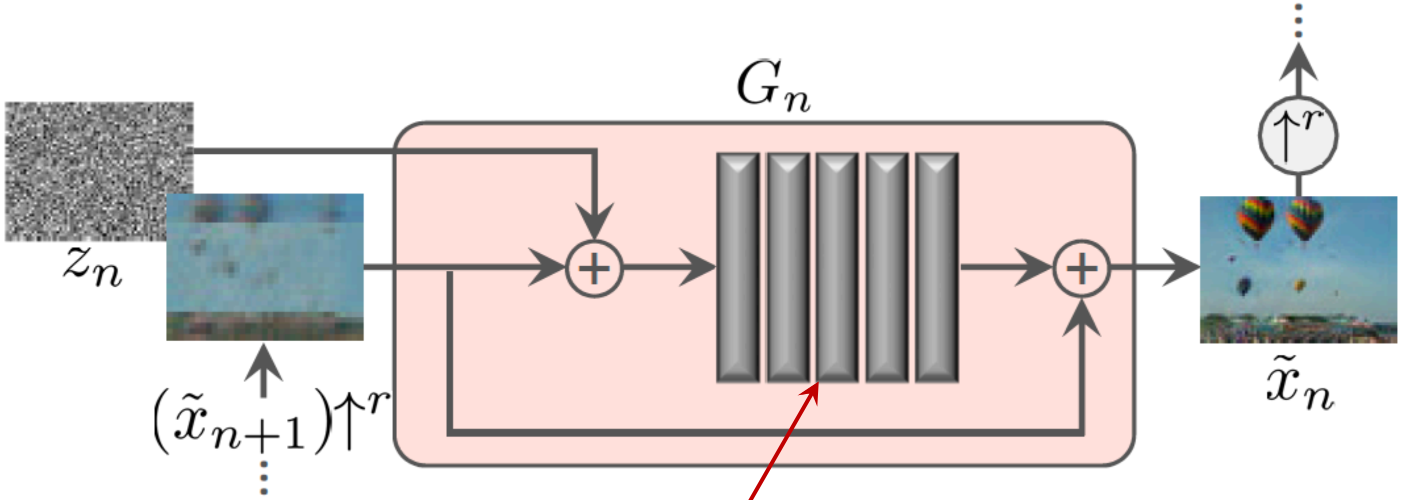
SinGAN

- SinGAN's multi-scale pipeline: A pyramid of GANs



SinGAN

- Single scale generation



$$\tilde{x}_n = G_n\left(z_n, (\tilde{x}_{n+1})\uparrow^r\right)$$

$$\tilde{x}_n = (\tilde{x}_{n+1})\uparrow^r + \boxed{\psi_n}\left(z_n + (\tilde{x}_{n+1})\uparrow^r\right)$$

SinGAN

- Training

Sequentially train from the **coarsest** scale to the **finest** one

Once each GAN is trained, it is kept fixed

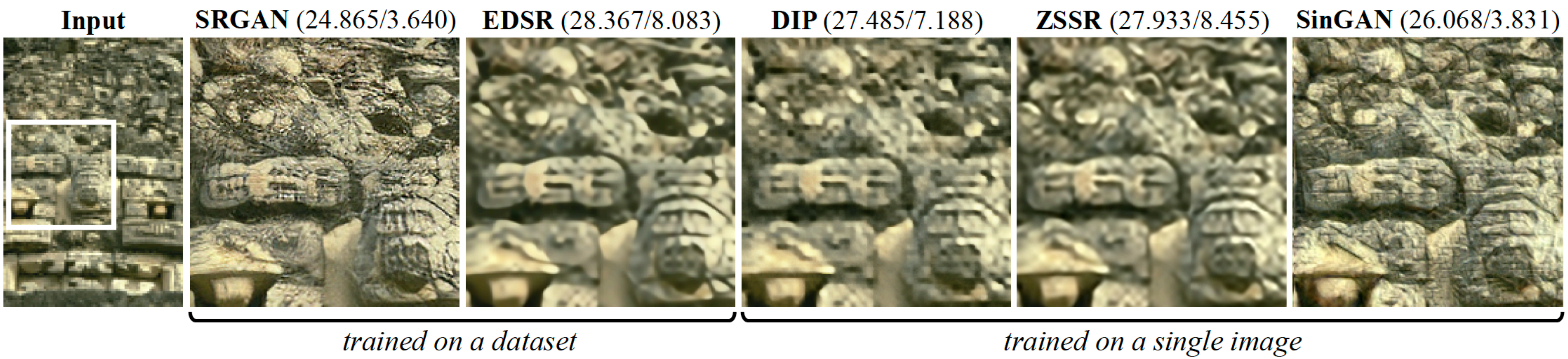
$$\min_{G_n} \max_{D_n} \underbrace{\mathcal{L}_{\text{adv}}(G_n, D_n)}_{\text{WGAN-GP loss}} + \alpha \mathcal{L}_{\text{rec}}(G_n)$$

WGAN-GP loss

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

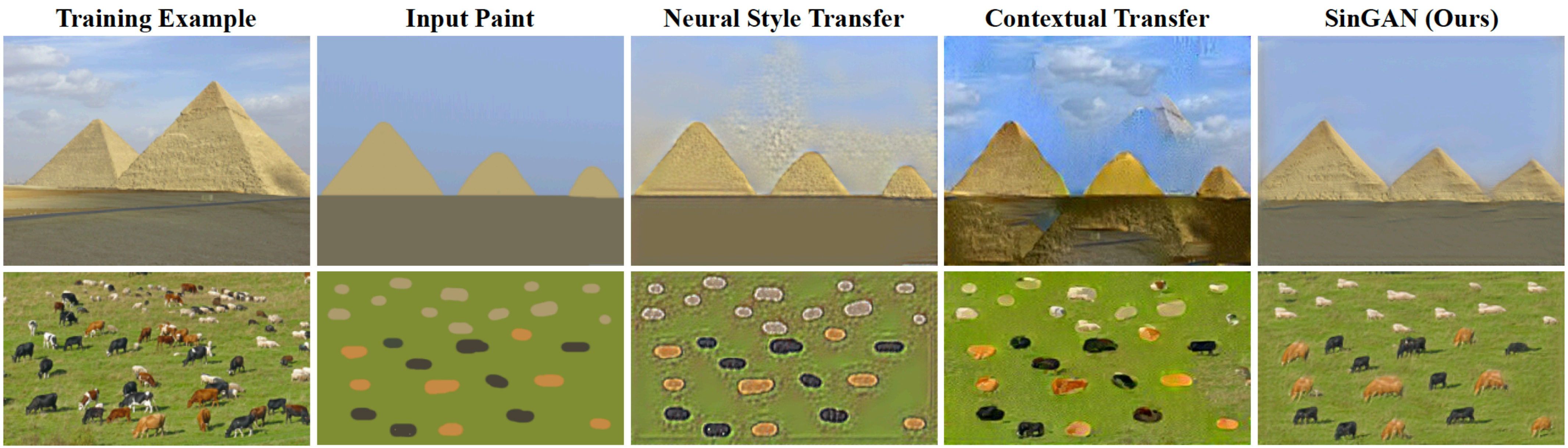
SinGAN

- Applications: Super Resolution



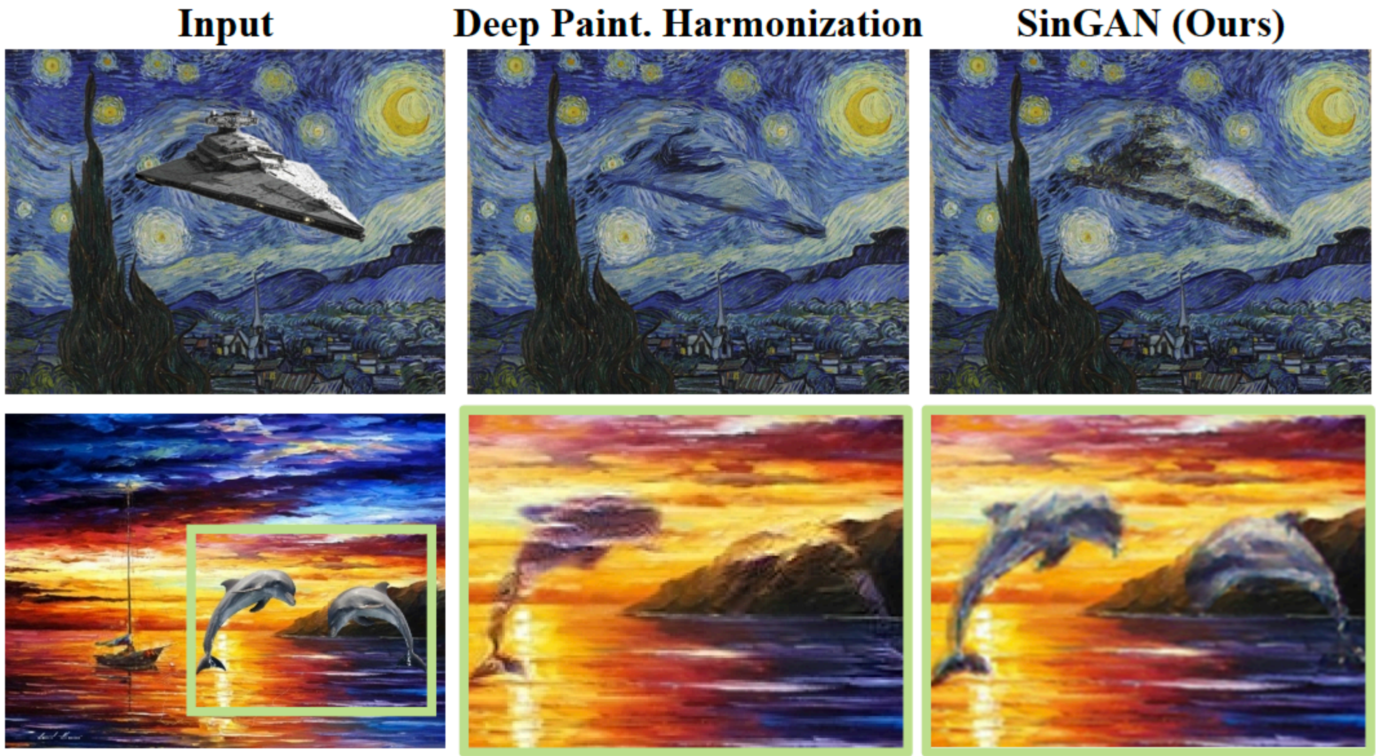
SinGAN

- Applications: Paint-to-Image



SinGAN

- Applications: Harmonization



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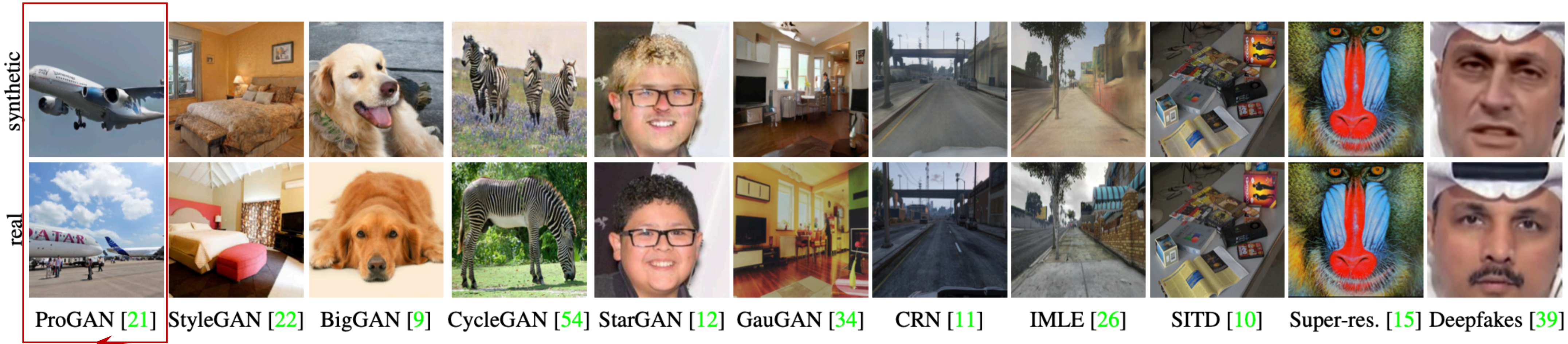
What it is in the frequency domain

- CNN-generated images are surprisingly easy to spot... for now

Are CNN-generated images hard to distinguish from real images?



A classifier trained to detect images **generated by only one CNN** (ProGAN, far left) **can detect those generated by many other models** (remaining columns)

What it is in the frequency domain

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ForenSynth : A dataset of CNN-based generation models

Family	Method	Image Source	# Images
Unconditional GAN	ProGAN [21]	LSUN	8.0k
	StyleGAN [22]	LSUN	12.0k
	BigGAN [9]	ImageNet	4.0k
Conditional GAN	CycleGAN [54]	Style/object transfer	2.6k
	StarGAN [12]	CelebA	4.0k
	GauGAN [34]	COCO	10.0k
Perceptual loss	CRN [11]	GTA	12.8k
	IMLE [26]	GTA	12.8k
Low-level vision	SITD [10]	Raw camera	360
	SAN [15]	Standard SR benchmark	440
Deepfake	FaceForensics++ [39]	Videos of faces	5.4k

What it is in the frequency domain

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Effect of data augmentation

Family	Name	Training settings: Train	Input	No. Class	Augments: Blur	Augments: JPEG	Pro-GAN	Style-GAN	Big-GAN	Cycle-GAN	Star-GAN	Gau-GAN	CRN	IMLE	SITD	SAN	Deep-Fake	Total mAP
Zhang et al. [50]	Cyc-Im	CycleGAN	RGB	–			84.3	65.7	55.1	100.	99.2	79.9	74.5	90.6	67.8	82.9	53.2	77.6
	Cyc-Spec	CycleGAN	Spec	–			51.4	52.7	79.6	100.	**100.**	70.8	64.7	71.3	92.2	78.5	44.5	73.2
	Auto-Im	AutoGAN	RGB	–			73.8	60.1	46.1	99.9	**100.**	49.0	82.5	71.0	80.1	86.7	80.8	75.5
	Auto-Spec	AutoGAN	Spec	–			75.6	68.6	84.9	**100.**	**100.**	61.0	80.8	75.3	89.9	66.1	39.0	76.5
Ours	2-class	ProGAN	RGB	2	✓	✓	98.8	78.3	66.4	88.7	87.3	87.4	94.0	97.3	85.2	52.9	58.1	81.3
	4-class	ProGAN	RGB	4	✓	✓	99.8	87.0	74.0	93.2	92.3	94.1	95.8	97.5	87.8	58.5	59.6	85.4
	8-class	ProGAN	RGB	8	✓	✓	99.9	94.2	78.9	94.3	91.9	95.4	98.9	99.4	91.2	58.6	63.8	87.9
	16-class	ProGAN	RGB	16	✓	✓	100.	98.2	87.7	96.4	95.5	**98.1**	**99.0**	**99.7**	95.3	63.1	71.9	91.4
	No aug	ProGAN	RGB	20			100.	96.3	72.2	84.0	**100.**	67.0	93.5	90.3	96.2	**93.6**	**98.2**	90.1
	Blur only	ProGAN	RGB	20	✓		100.	99.0	82.5	90.1	**100.**	74.7	66.6	66.7	**99.6**	53.7	95.1	84.4
	JPEG only	ProGAN	RGB	20		✓	100.	99.0	87.8	93.2	91.8	97.5	**99.0**	99.5	88.7	78.1	88.1	**93.0**
	Blur+JPEG (0.5)	ProGAN	RGB	20	✓	✓	100.	98.5	**88.2**	96.8	95.4	**98.1**	98.9	99.5	92.7	63.9	66.3	90.8
	Blur+JPEG (0.1)	ProGAN	RGB	20	†	†	100.	**99.6**	84.5	93.5	98.2	89.5	98.2	98.4	97.2	70.5	89.0	92.6

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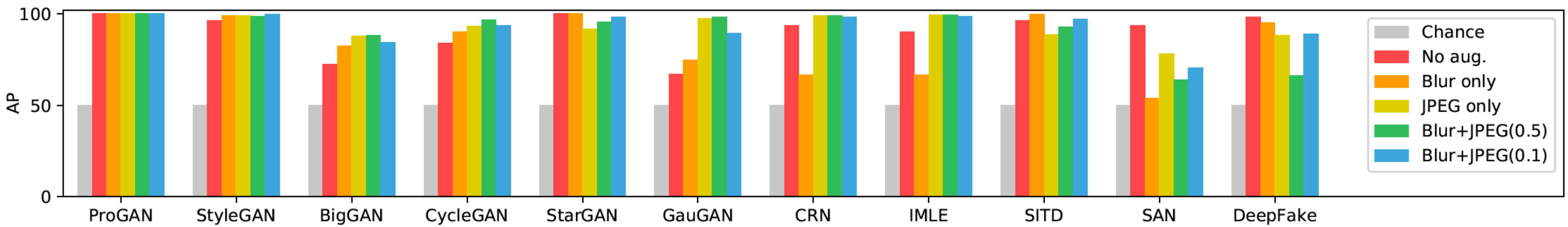
Effect of data augmentation



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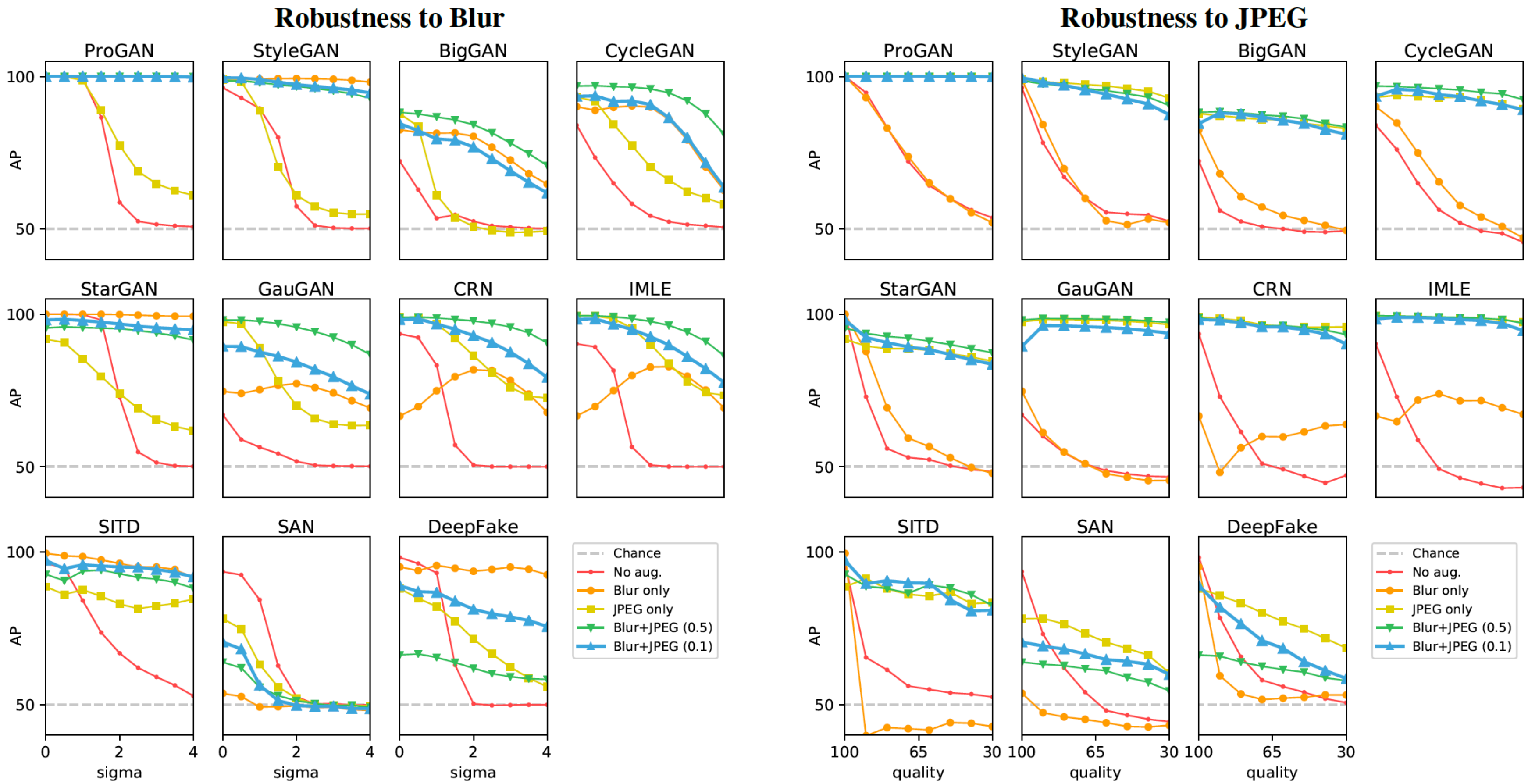

What it is in the frequency domain

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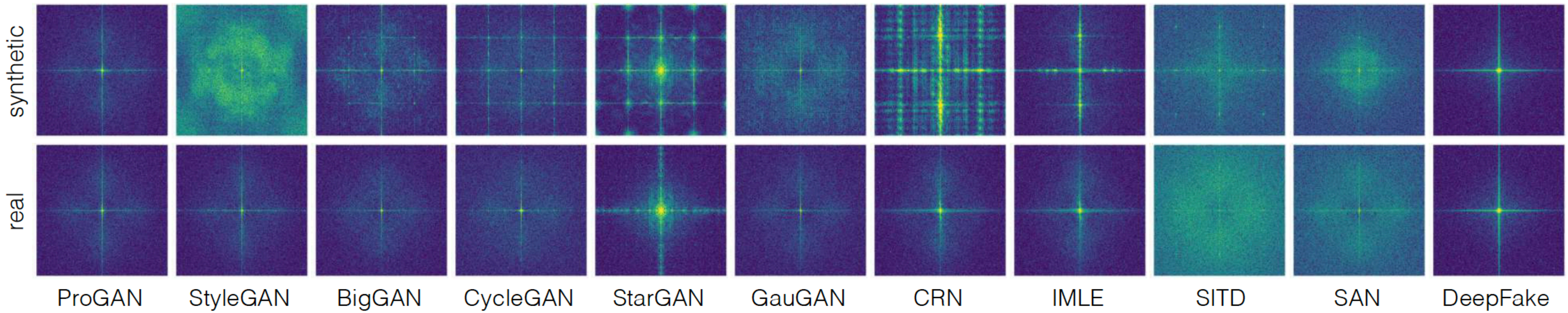
Frequency analysis on each dataset



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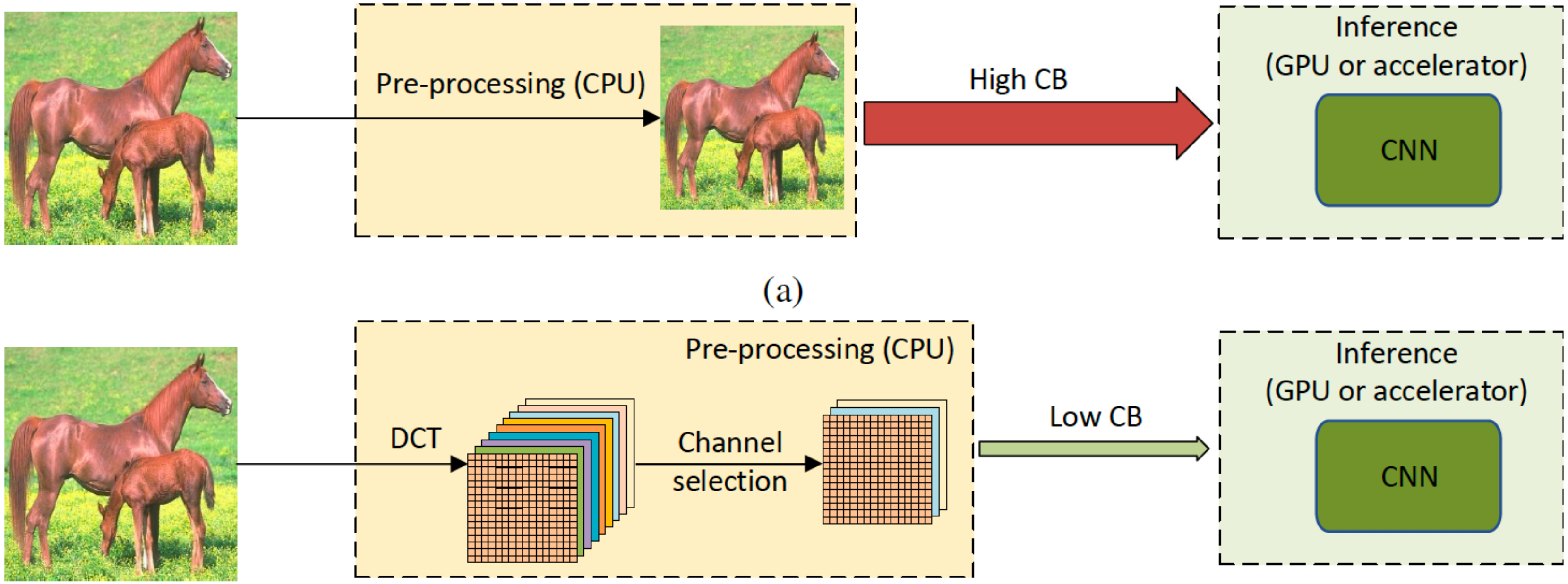
What it is in the frequency domain

- Learning in the Frequency Domain

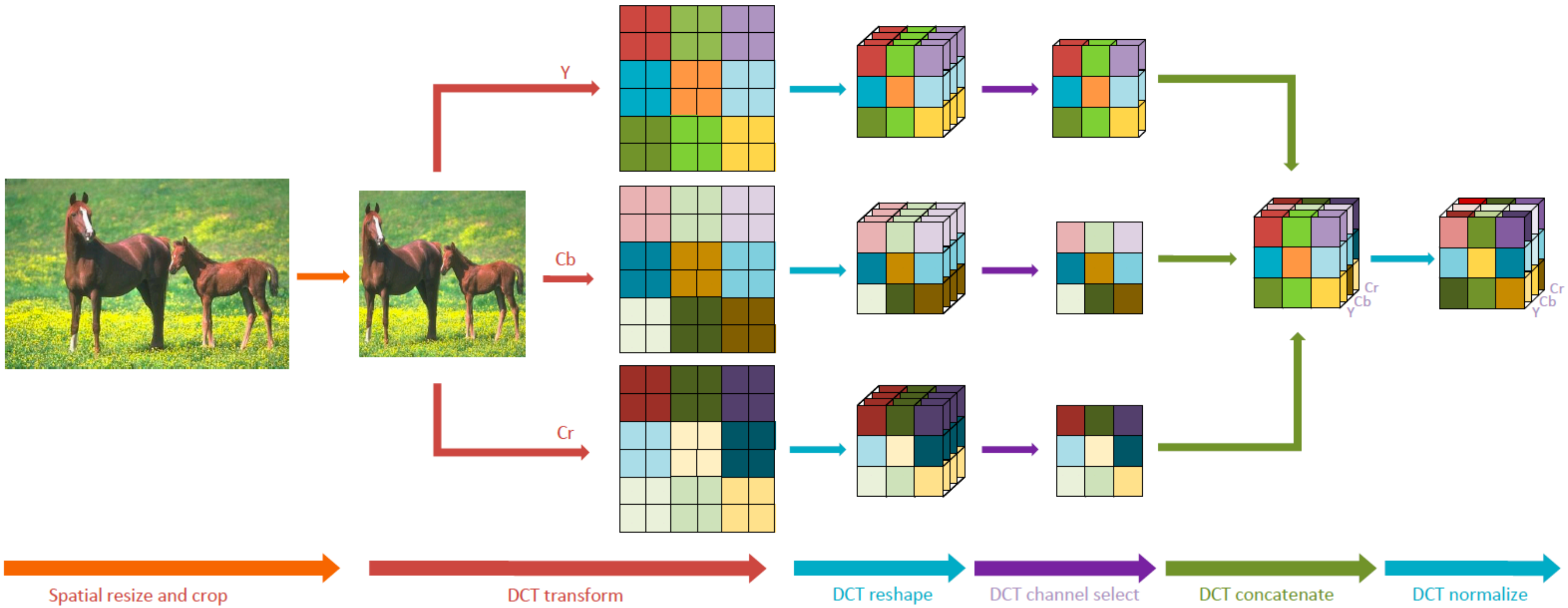
Why in the frequency domain?



What it is in the frequency domain

- Learning in the Frequency Domain

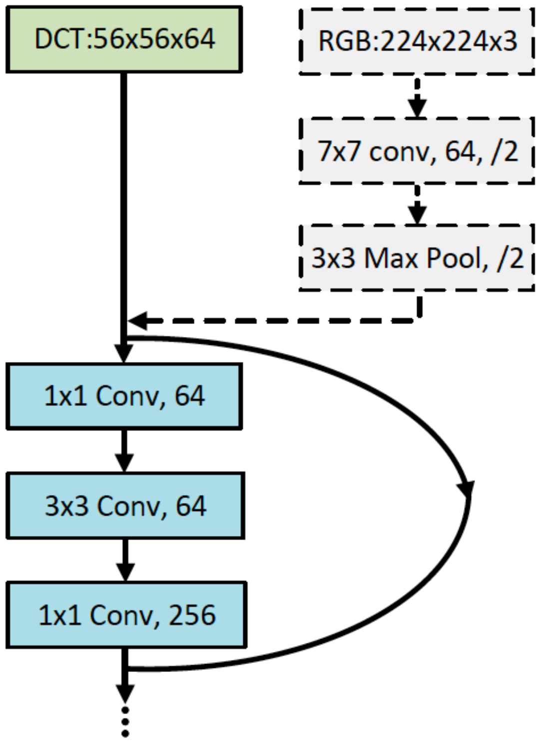
Data pre-processing pipeline



What it is in the frequency domain

- Learning in the Frequency Domain

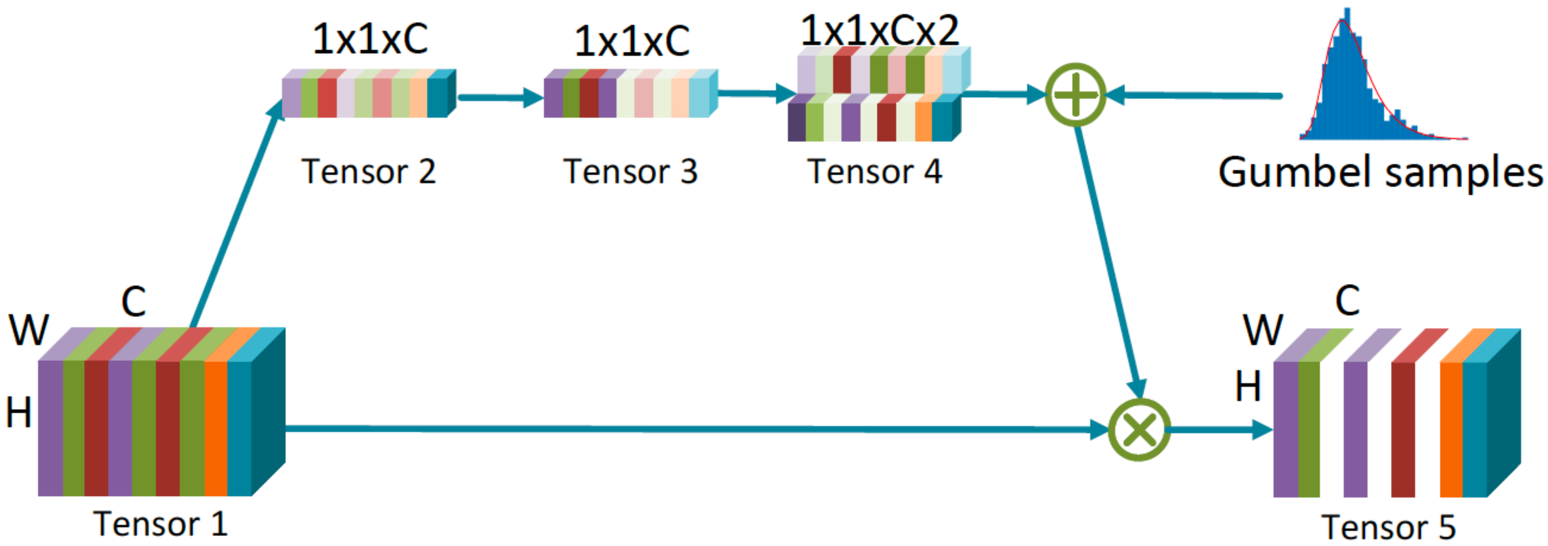
  How to convert into the frequency domain?



What it is in the frequency domain

- Learning in the Frequency Domain

  Channel Selection



What it is in the frequency domain

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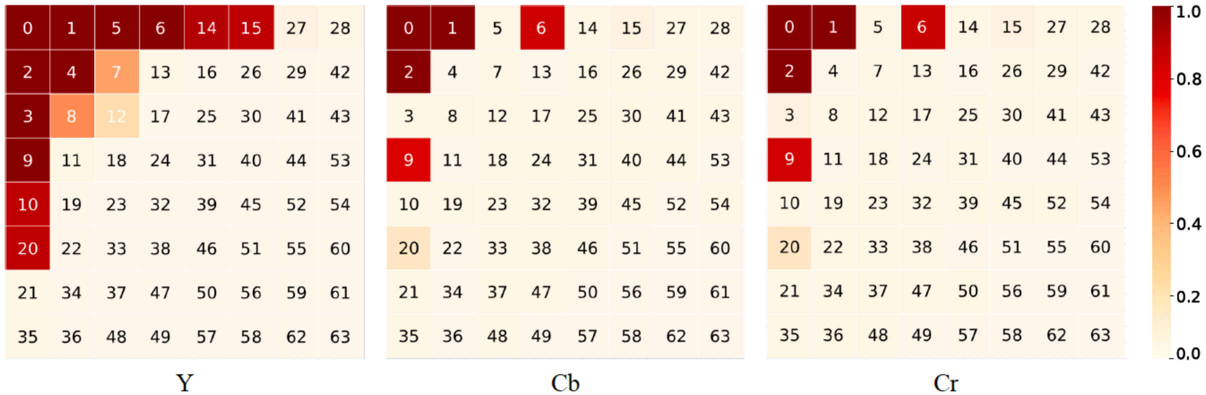
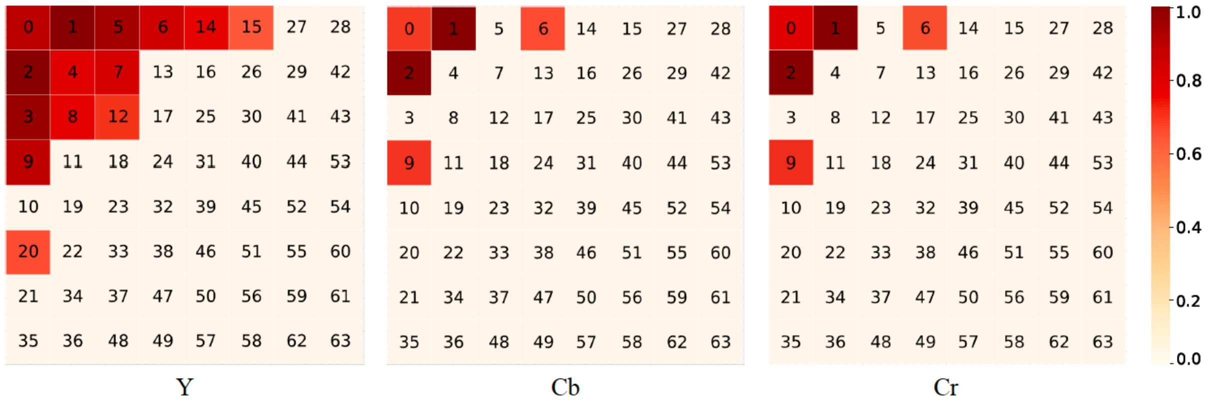


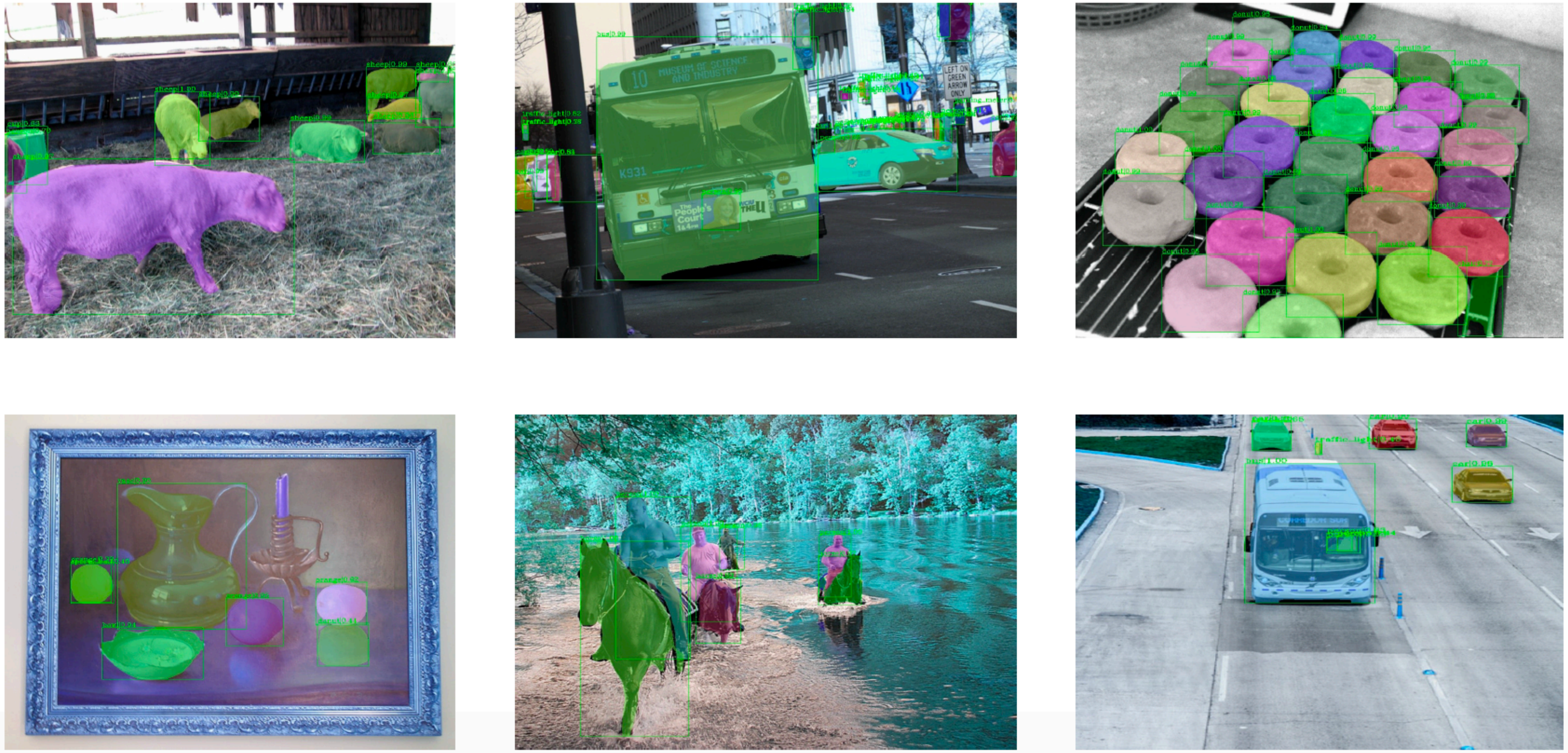
(a) Heat maps of Y, Cb, and Cr components on the ImageNet validation dataset.



(b) Heat maps of Y, Cb, and Cr components on the COCO validation dataset

What it is in the frequency domain

- Learning in the Frequency Domain



Examples of instance segmentation results on the COCO dataset

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What it learns

- GAN Dissection

How to visualize GANs?

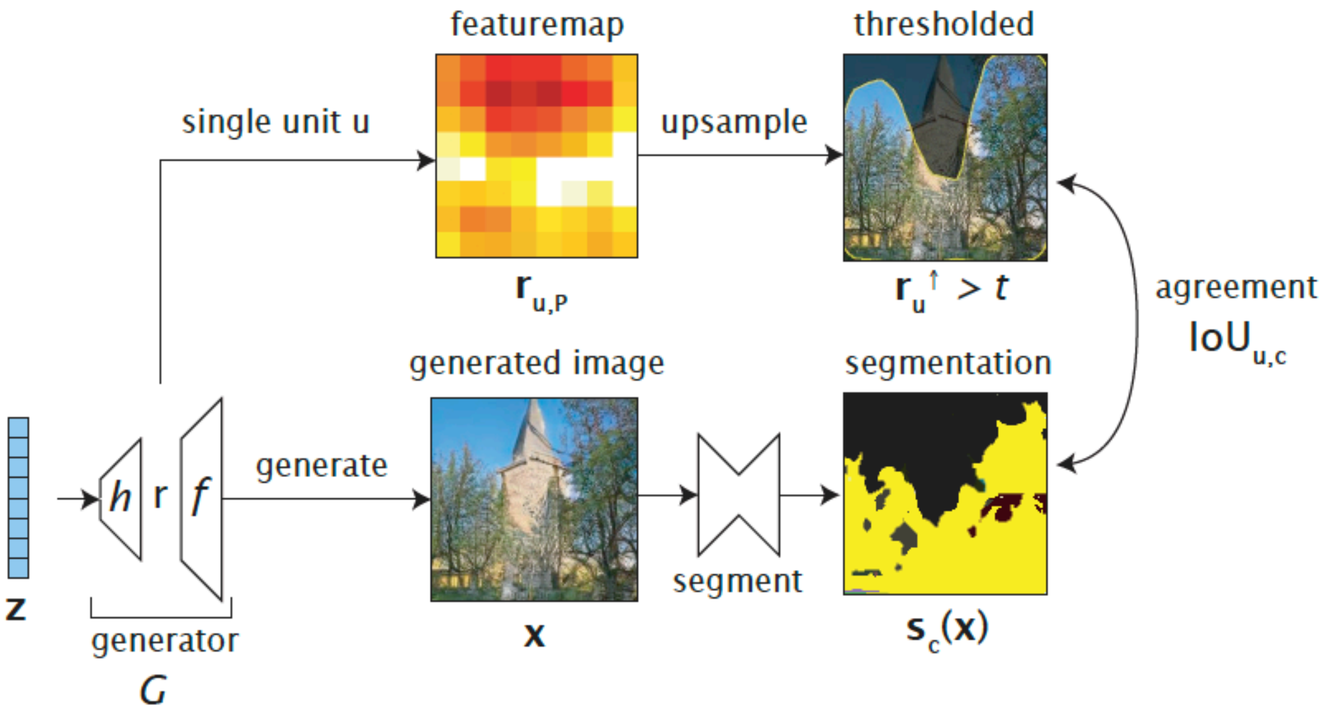
How to understand GANs?

Bau, David, et al. "Gan dissection: Visualizing and understanding generative adversarial networks." arXiv preprint arXiv:1811.10597 (2018).

What it learns

- GAN Dissection

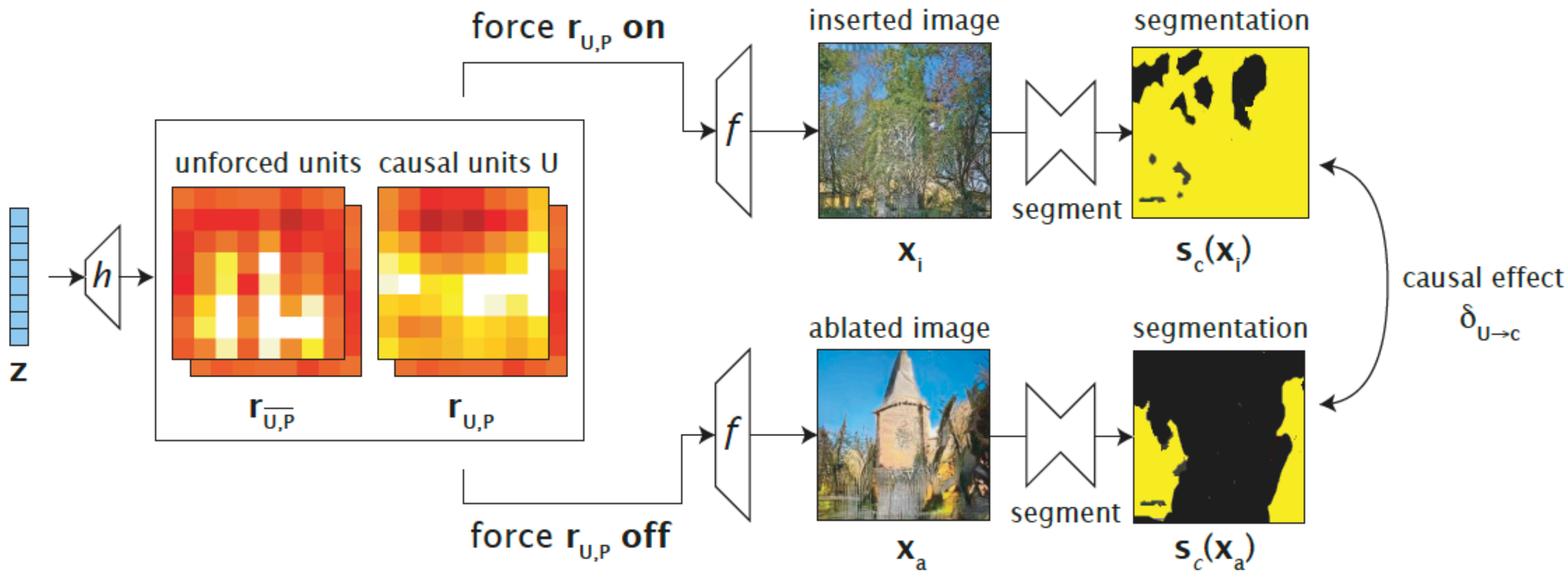
  Analytical Framework: Characterizing Units by **Dissection**



What it learns

- GAN Dissection

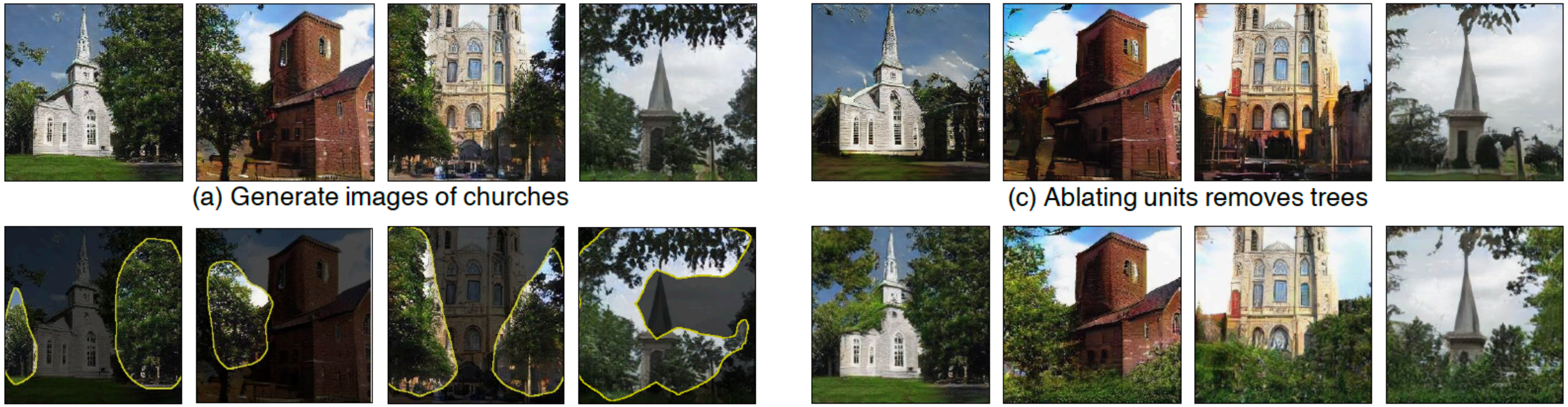
  Analytical Framework: Measuring Causal Relationships Using **Intervention**



What it learns

- GAN Dissection

Finding concepts



(a) Generate images of churches

(b) Identify GAN units that match trees

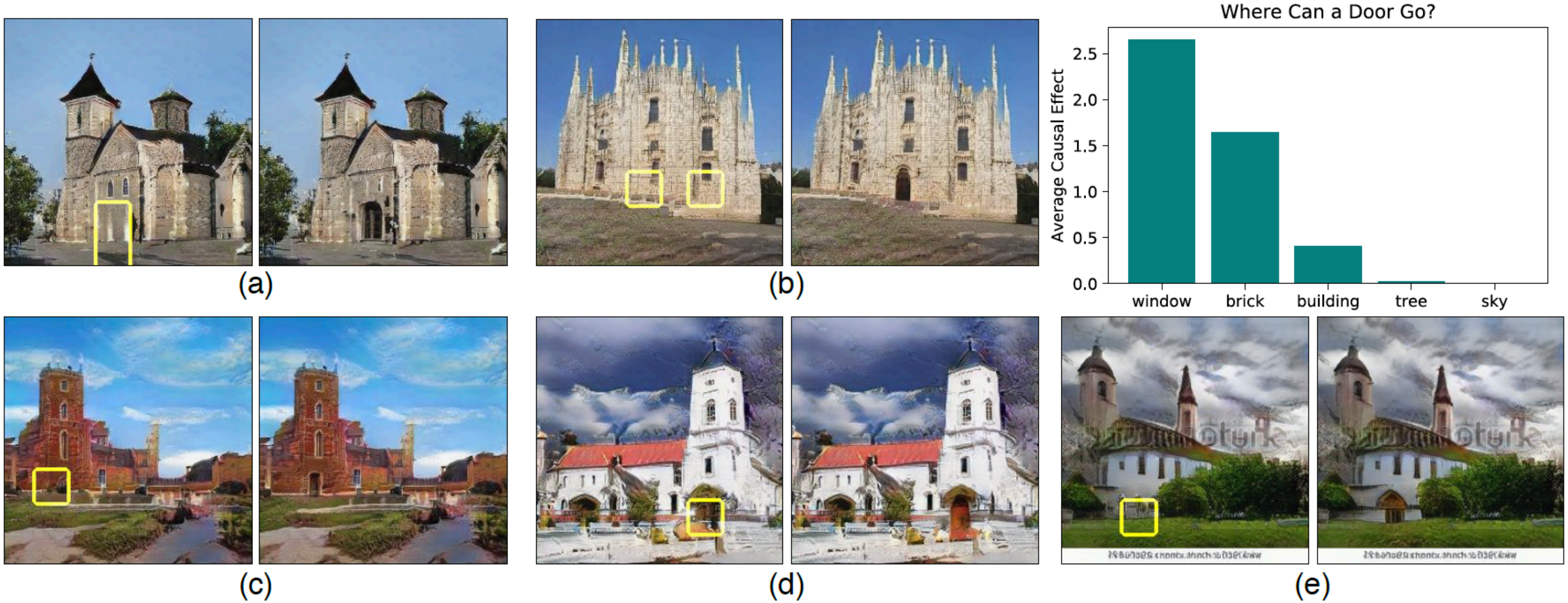
(c) Ablating units removes trees

(d) Activating units adds trees

What it learns

- GAN Dissection

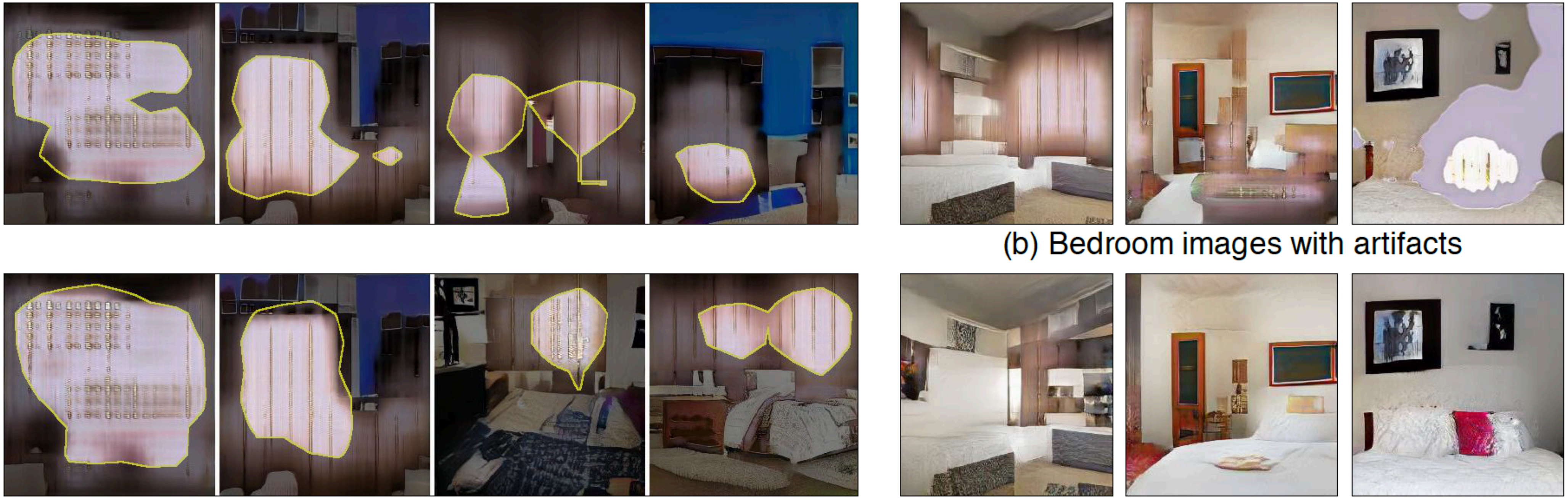
  Effect of Intervention



What it learns

- GAN Dissection

  Results



(a) Example artifact-causing units (b) Bedroom images with artifacts (c) Ablating “artifact” units improves results

What it learns

- GAN Dissection

https://gandissect.csail.mit.edu

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What it learns

- Mode Collapse

How do we know what a GAN cannot generate?

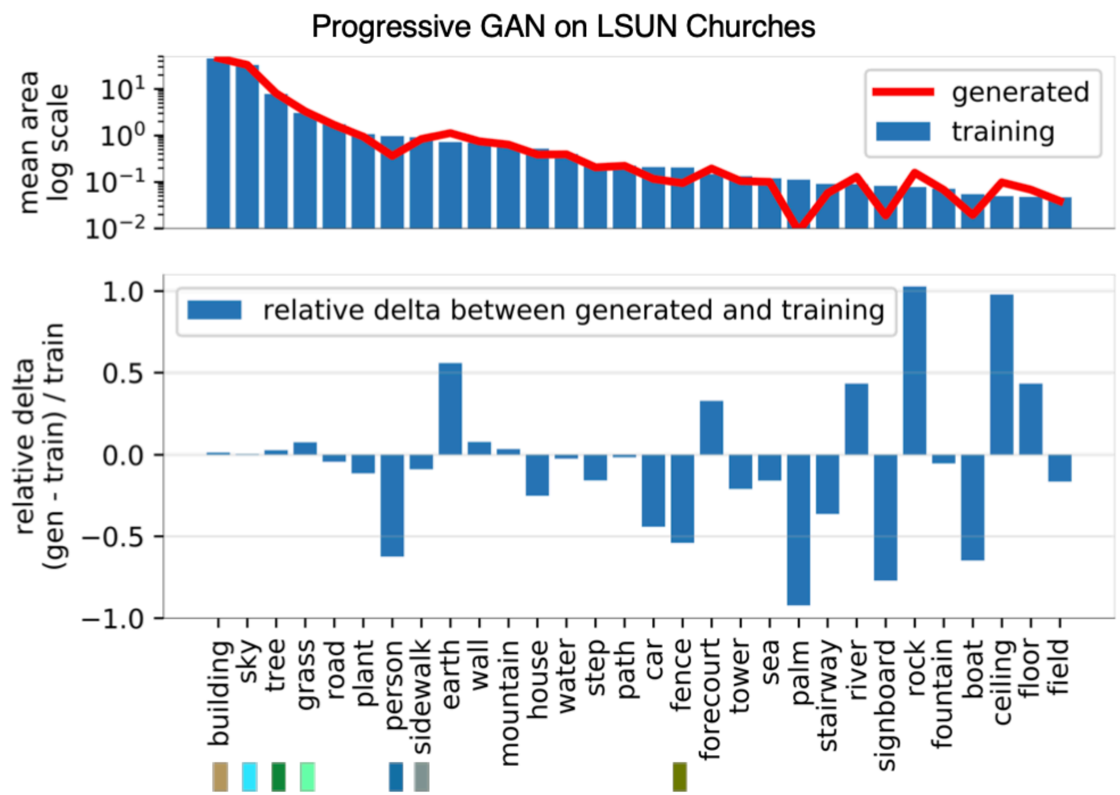
How to visualize the problem of mode collapse ?

Bau, David, et al. "**Seeing what a GAN cannot generate**." Proceedings of the IEEE International Conference on Computer Vision. 2019.

What it learns

- Seeing what a GAN cannot generate

  Generated vs. Training object segmentation statistics



What it learns

- Seeing what a GAN cannot generate

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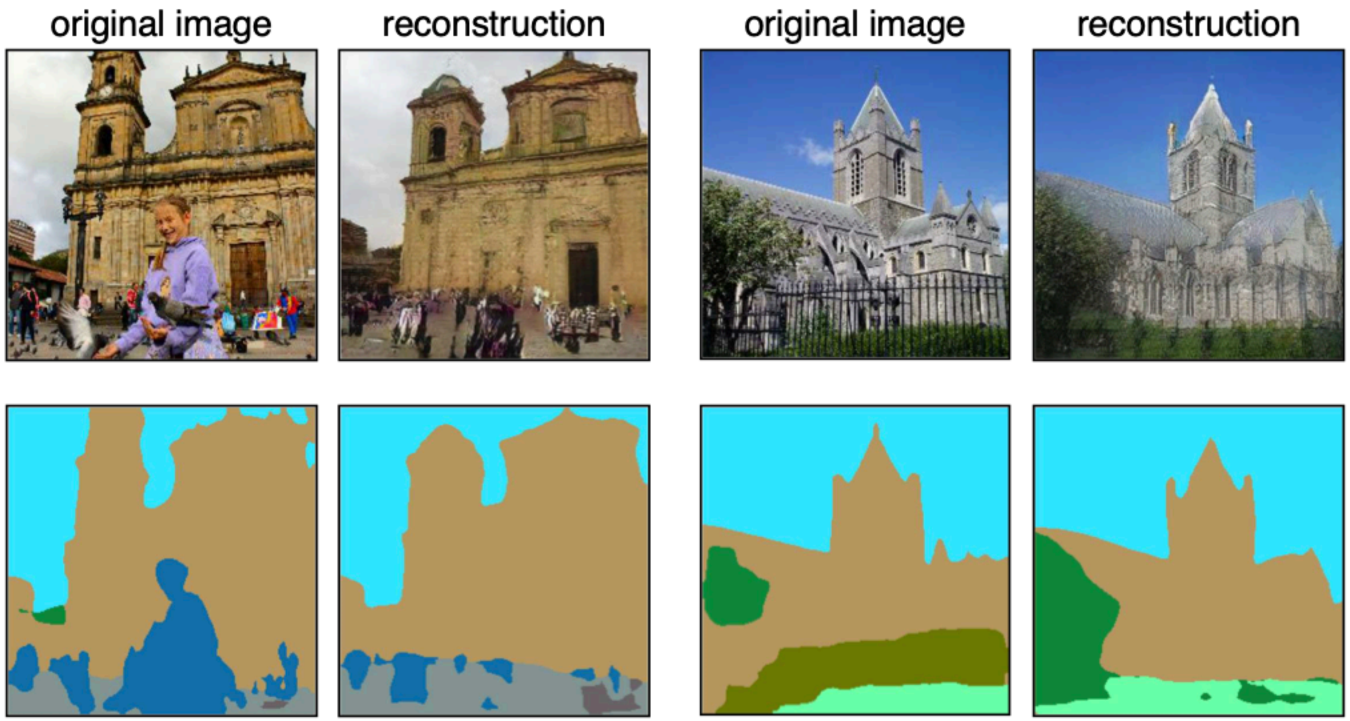
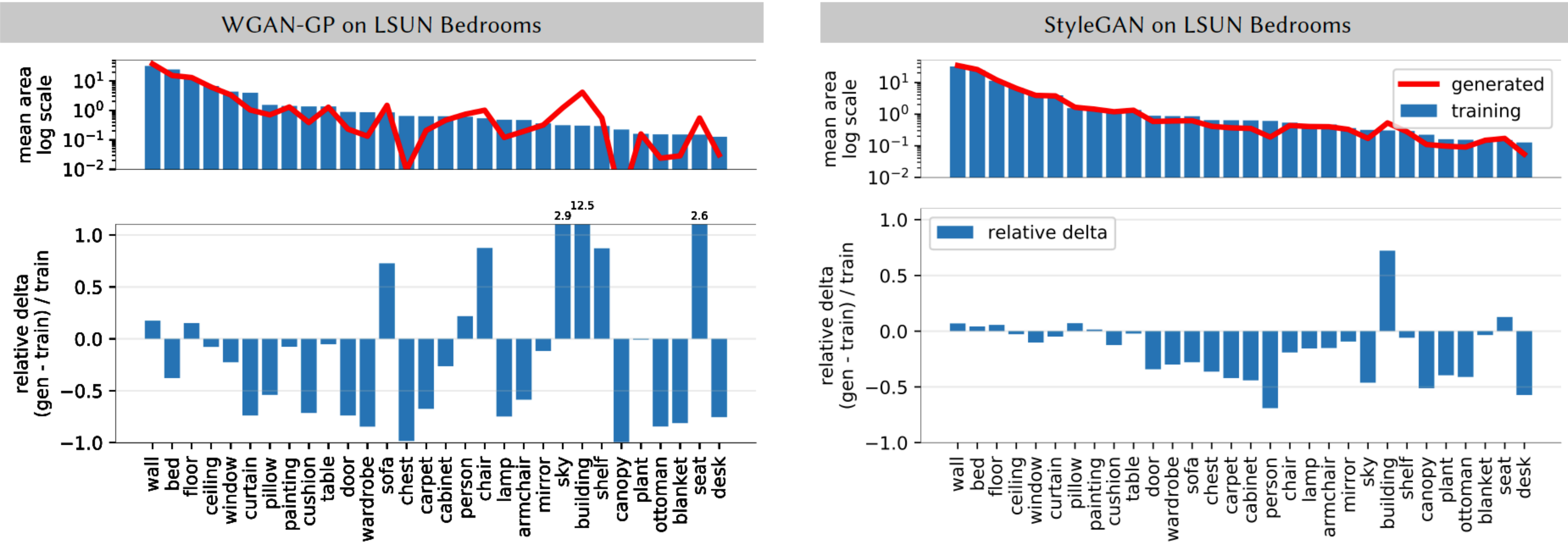


(b) real images vs. reconstructions

What it learns

- Seeing what a GAN cannot generate

  Method: Quantifying **distribution-level** mode collapse



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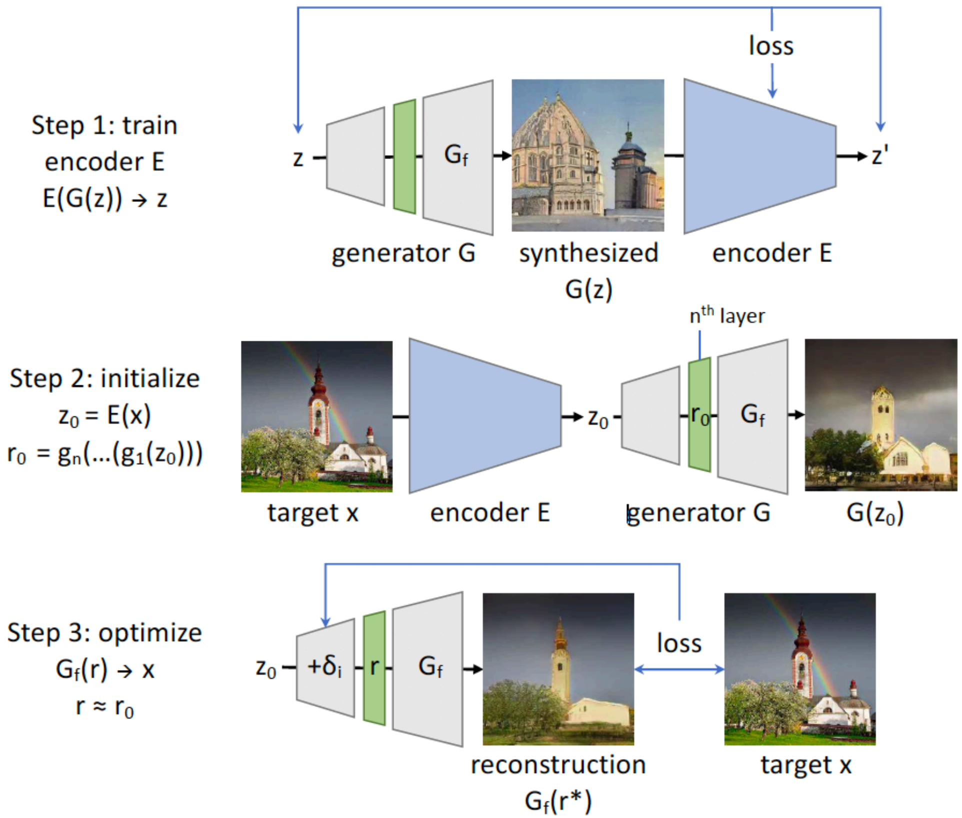
What it learns

- Seeing what a GAN cannot generate

  Method: Quantifying **instance-level** mode collapse



$$G = G_f(g_n(\cdots((g_1(\mathbf{z})))))$$

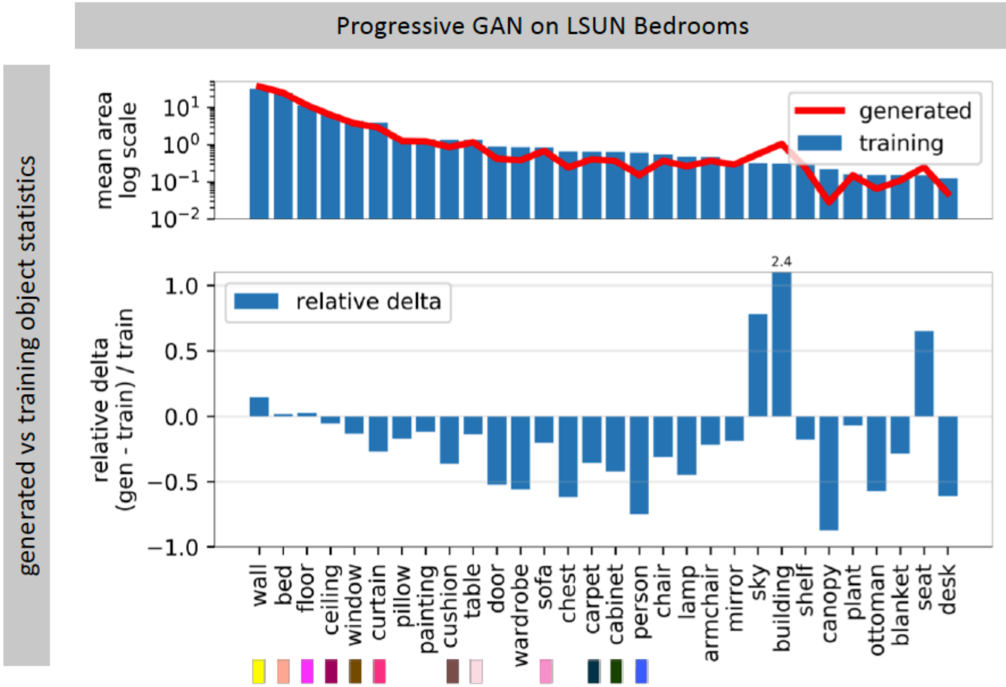
$$\mathcal{L}_\mathrm{L} \equiv \mathbb{E}_\mathbf{z}[||\mathbf{r}_{i-1} - e(g_i(\mathbf{r}_{i-1}))||_1]$$
$$\mathcal{L}_\mathrm{R} \equiv \mathbb{E}_\mathbf{z}[||\mathbf{r}_i - g_i(e(\mathbf{r}_i))||_1]$$
$$e_i = \arg\min_e \quad \mathcal{L}_\mathrm{L} + \lambda_\mathrm{R}\mathcal{L}_\mathrm{R},$$
$$E^* = e_1(e_2(\cdots(e_n(e_f(\mathbf{x})))))$$

$$\mathbf{x}' = G_f(\mathbf{r}^*),$$
$$\text{where } \mathbf{r}^* = \arg\min_\mathbf{r} \ell(G_f(\mathbf{r}), \mathbf{x})$$

What it learns

- Seeing what a GAN cannot generate

  Results



What it learns

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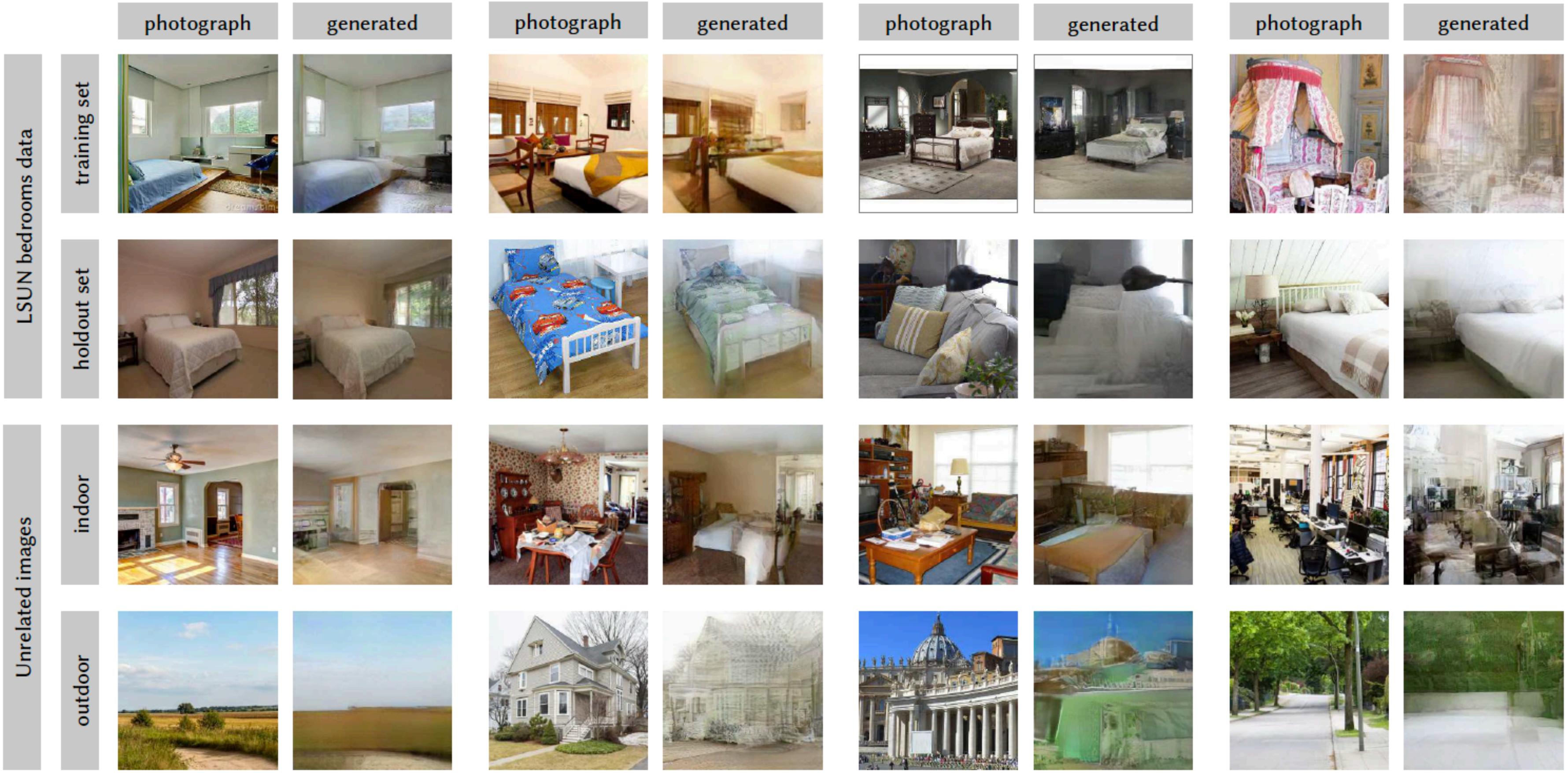

What it learns

- Seeing what a GAN cannot generate

Results

Summary

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