Self-Attention Generative Adversarial Networks

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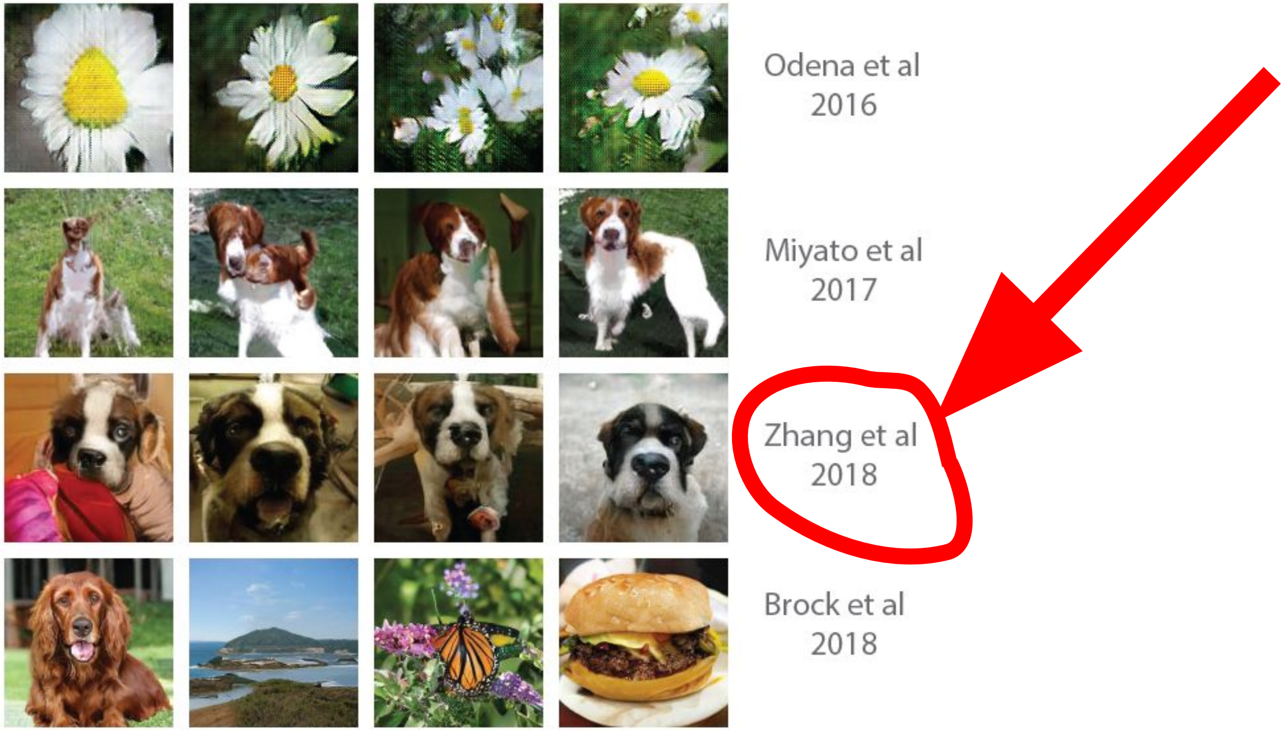
Which GAN paper are we talking about?



What did we do?

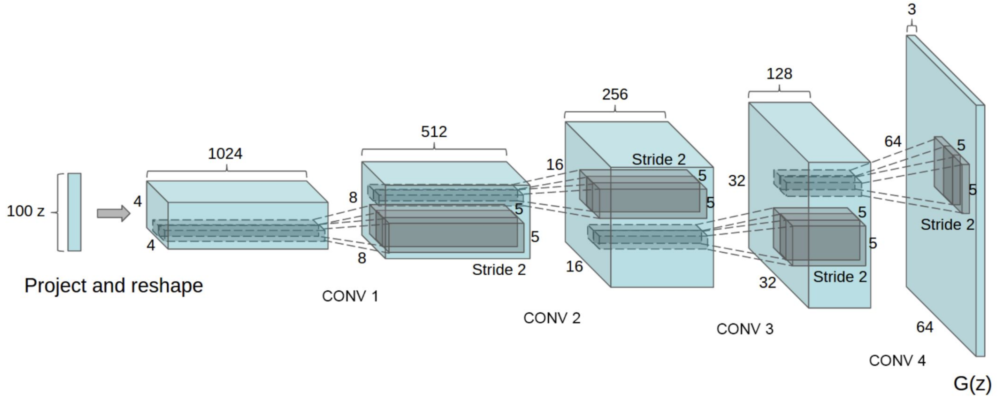
- Add Self-Attention blocks to Generator and Discriminator
- Spectral Normalization (Miyato et al., ICLR, 2018) in both Generator and Discriminator
- Different learning rate for Generator and Discriminator (TTUR: Heusel et al., NIPS, 2017)

What were the results?

Model	Inception Score	Intra-FID	FID
AC-GAN	28.5	260	\
SNGAN-projection	36.8	92.4	27.62
Our SAGAN	52.52	83.7	18.65

Comparison of SAGAN and AC-GAN (A. Odena et al., ICLR, 2017),
SNGAN-projection (T. Miyato et al., ICLR, 2018) on ImageNet

What's wrong with convolutions?



DCGAN (Radford et al, ICLR, 2016)

Improved GAN
(Salimans et al, NIPS, 2016)

+ Excel at synthesizing image classes with few structural constraints
- Fail to capture geometric or structural patterns

What is Self-Attention?

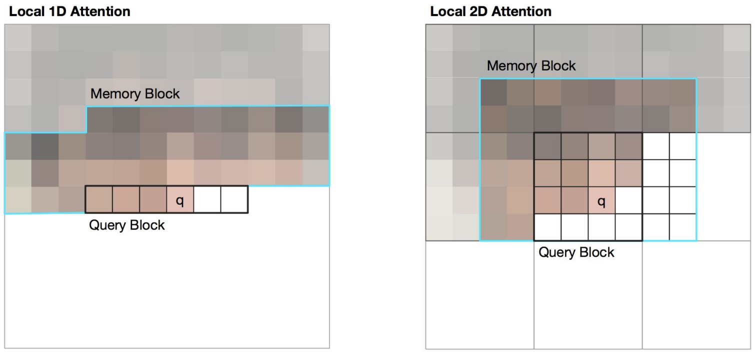
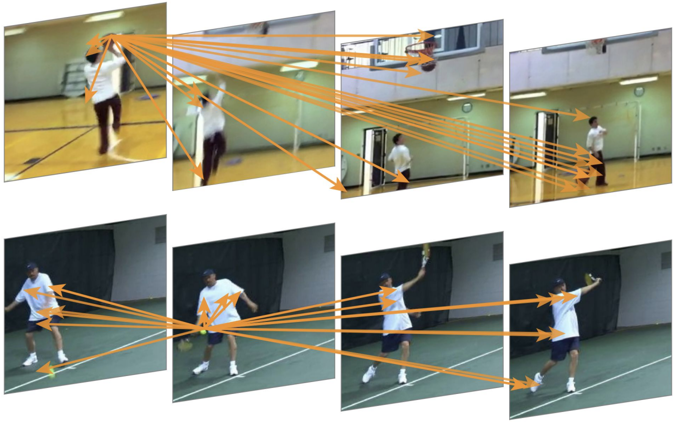


Image Transformer
(Parmar et al, ICML, 2018)



Non-local Neural Networks
(Wang et al, CVPR, 2018)

+ Models long-range dependencies more efficiently

Self-Attention in GANs

$$y_i = \frac{1}{C(x)} \sum_j f(x_i, x_j) g(x_j)$$

Self-Attention in GANs

$$\overbrace{y_i}^{\text{Single output location}} = \frac{1}{\underbrace{C(x)}_{\sum_j f(x_i,x_j)\ \text{Normalizing constant}}} \sum_j \overbrace{f(x_i,x_j)}^{\text{"relevance" of } x_j \text{ to } x_i} \underbrace{g(x_j)}_{\text{learned function of a location}}$$

Self-Attention in GANs

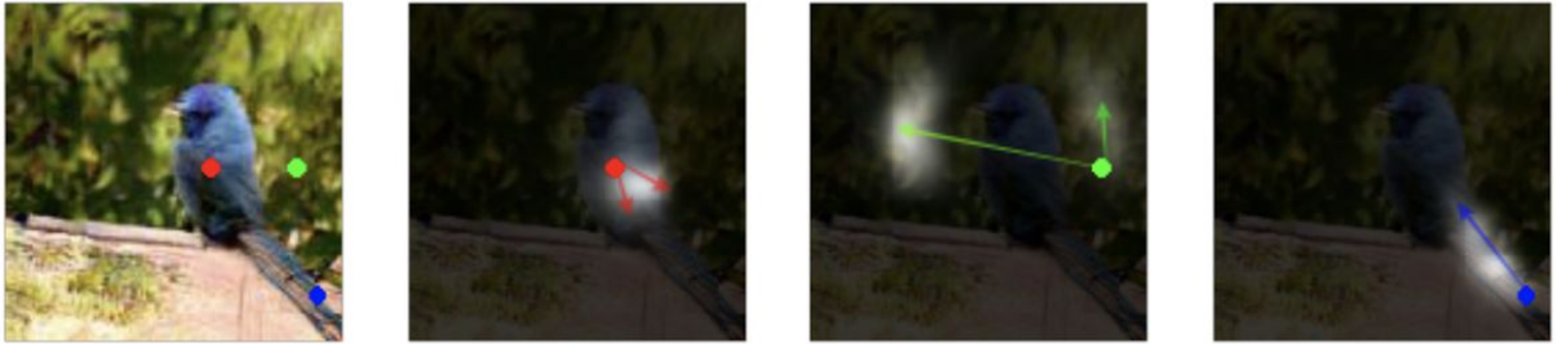
$$y_i = \frac{1}{C(x)} \sum_j f(x_i, x_j)\, g(x_j)$$

$$f(x_i, x_j) := \exp\left(\langle \theta(x_i) \mid \phi(x_j) \rangle \right)$$

$$\Rightarrow \frac{1}{C(x)} \sum_j f(x_i, x_j)$$ is a "softmax"

$g(x_j)$ is just an embedding lookup

What does self-attention do?

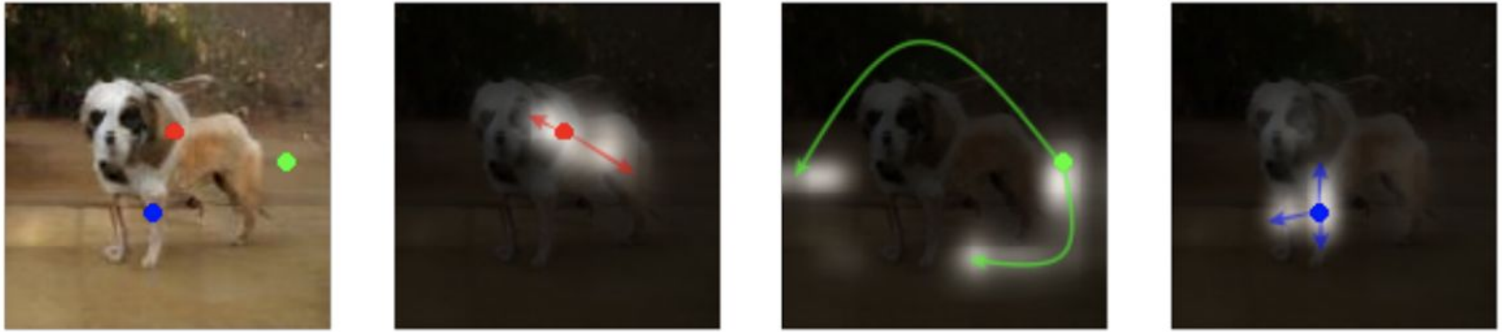


Generator allocates attention according to similarity of color and texture

What does self-attention do?

Adjacent query points may result in very different attention maps

What does self-attention do?



Attention lets you draw dogs with 4 legs!

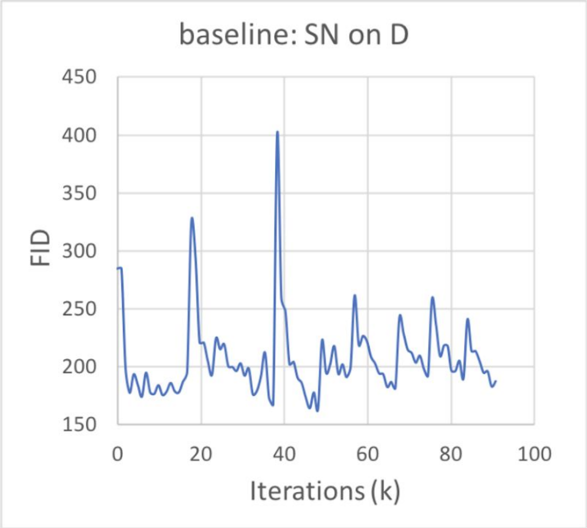
There's a learned distinction between background and foreground

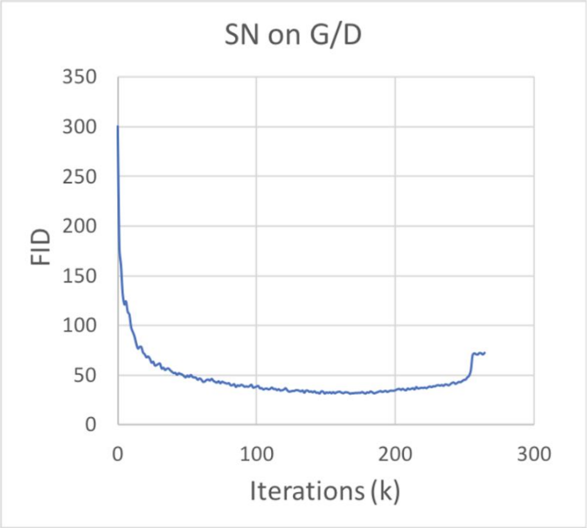
Spectral Normalization in the Generator

- SN-GAN (Miyato et al., ICLR, 2018) only adds SN to the discriminator.
- We add it to the generator as well
- The fact that this works suggests that the motivation given in e.g. the WGAN paper is incomplete

What does Spectral Norm do?

- Spectral Normalization (SN) in both G and D





Baseline: Very unstable

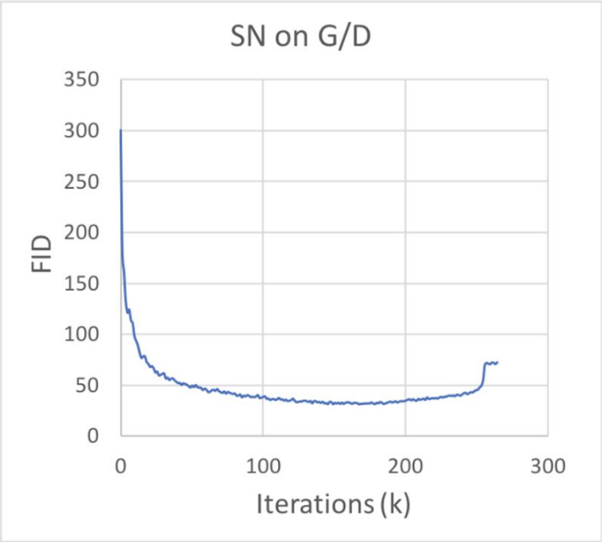
SN on G/D: More stable

Different learning rates for G and D

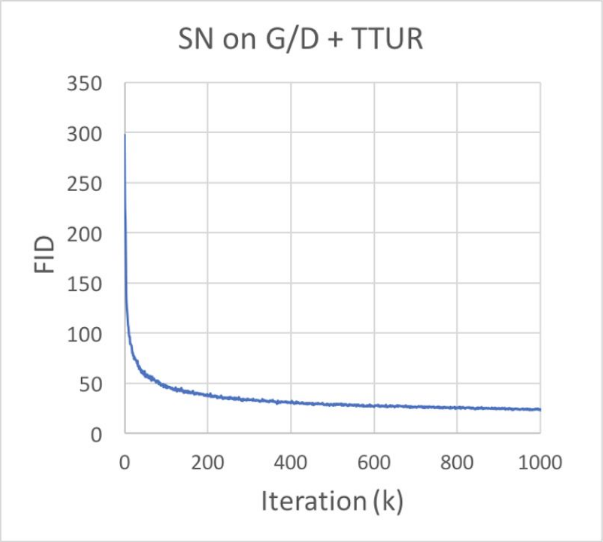
- Regularized Discriminators use more steps than generators
- This is wasteful! It throws out useful computations and it makes training go slower.
- If you use a lower learning rate for the generator, everything works better.

What do different learning rates do?

- Imbalanced learning rate, TTUR, for G and D updates



Best FID: 33.39



Best FID: 18.65

Results (all ImageNet classes)

Model	no attention	SAGAN				Residual			
		$feat_8$	$feat_{16}$	$feat_{32}$	$feat_{64}$	$feat_8$	$feat_{16}$	$feat_{32}$	$feat_{64}$
FID	22.96	22.98	22.14	**18.28**	18.65	42.13	22.40	27.33	28.82
IS	42.87	43.15	45.94	51.43	**52.52**	23.17	44.49	38.50	38.96

Comparison of Self-Attention and Residual block on GANs

Adding attention at "higher" layers is better.

Results (all ImageNet classes)

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		$feat_8$	$feat_{16}$	$feat_{32}$	$feat_{64}$	$feat_8$	$feat_{16}$	$feat_{32}$	$feat_{64}$
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Comparison of Self-Attention and Residual block on GANs

This comparison shows that attention really helps.

Results (all ImageNet classes)

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		$feat_8$	$feat_{16}$	$feat_{32}$	$feat_{64}$	$feat_8$	$feat_{16}$	$feat_{32}$	$feat_{64}$
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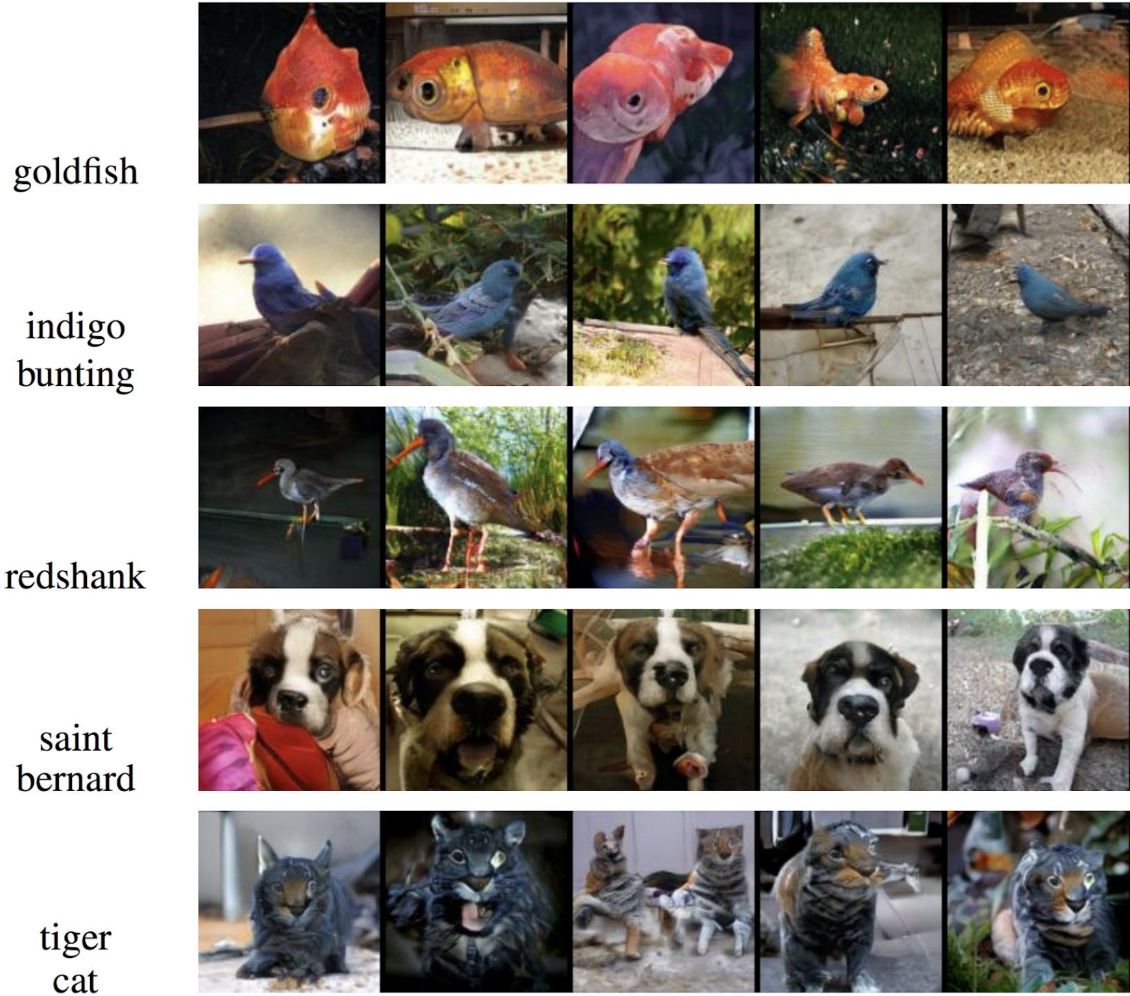
Comparison of Self-Attention and Residual block on GANs

This comparison shows that attention is better than just adding the same number of parameters to convolutions.

Intra-FID for example classes

Model	SNGAN-projection	Our SAGAN
Goldfish	58.1	44.4
Indigo bunting	66.8	53.0
Redshank	60.1	48.9
Saint bernard	55.3	35.7
Tiger cat	90.2	88.1



More Info

Paper: arxiv.org/pdf/1805.08318

Code: github.com/brain-research/self-attention-gan

Poster: 06:30 -- 09:00 PM @ Pacific Ballroom #11