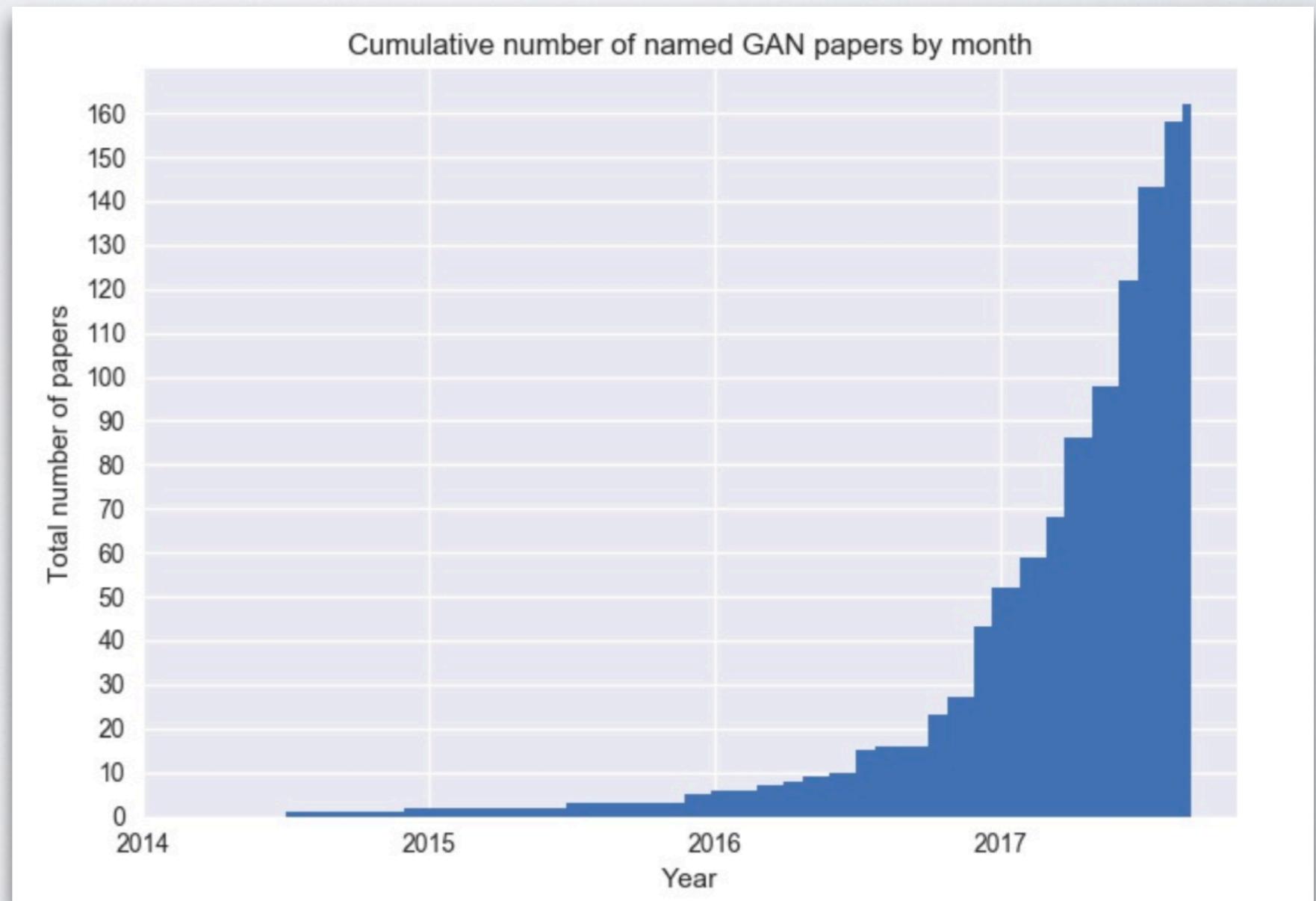


GENERATIVE ADVERSARIAL NETWORKS TUTORIAL

ATML 2020
Simon Jenni

GAN VARIANTS: OVERVIEW

- A large variety of GANs have been proposed in recent years:



GAN VARIANTS: DCGAN

- Convolutional version of the original with design heuristics

$$\mathcal{L}_D^{\text{NSGAN}} = -\mathbb{E}_{x \sim p_d} [\log(D(x))] - \mathbb{E}_{\hat{x} \sim p_g} [\log(1 - D(\hat{x}))]$$

$$\mathcal{L}_G^{\text{NSGAN}} = -\mathbb{E}_{\hat{x} \sim p_g} [\log(D(\hat{x}))]$$

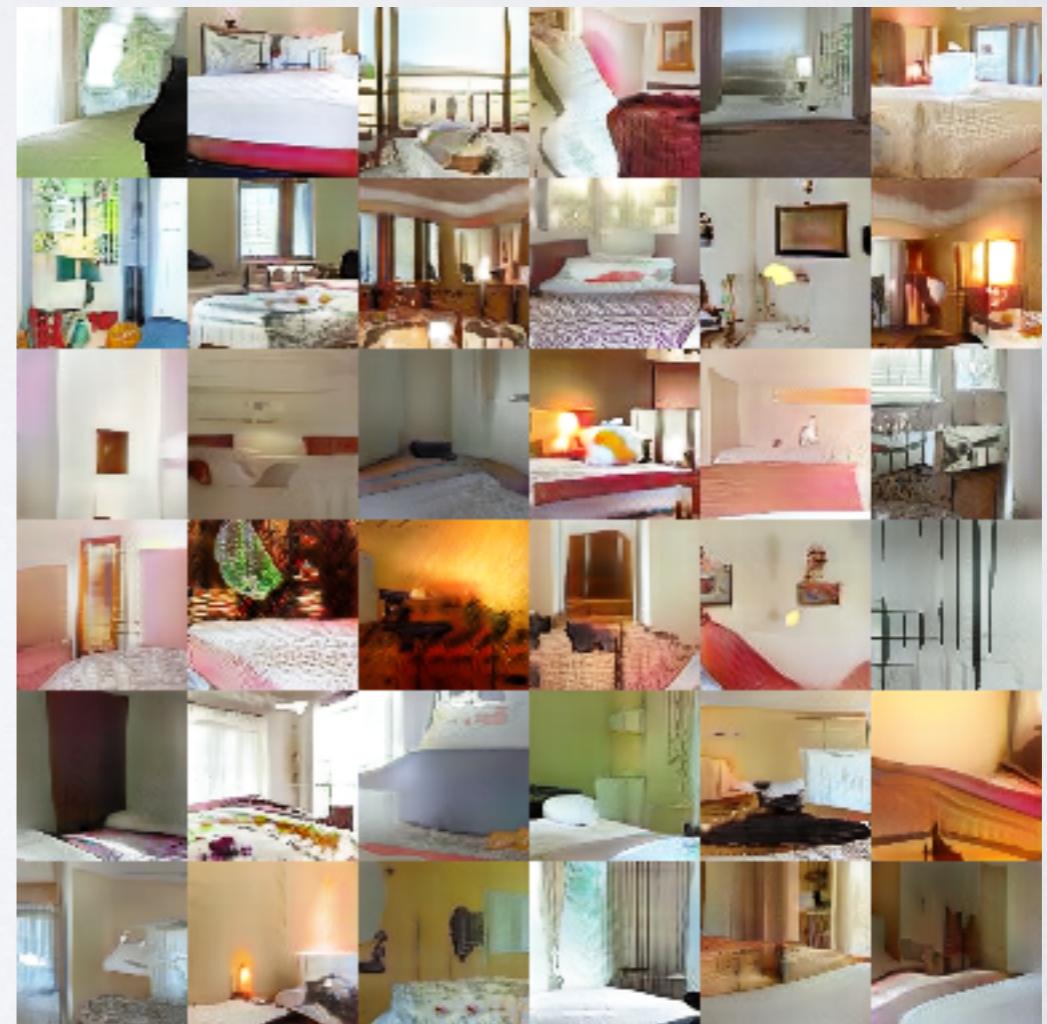
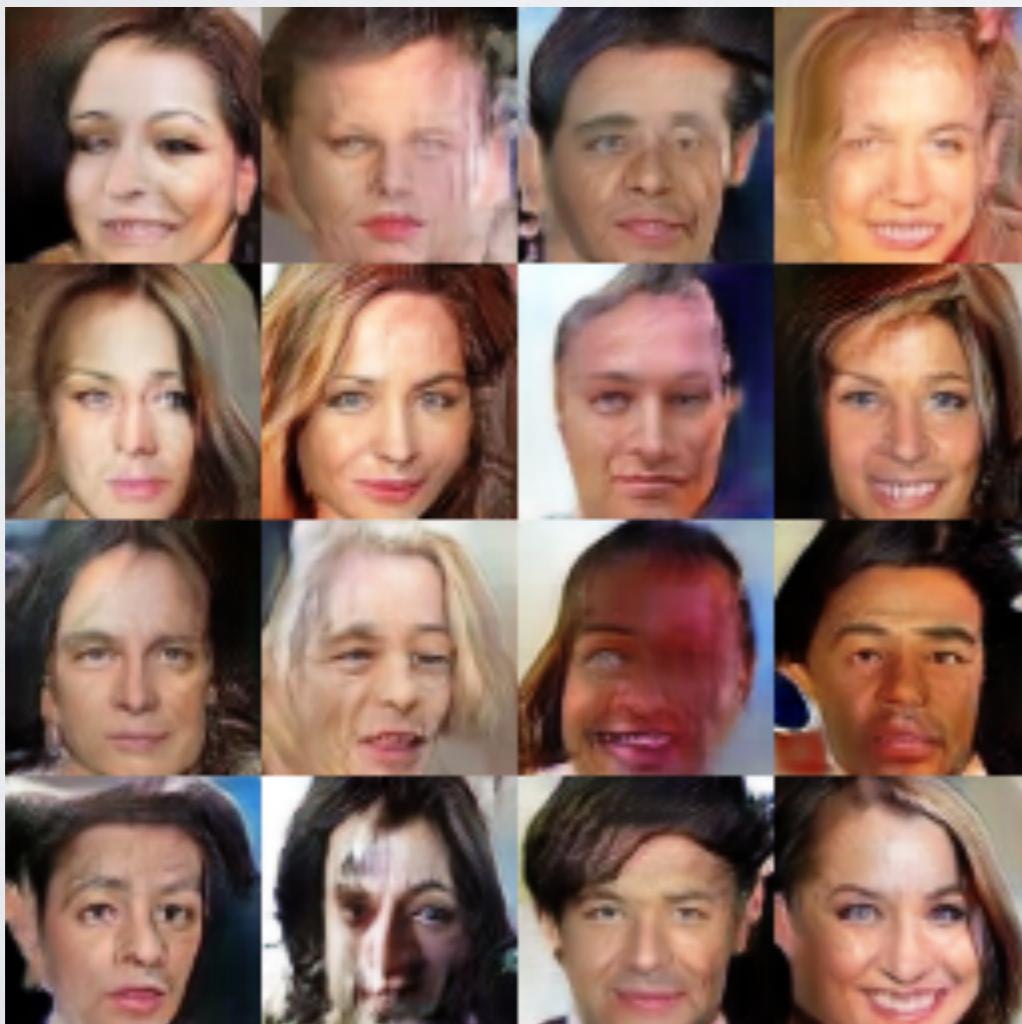


GAN VARIANTS: WGAN

- Based on the Wasserstein distance (D has linear activation)

$$\mathcal{L}_D^{\text{WGAN}} = -\mathbb{E}_{x \sim p_d}[D(x)] + \mathbb{E}_{\hat{x} \sim p_g}[D(\hat{x})]$$

$$\mathcal{L}_G^{\text{WGAN}} = -\mathbb{E}_{\hat{x} \sim p_g}[D(\hat{x})]$$

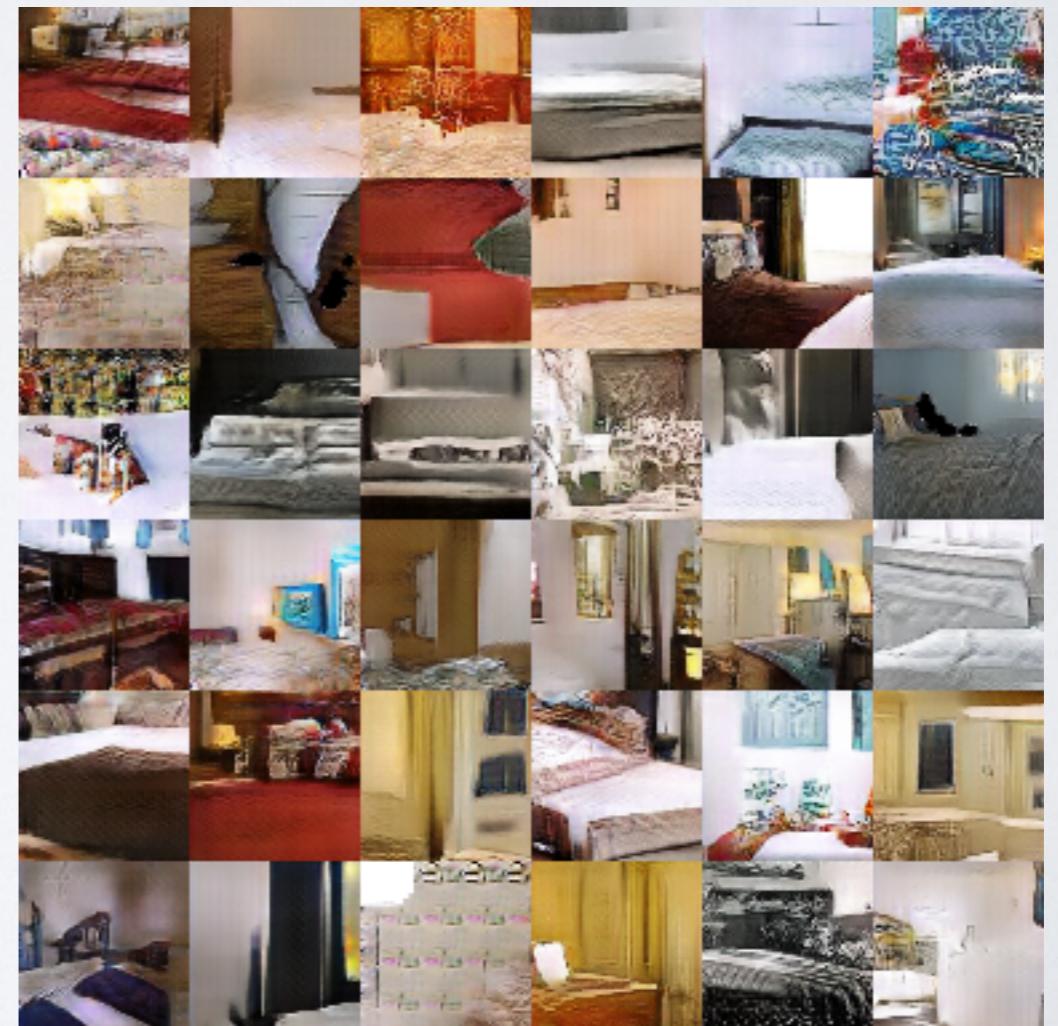
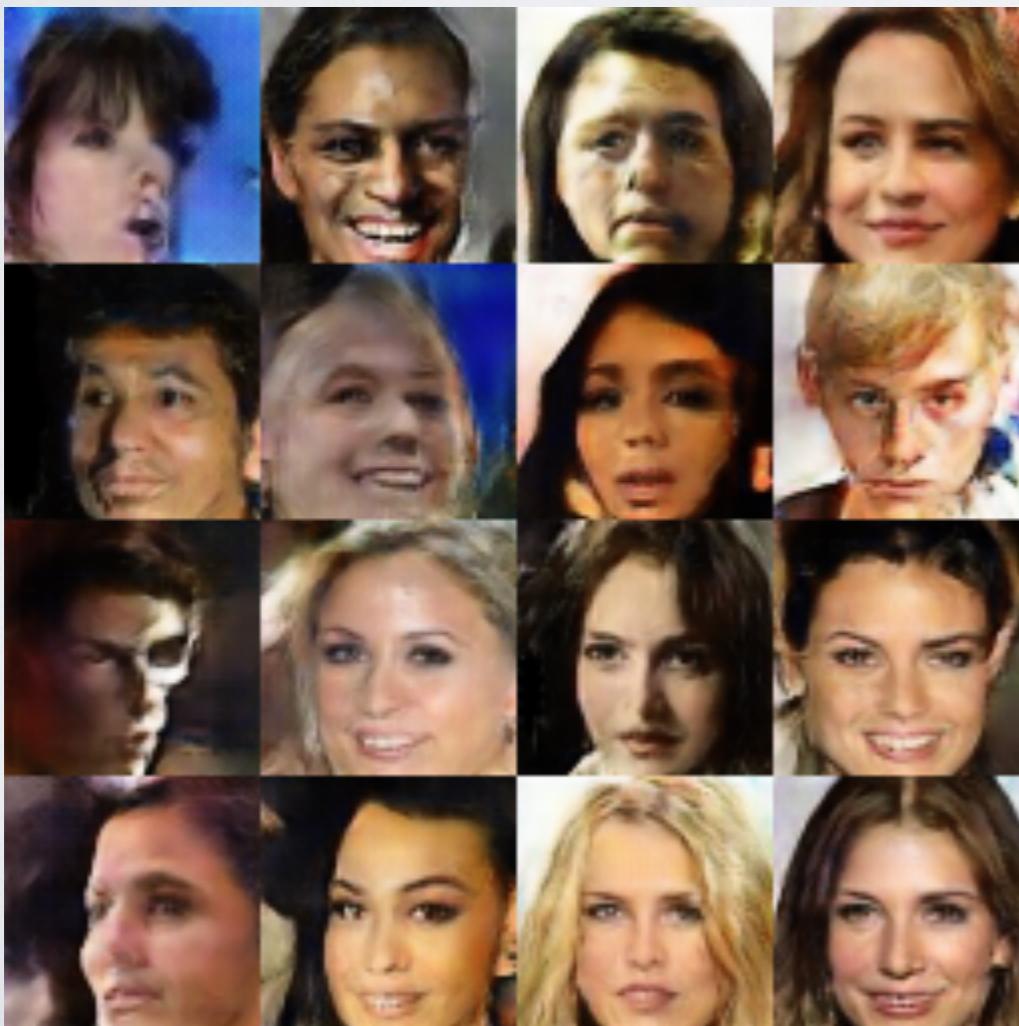


GAN VARIANTS: LSGAN

- Based on a least-squares loss (D has linear activation)

$$\mathcal{L}_D^{\text{LSGAN}} = -\mathbb{E}_{x \sim p_d} [(D(x) - 1)^2] + \mathbb{E}_{\hat{x} \sim p_g} [D(\hat{x})^2]$$

$$\mathcal{L}_G^{\text{LSGAN}} = -\mathbb{E}_{\hat{x} \sim p_g} [(D(\hat{x} - 1)^2)]$$



GAN VARIANTS: BEGAN

- Based on reconstruction loss (D is an AE)

$$\mathcal{L}_D^{\text{BEGAN}} = \mathbb{E}_{x \sim p_d} [\|x - \text{AE}(x)\|_1] - k_t \mathbb{E}_{\hat{x} \sim p_g} [\|\hat{x} - \text{AE}(\hat{x})\|_1] \quad \mathcal{L}_G^{\text{BEGAN}} = \mathbb{E}_{\hat{x} \sim p_g} [\|\hat{x} - \text{AE}(\hat{x})\|_1]$$



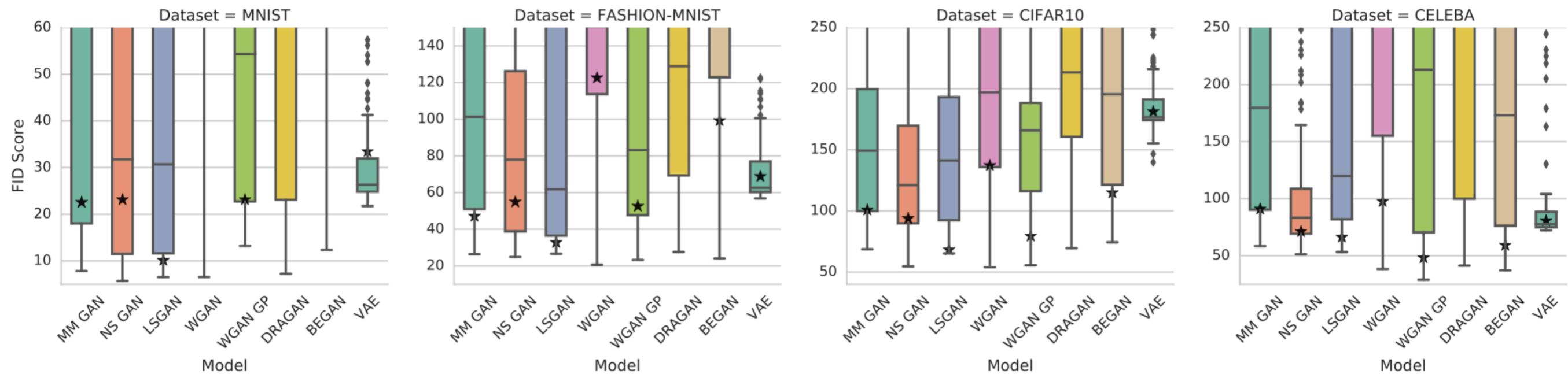
HOW TO COMPARE/ EVALUATE GANS?

- Human ratings: Expensive and not scalable
- Alternative: The Fréchet Inception Distance
 - Embed a large number ($\sim 50K$) of generated and real samples into the feature space of an Inception Network (trained on ImageNet)
 - Compute mean and variance of real/fake features

$$\text{FID}(x, g) = \|\mu_x - \mu_g\|_2^2 + \text{Tr}(\Sigma_x + \Sigma_g - 2(\Sigma_x \Sigma_g)^{\frac{1}{2}})$$

WHICH GAN IS BEST?

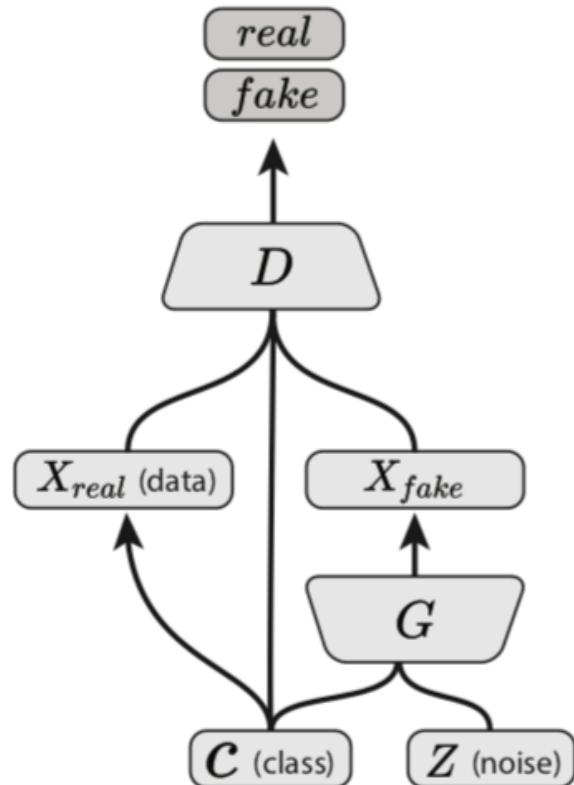
- Results of a large scale study reporting FID for a large set of hyper-parameter choices:



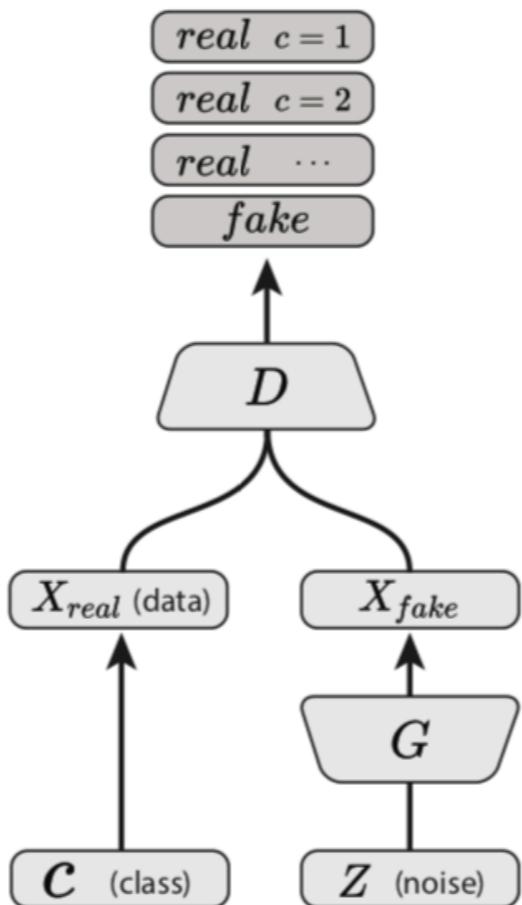
- No one GAN to rule them all (yet...)

<https://arxiv.org/abs/1711.10337>

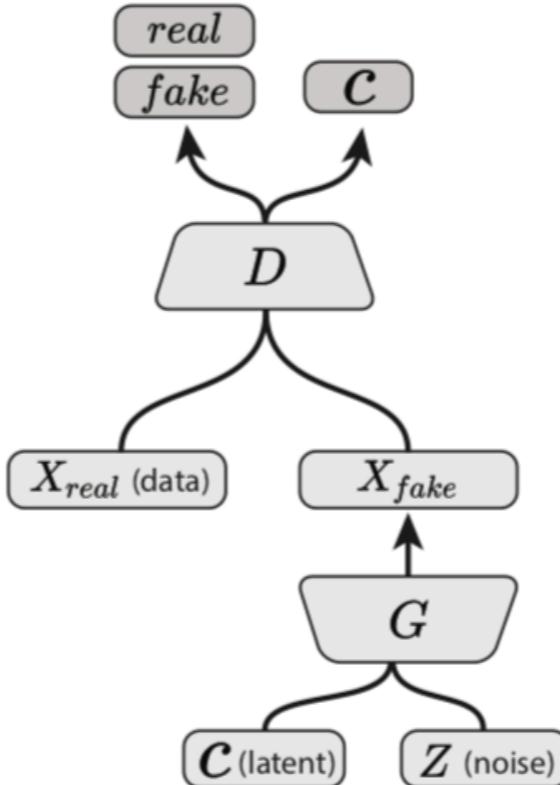
USING LABELS: CONDITIONAL GANS



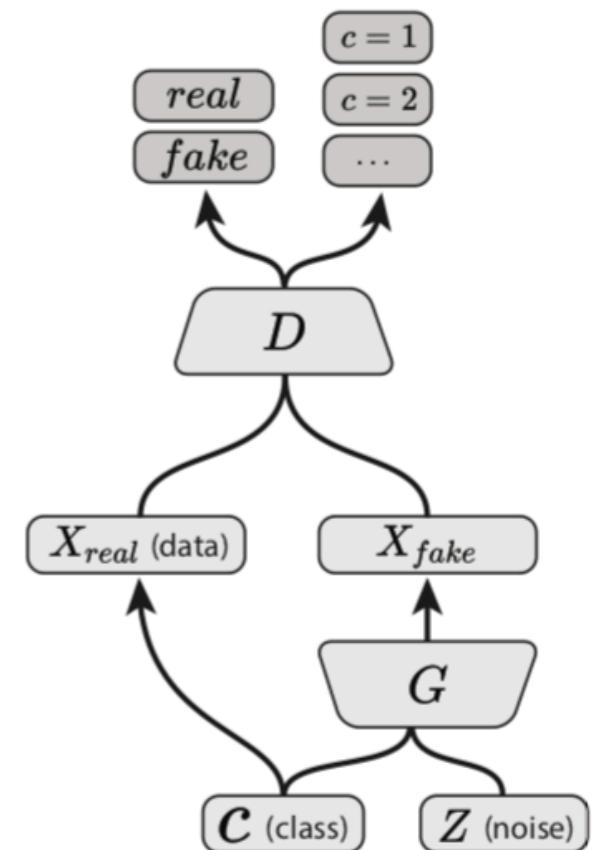
Conditional GAN
(Mirza & Osindero, 2014)



Semi-Supervised GAN
(Odena, 2016; Salimans, et al., 2016)

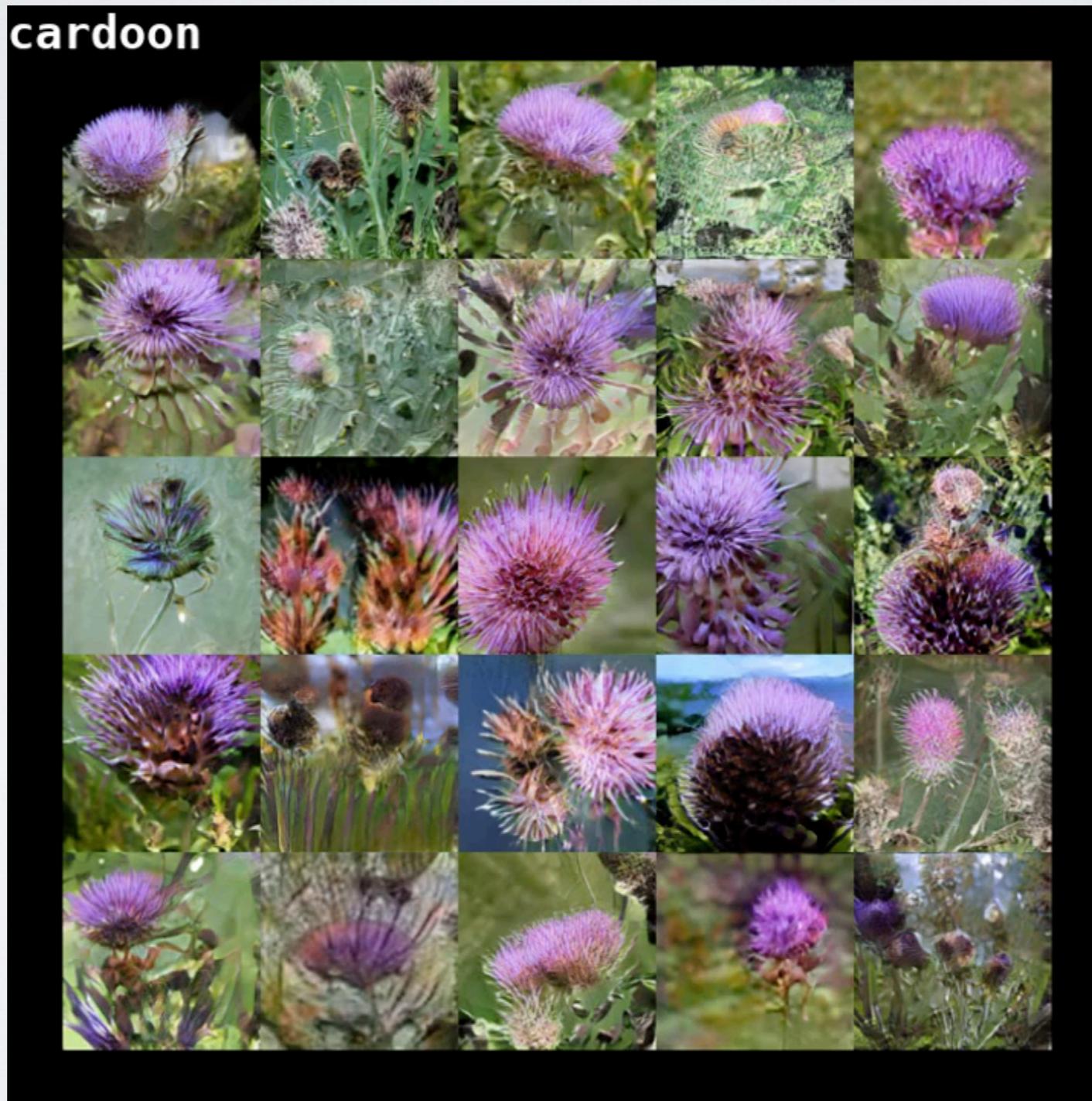


InfoGAN
(Chen, et al., 2016)



AC-GAN
(Present Work)

GAN REGULARISATION: SPECTRAL NORMALIZATION



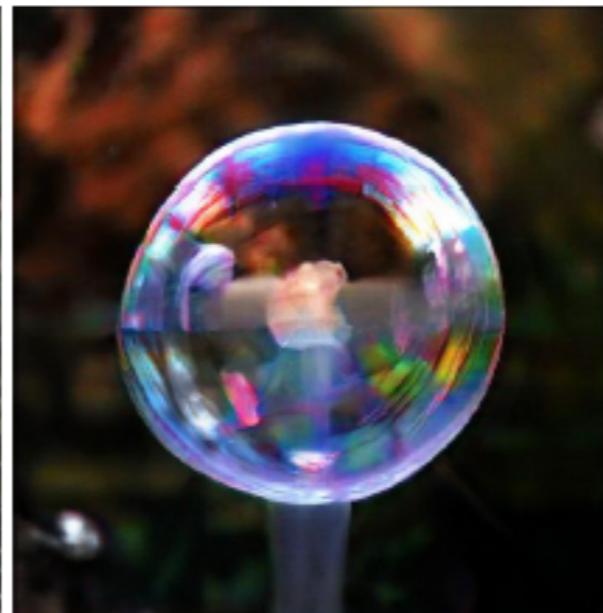
<https://www.youtube.com/watch?v=q3yy5Fxs7Lc>

Current SOTA in GANs



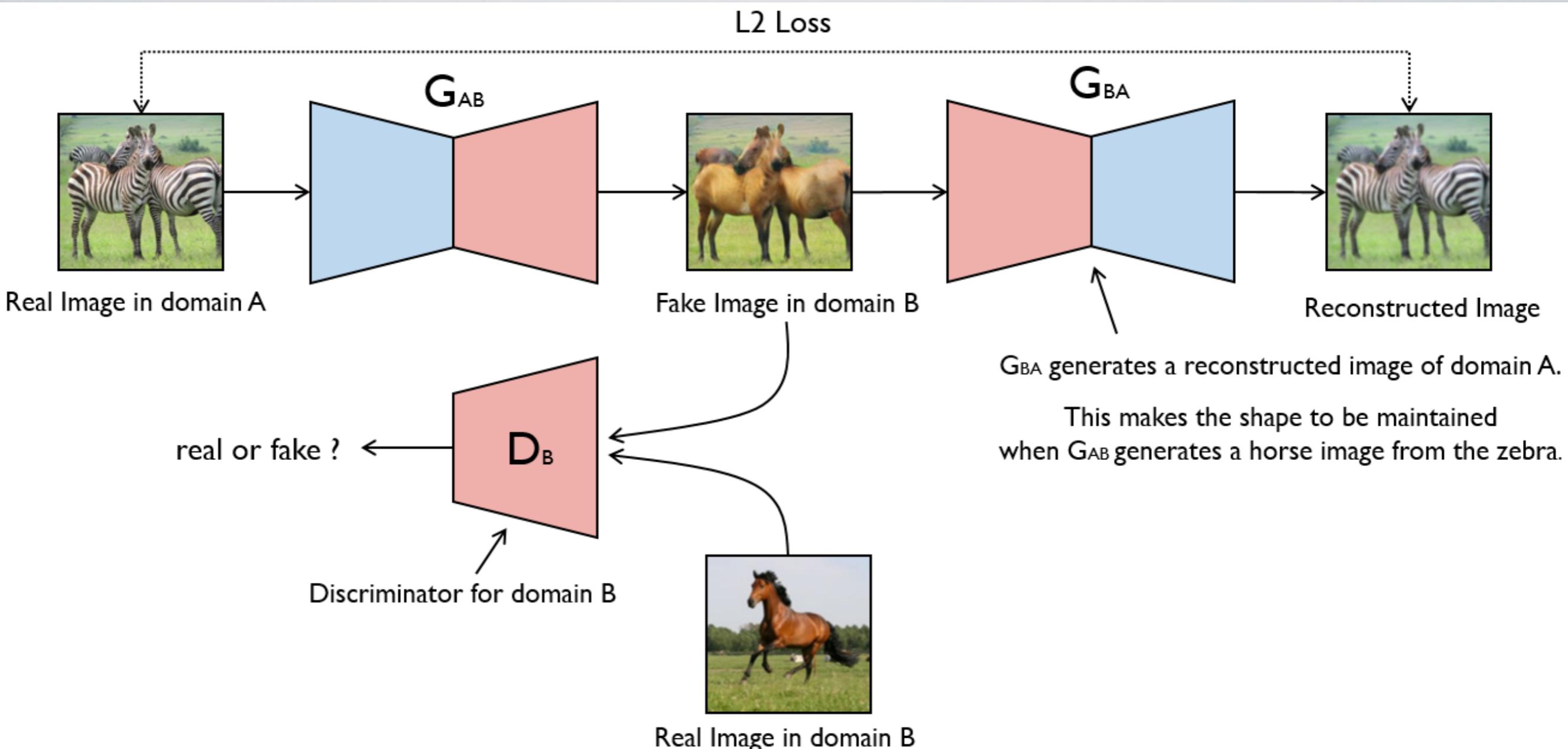
(Karras et al, 2018)

Current SOTA in GANs



(Brock et al, 2018)

GAN APPLICATIONS: CYCLE-GAN



GAN APPLICATIONS: CYCLE-GAN

Monet \curvearrowright Photos



Monet \rightarrow photo

Zebras \curvearrowright Horses



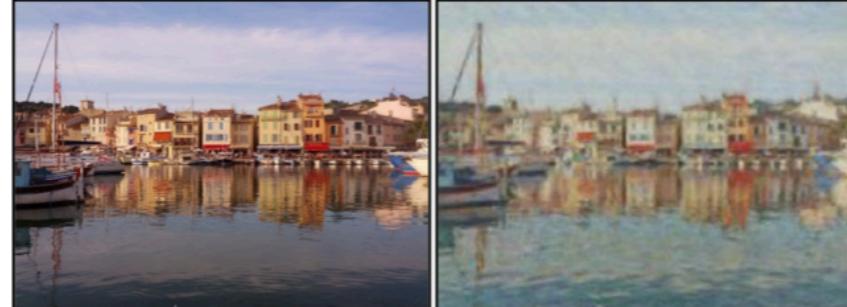
zebra \rightarrow horse

Summer \curvearrowright Winter



summer \rightarrow winter

photo \rightarrow Monet



horse \rightarrow zebra

winter \rightarrow summer

Photograph



Monet

Van Gogh

Cezanne

Ukiyo-e