

# Generative Adversarial Networks

## lecture

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HSE

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Figure: density estimation

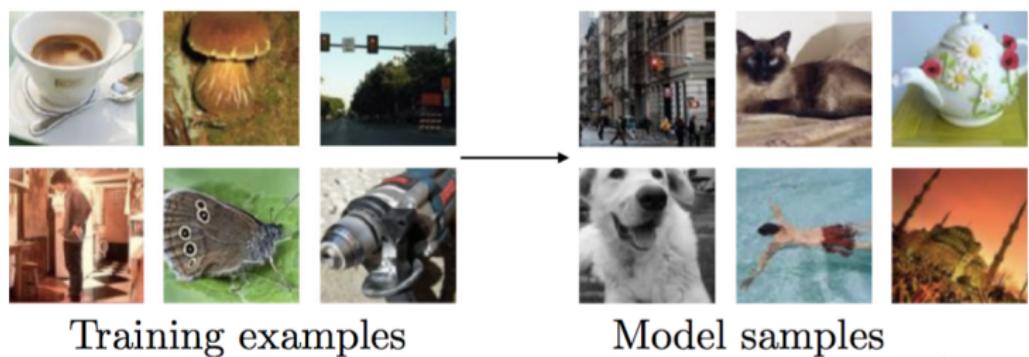


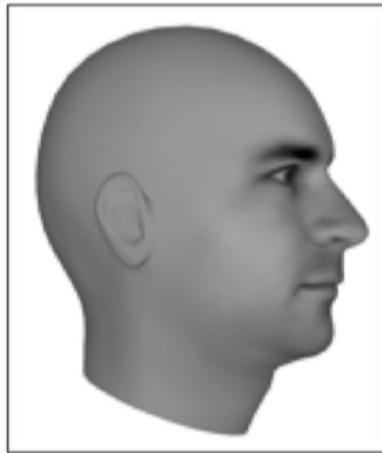
Figure: sampling

## motivation

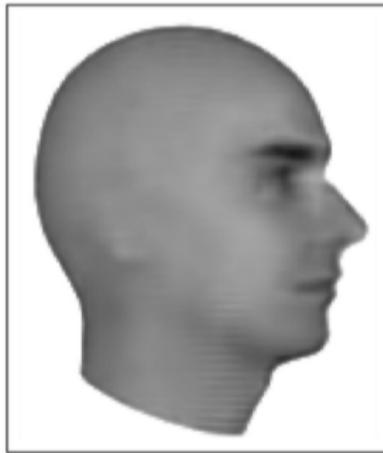
- ▶ high-dimensional sampling is a tricky problem by itself
- ▶ semi-supervised learning
- ▶ simulation multimodal distributions
- ▶ adversarial loss has plenty of applications

## about multimodality

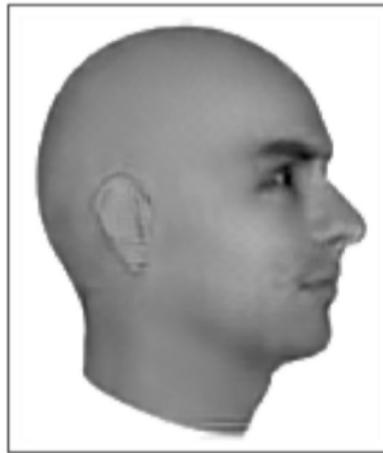
Ground Truth



MSE



Adversarial



# about super resolution

bicubic  
(21.59dB/0.6423)



SRResNet  
(23.53dB/0.7832)



SRGAN  
(21.15dB/0.6868)



original

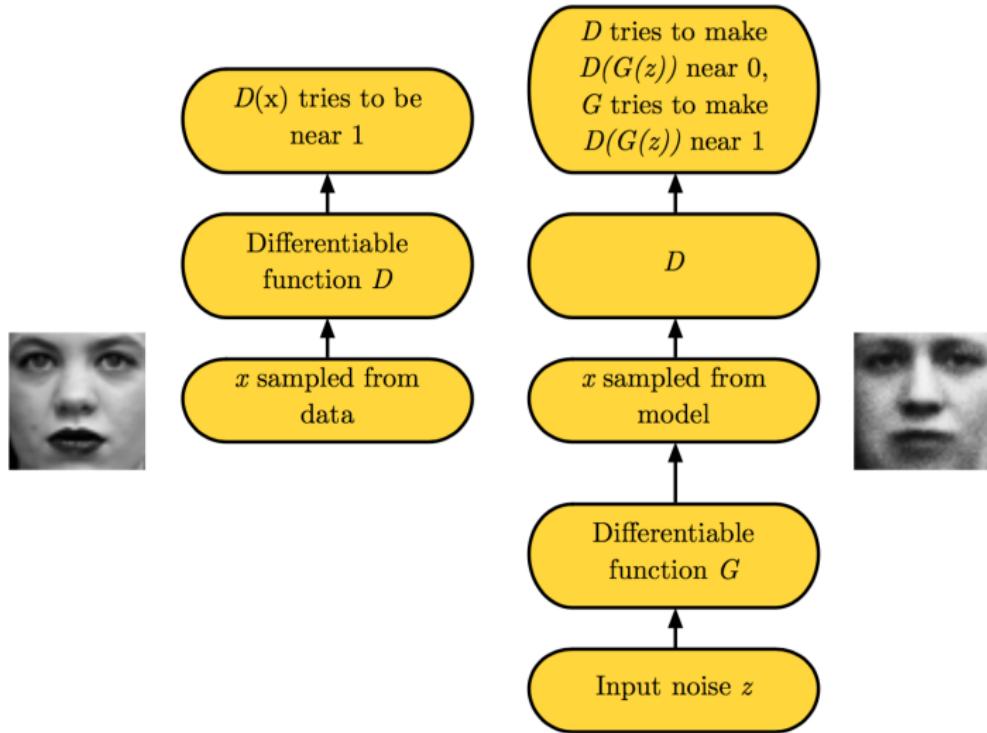


## General formulation

$$L^{(G)}(\theta^{(G)}, \theta^{(D)}) \rightarrow \min_{\theta^{(G)}}, \quad (1)$$

$$L^{(D)}(\theta^{(G)}, \theta^{(D)}) \rightarrow \min_{\theta^{(D)}}. \quad (2)$$

# Framework



## Discriminator objectives

$$L^{(D)}(\theta^{(D)}, \theta^{(G)}) = -\frac{1}{2} \mathbb{E}_{x \sim p_{\text{data}}} \log D(x) - \frac{1}{2} \mathbb{E}_z \log(1 - D(G(z))).$$

# Minimax

$$L^{(G)}(\theta^{(D)}, \theta^{(G)}) = -L^{(D)}(\theta^{(D)}, \theta^{(G)}).$$

$$\theta^{(G)*} = \min_{\theta(G)} \max_{\theta(D)} -L^{(D)}(\theta^{(D)}, \theta^{(G)})$$

## non-saturating game

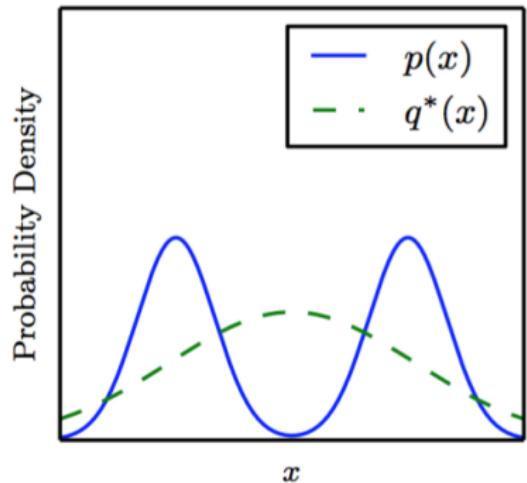
$$L^{(G)}(\theta^{(D)}, \theta^{(G)}) = -\frac{1}{2} \mathbb{E}_z \log D(G(z))$$

## maximum likelihood

$$L^{(G)}(\theta^{(D)}, \theta^{(G)}) = -\frac{1}{2} \mathbb{E}_z \exp \left[ \sigma^{-1} \left( D(G(z)) \right) \right]$$

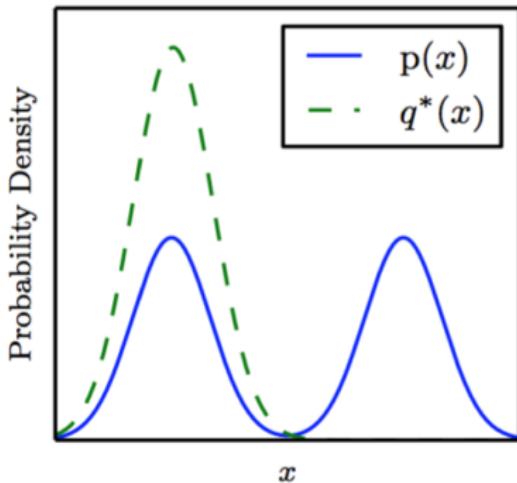
# maximum likelihood

$$q^* = \operatorname{argmin}_q D_{\text{KL}}(p\|q)$$



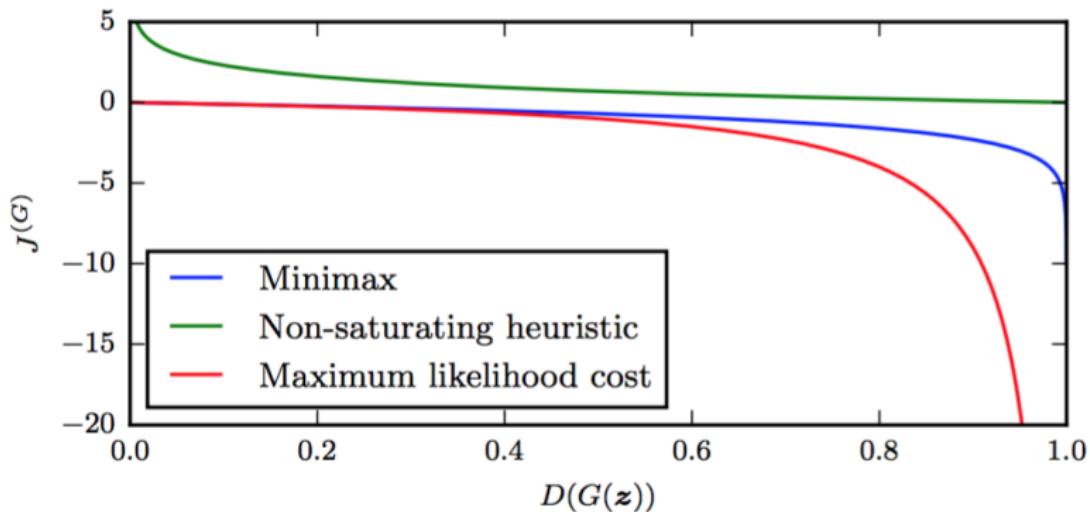
Maximum likelihood

$$q^* = \operatorname{argmin}_q D_{\text{KL}}(q\|p)$$

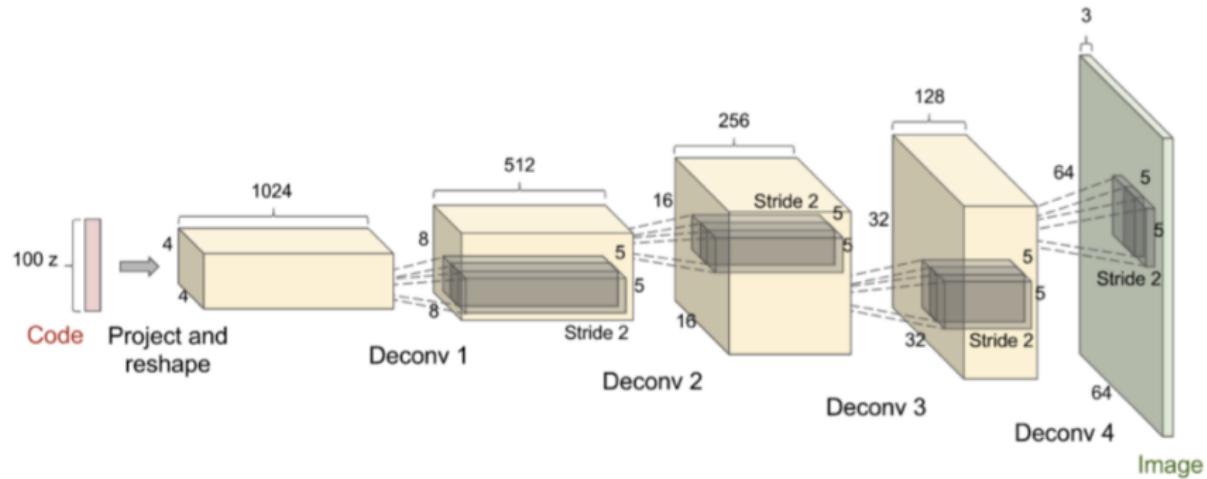


Reverse KL

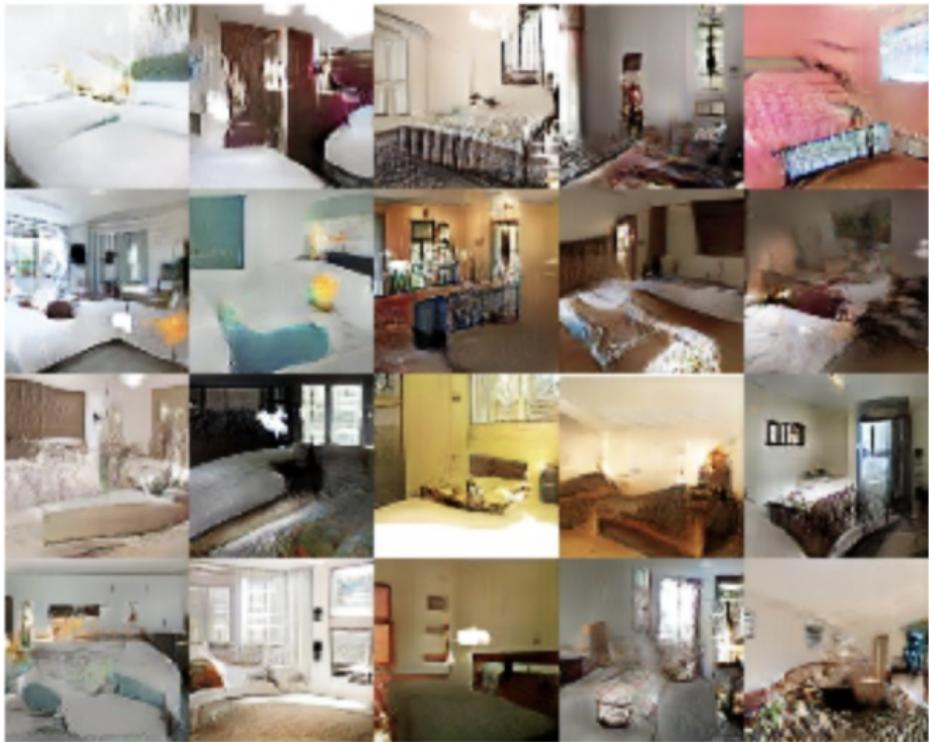
## comparison



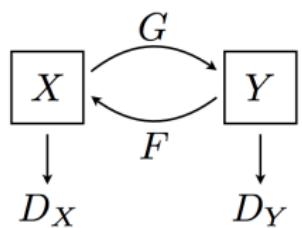
# DCGAN



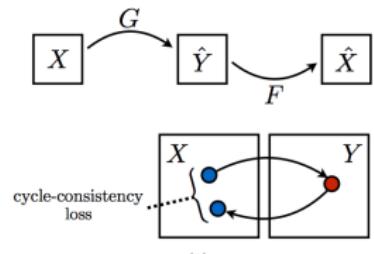
# DCGAN examples



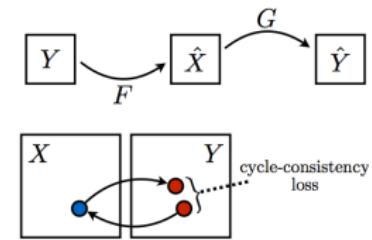
# cycle GAN



(a)



(b)



(c)

orange ↔ apple



apple → orange



orange → apple

# winter ↔ summer

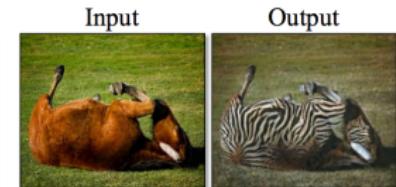
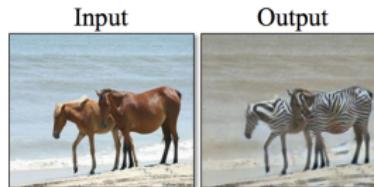


winter Yosemite → summer Yosemite



summer Yosemite → winter Yosemite

horse ↔ zebra



horse → zebra



zebra → horse