Generative Adversarial Networks (GAN)

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GANs

- Invented by Ian Goodfellow in 2014
- Prof. Yan Lecun believes it is the coolest idea in ML in the last two decades

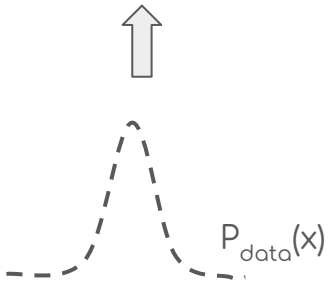
GANs

- Aim is
  - Not to model p(x)
  - To enable sampling from p(x)
- Generative models with implicit density

GANs

Learning

GAN



GANs - Setup

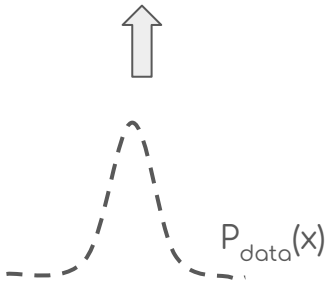
- Latent variable (z) with simple prior $p(z)$
- $z \sim p(z)$ and forward through the Generator part $\rightarrow x = G(z)$
- x is a sample from the Generator distribution p_G
- Goal is to make $p_{data} = p_G$

GANs

Learning

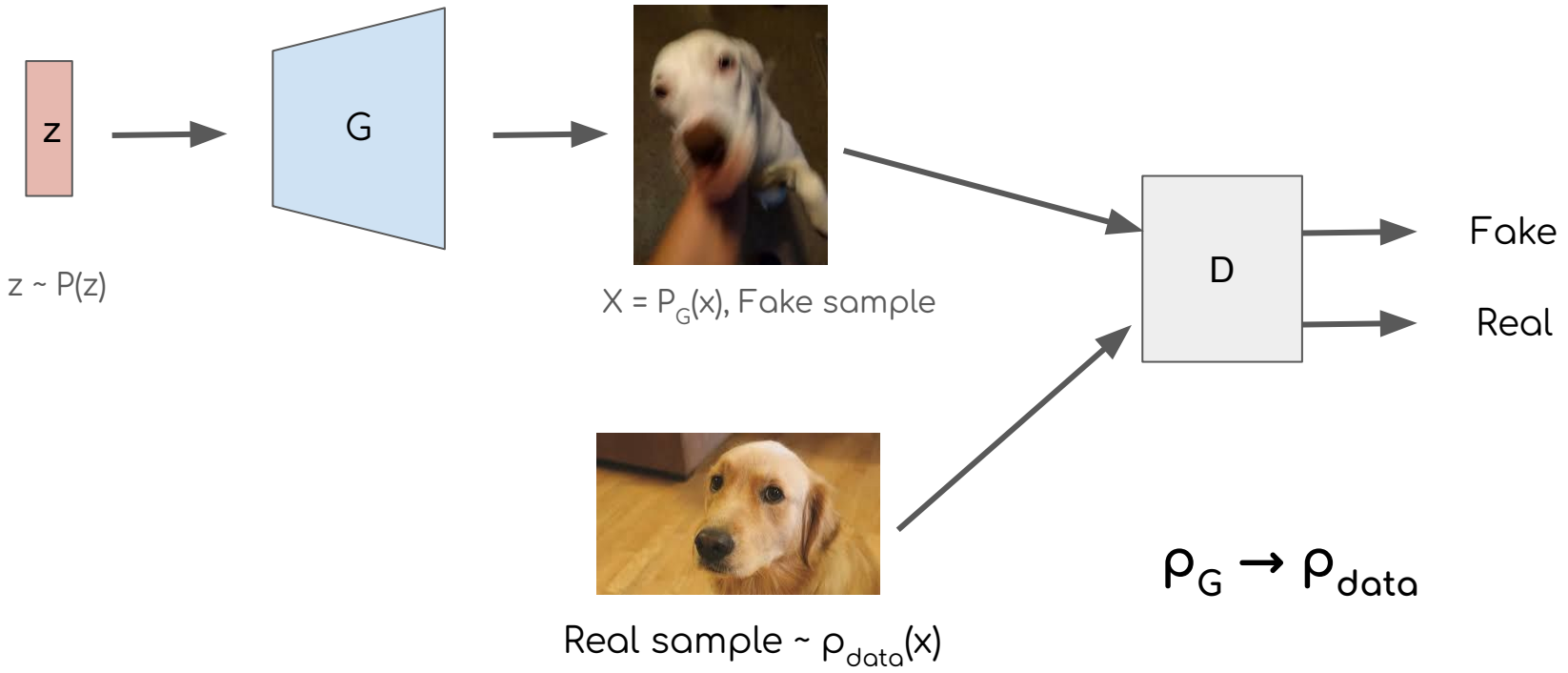
GAN

$X = P_G(x)$

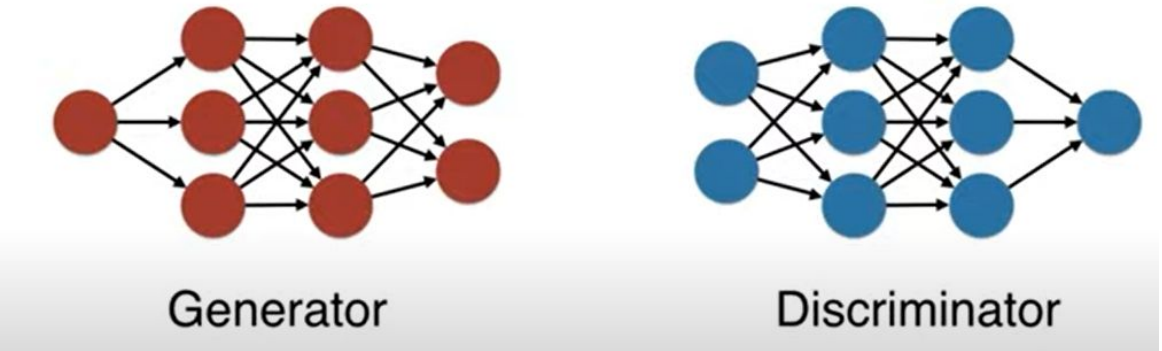


$p_{data} = p_G$

GANs (Generator + Discriminator)



Generative Adversarial Network



How Does a GAN work?

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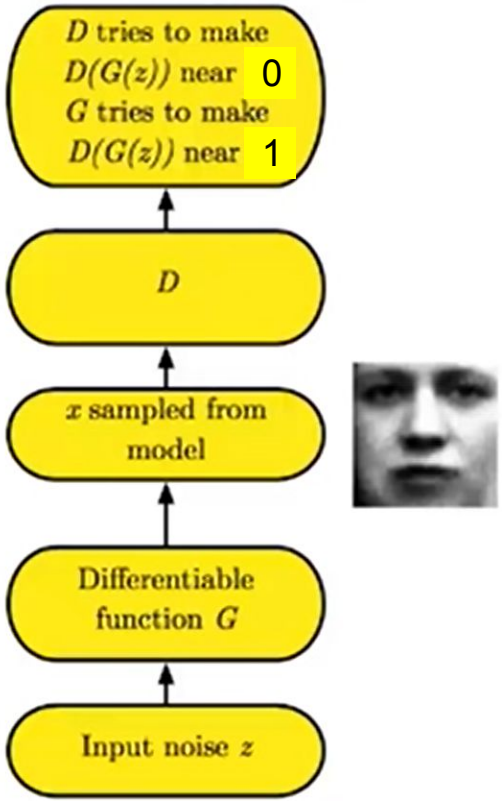
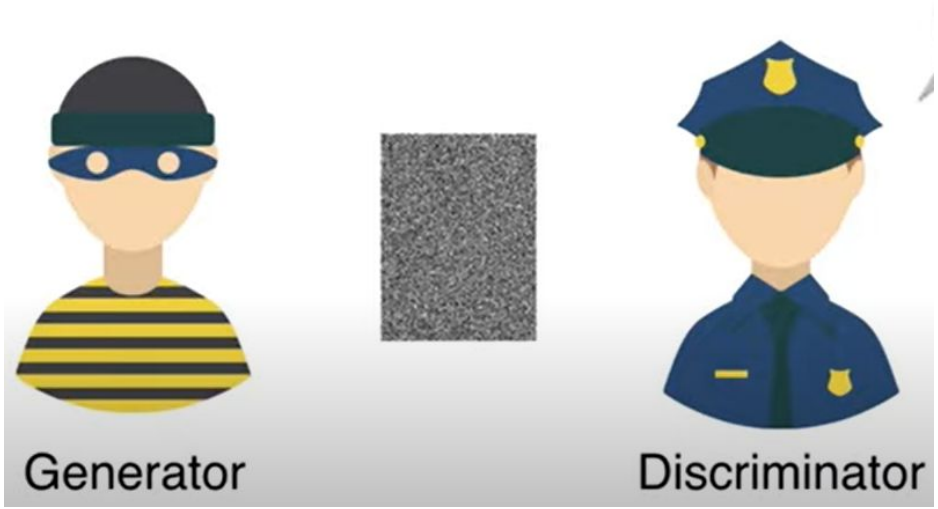


Role of the discriminator

- To inspect a sample (real or fake)
- Can be discarded after the training is over
    - Some applications exist

Generative Adversarial Network

Generative Adversarial Network



Generative Adversarial Network

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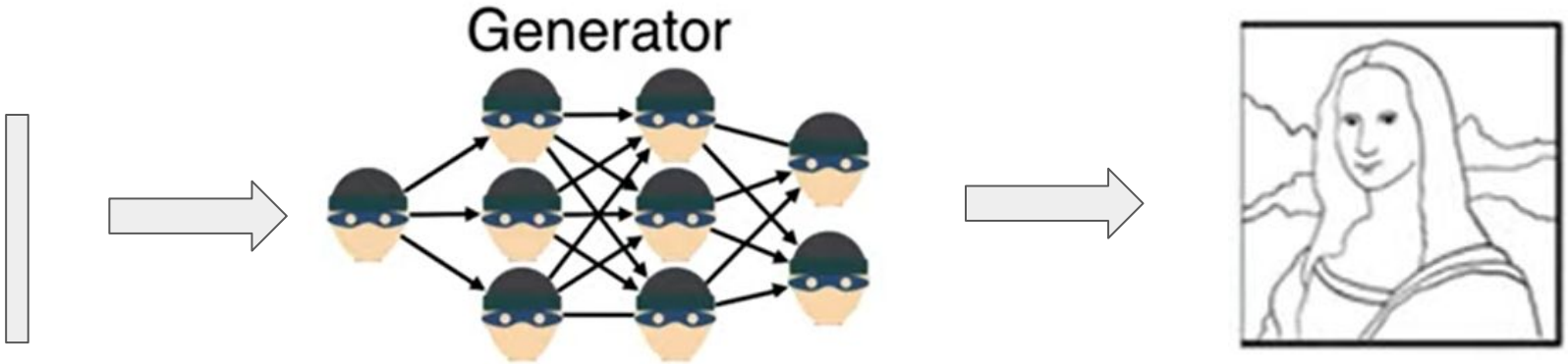
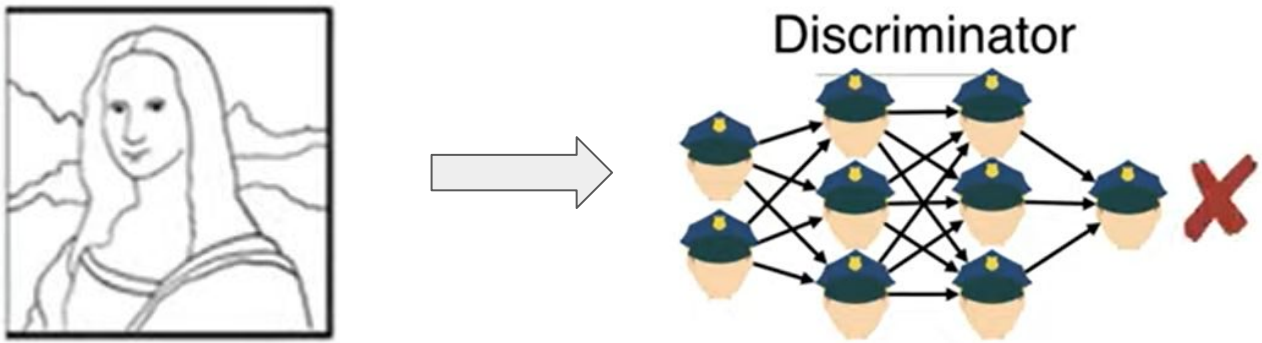
Generator

- Takes a random (noise) sample
- Generates a sample of data

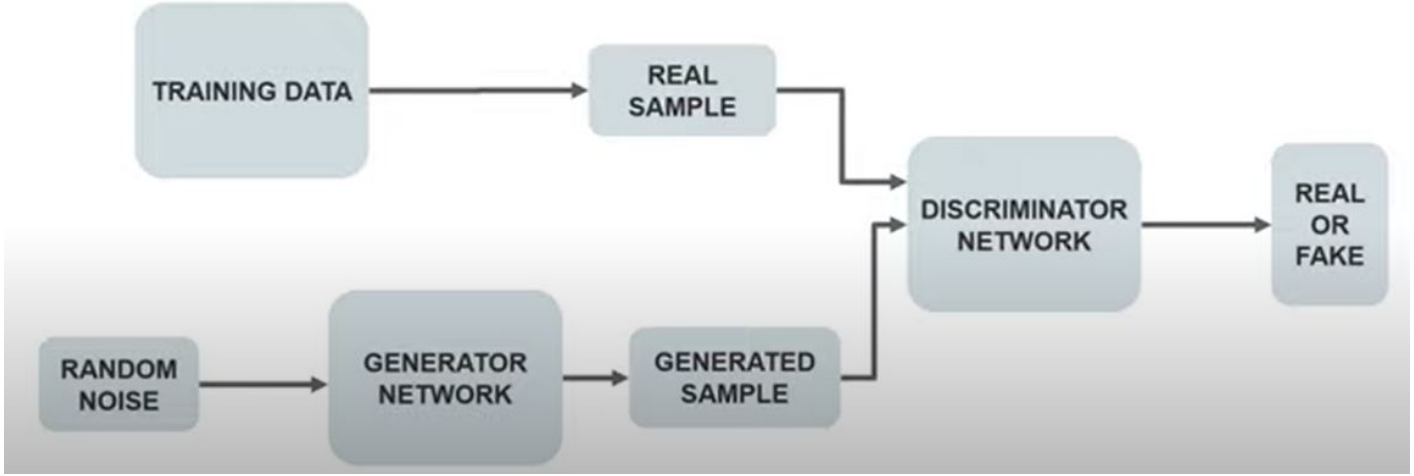


Discriminator

- Decides if the data is generated (fake) or real?
- Binary classification
- p(input is real) → [0, 1]

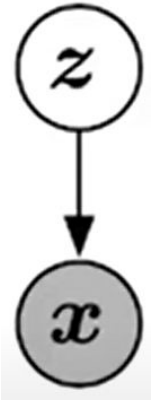


How does GAN work?



Generator Network

- Differentiable
- Typically realized with a neural network
- z: latent vector



$$\boldsymbol{x} = G(\boldsymbol{z}; \boldsymbol{\theta}^{(G)})$$

Training

- SGD on two mini-batches
  - One with training examples
  - Another with generated examples
- Two player game
  - Run k steps of one player for every step of other

Training objective (MiniMax Game)

$$J^{(D)} = -\frac{1}{2}\mathbb{E}_{\boldsymbol{x}\sim p_{\text{data}}} \log D(\boldsymbol{x}) - \frac{1}{2}\mathbb{E}_{\boldsymbol{z}} \log\left(1 - D\left(G(\boldsymbol{z})\right)\right)$$

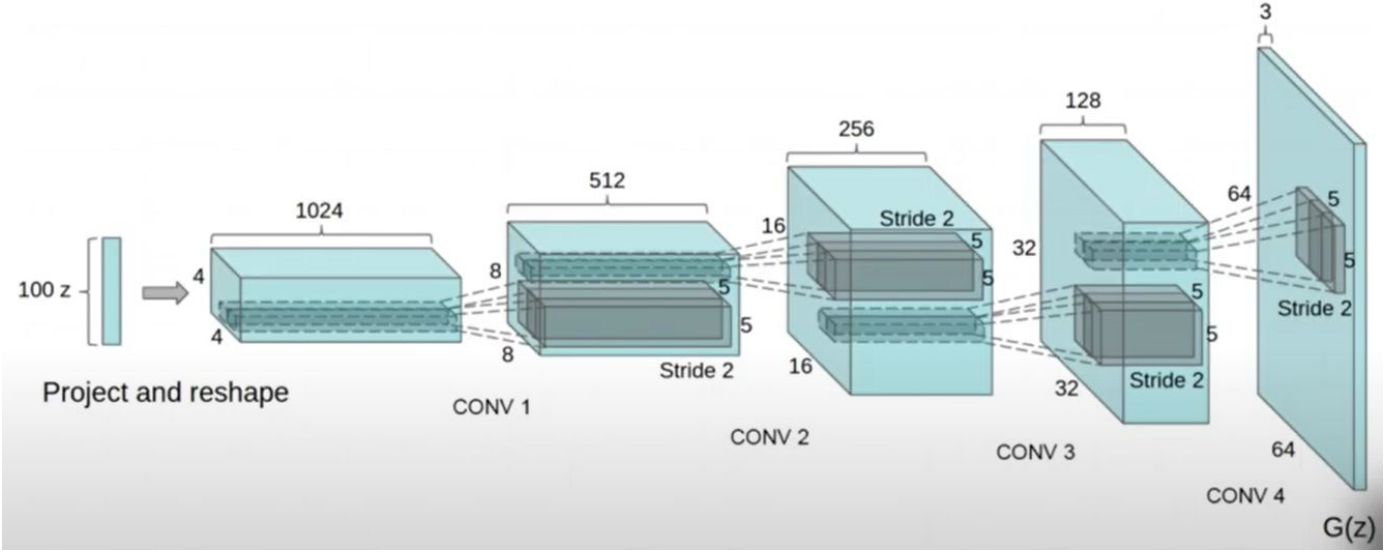
$$J^{(G)} = -J^{(D)}$$

- We are looking for an equilibrium

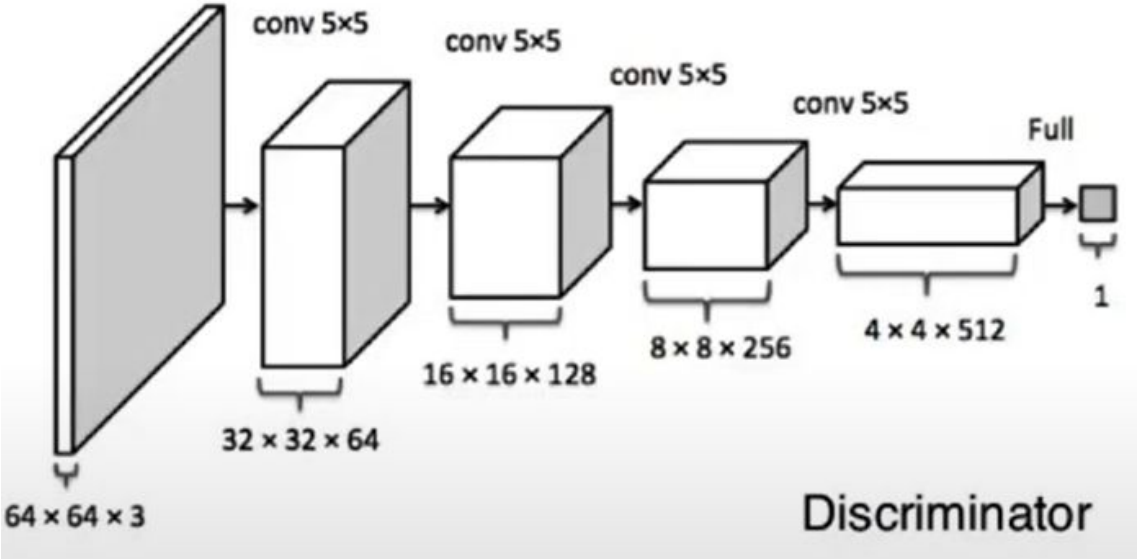
https://developers.google.com/machine-learning/gan/loss

https://youtu.be/5WoItGTWV54?t=3255

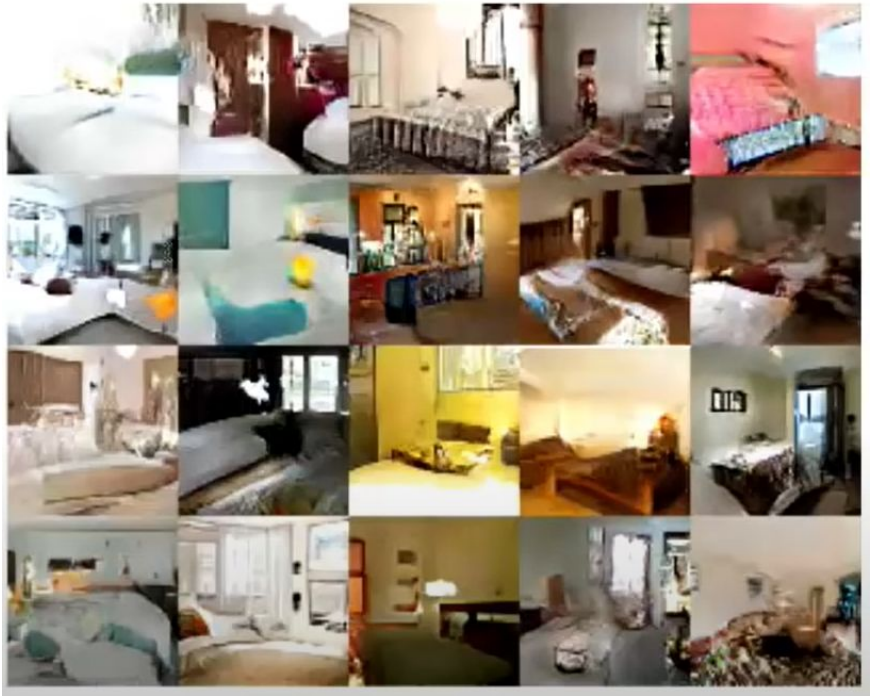
DCGAN Generator



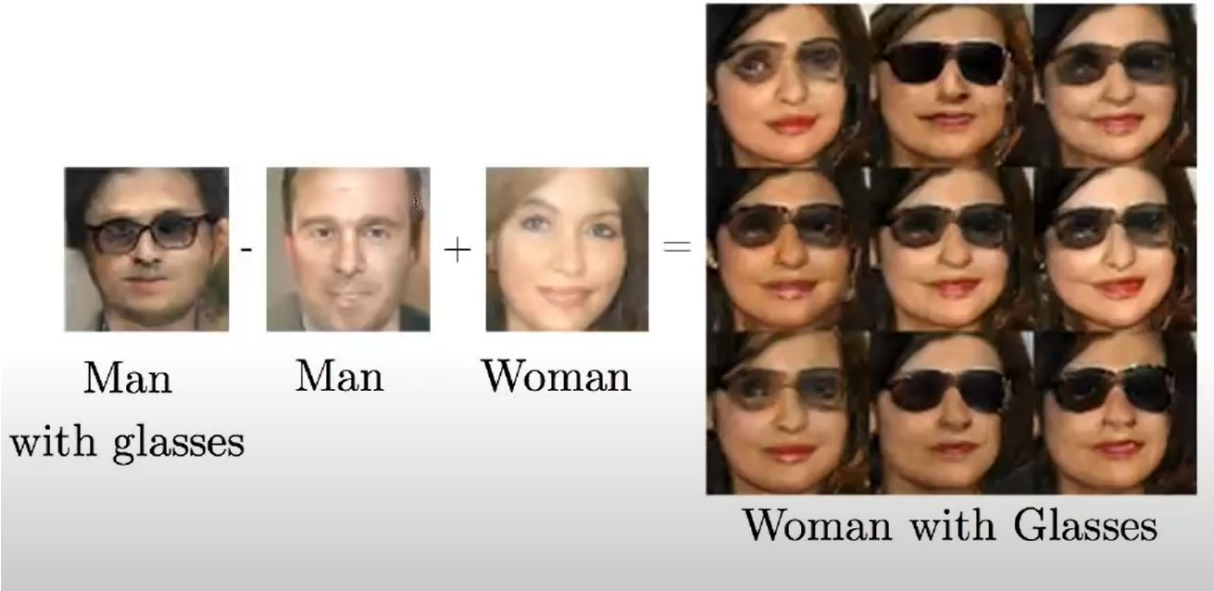
DCGAN Discriminator



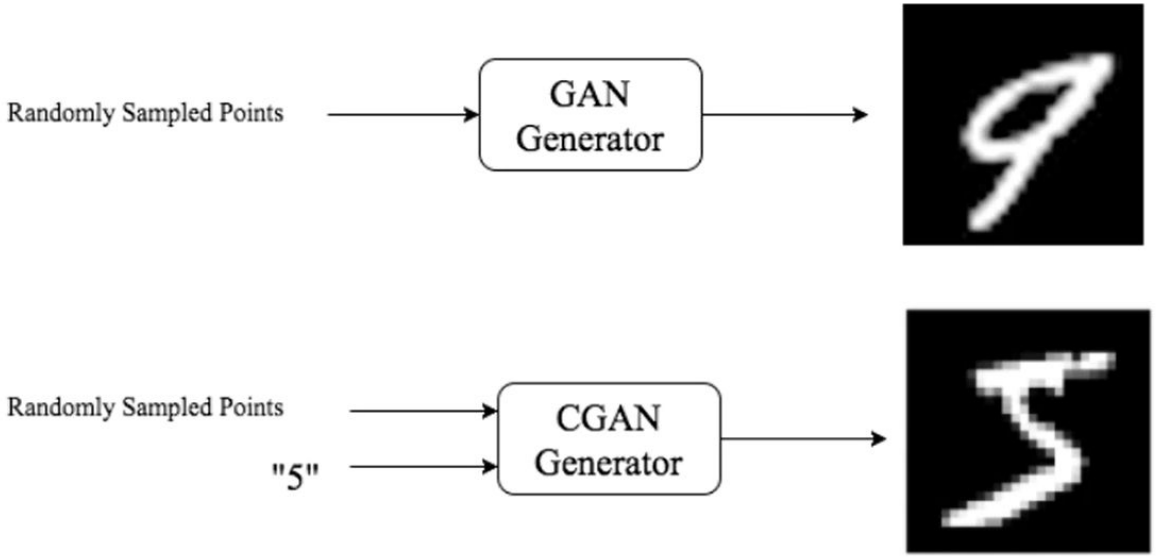
DCGAN for LSUN Bedroom dataset



Vector Space Arithmetic



Conditional GAN



GANs learn to Compose Music

GANs Create Fake Videos

Generate Realistic Photographs

Image-to-Image Translation

Photos to Emojis

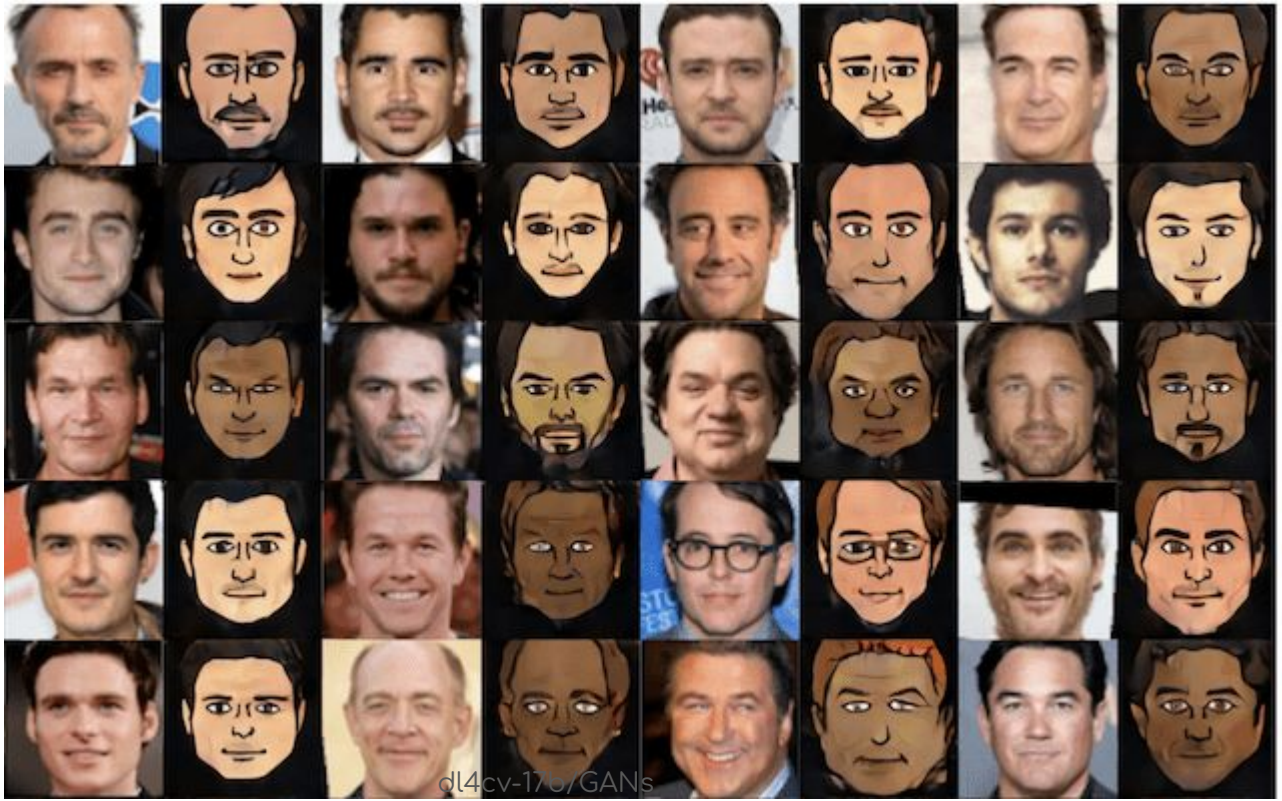
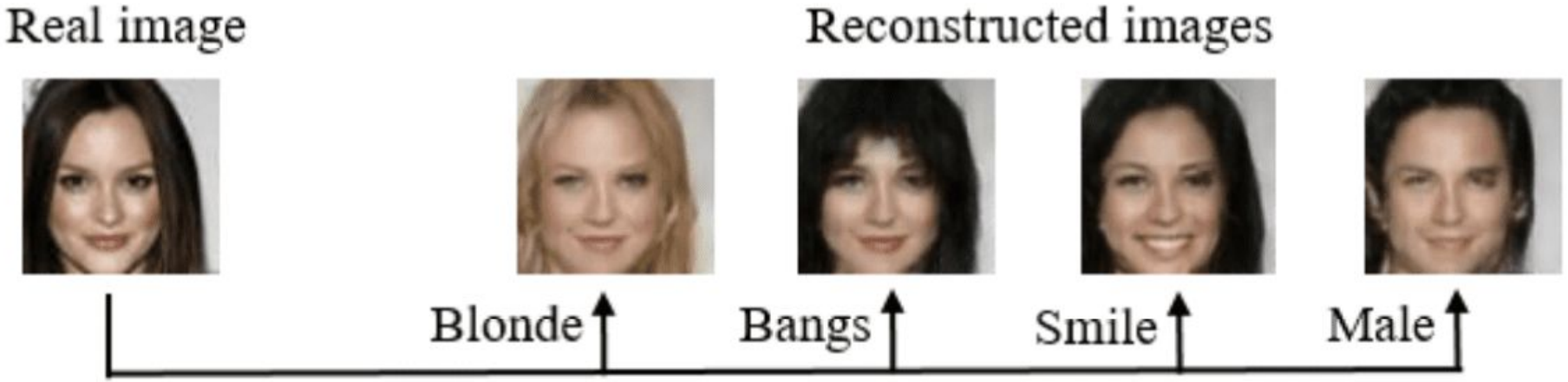
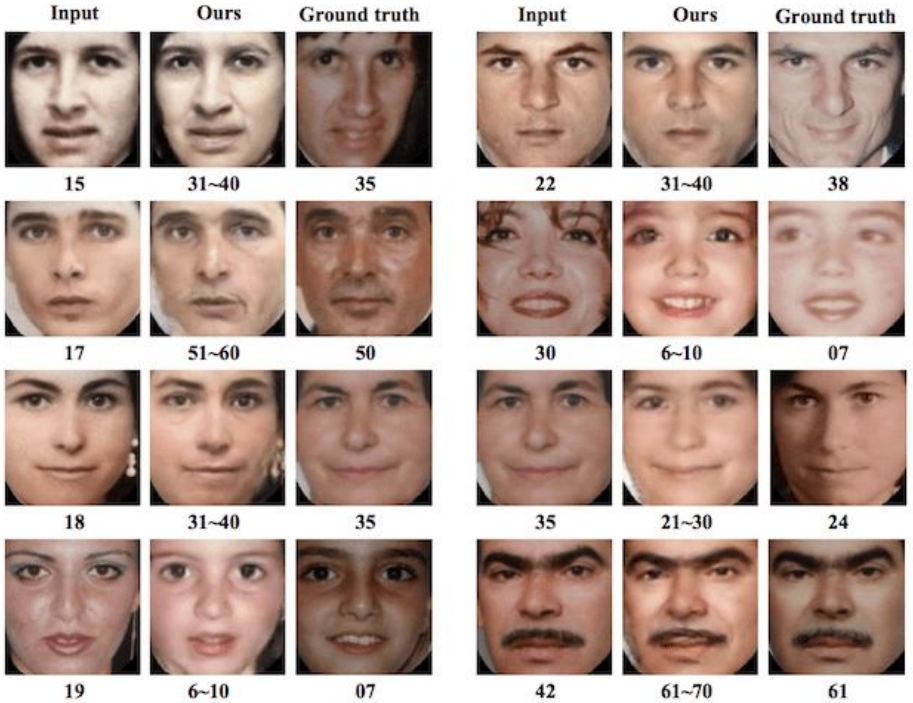


Photo Editing

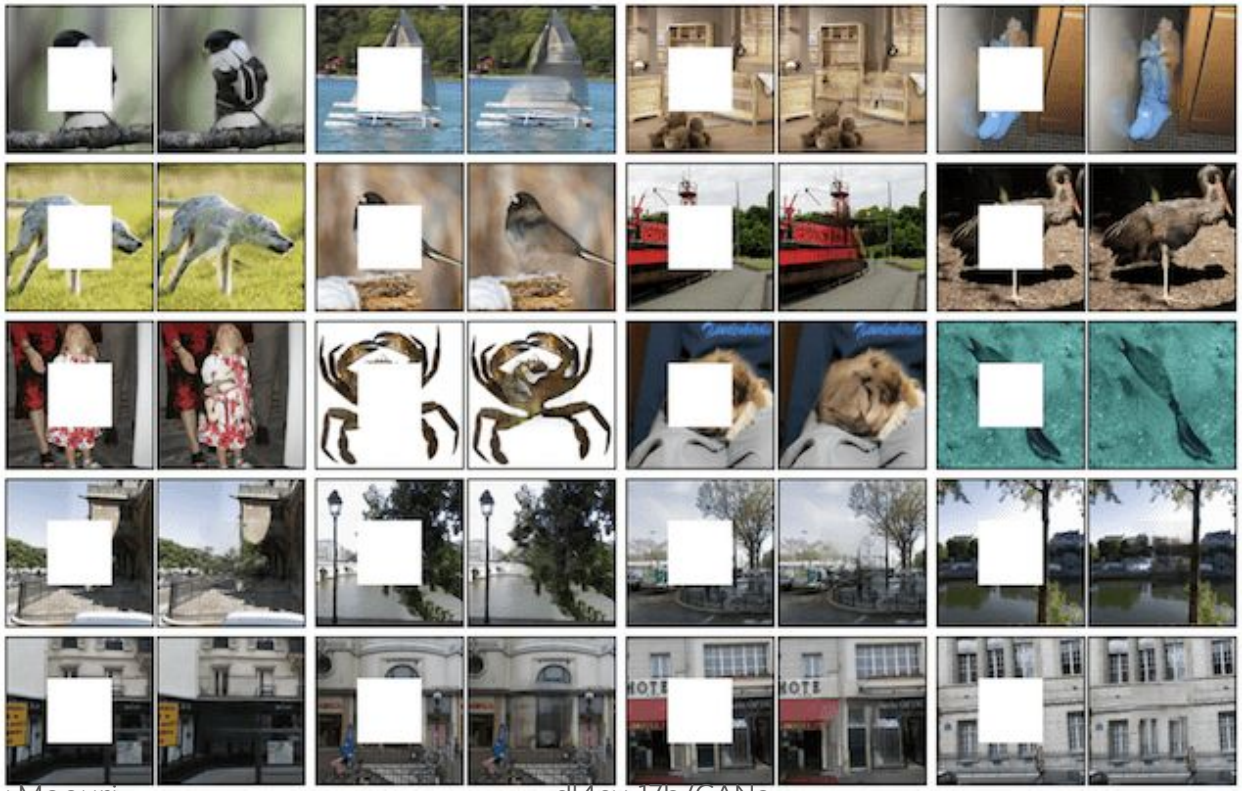


Face Aging


Input
Ours
Ground truth
Input
Ours
Ground truth
15
31~40
35
22
31~40
38
17
51~60
50
30
6~10
07
18
31~40
35
35
21~30
24
19
6~10
07
42
61~70
61

Super Resolution

Inpainting



Sample code

Thank You