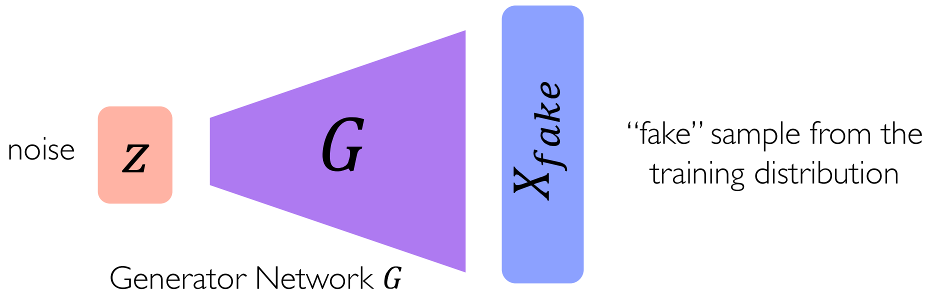
Generative Adversarial Networks (GANs)

What if we just want to sample?

Idea: don't explicitly model density, and instead just sample to generate new instances.

Problem: want to sample from complex distribution – can't do this directly!

Solution: sample from something simple (noise), learn a transformation to the training distribution.

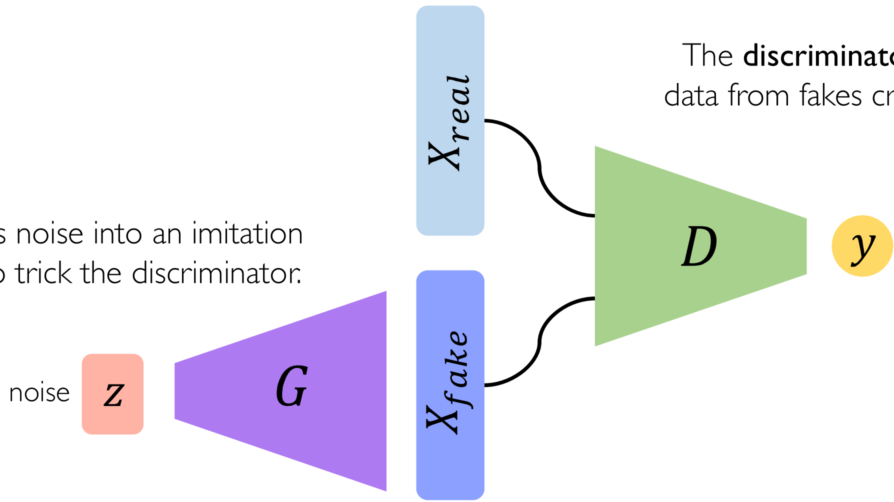


Generative Adversarial Networks (GANs)

Generative Adversarial Networks (GANs) are a way to make a generative model by having two neural networks compete with each other.

The **discriminator** tries to identify real data from fakes created by the generator.

The **generator** turns noise into an imitation of the data to try to trick the discriminator.



Intuition behind GANs

Generator starts from noise to try to create an imitation of the data.

Generator

Fake data

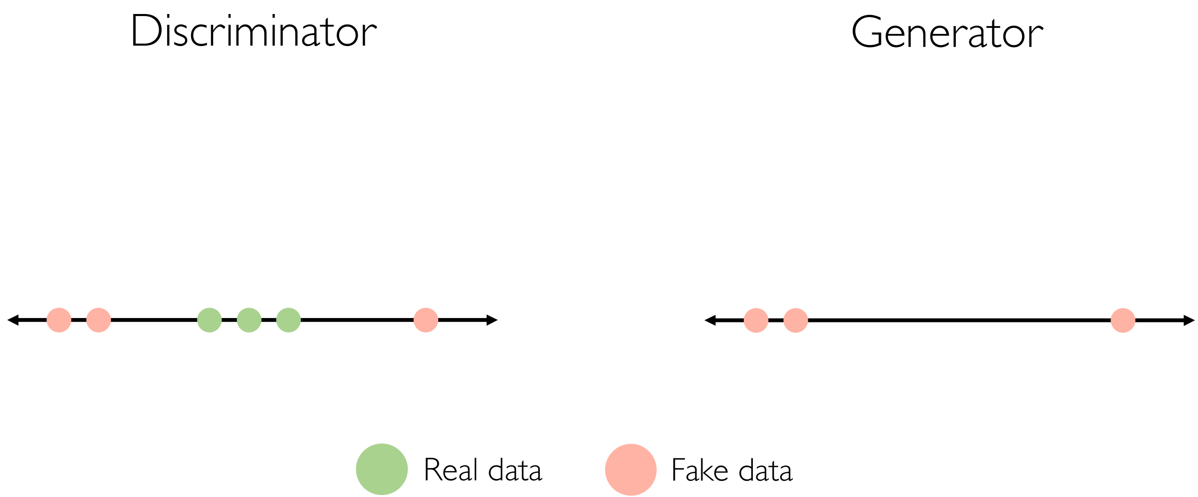
Intuition behind GANs

Discriminator looks at both real data and fake data created by the generator.

Discriminator Generator

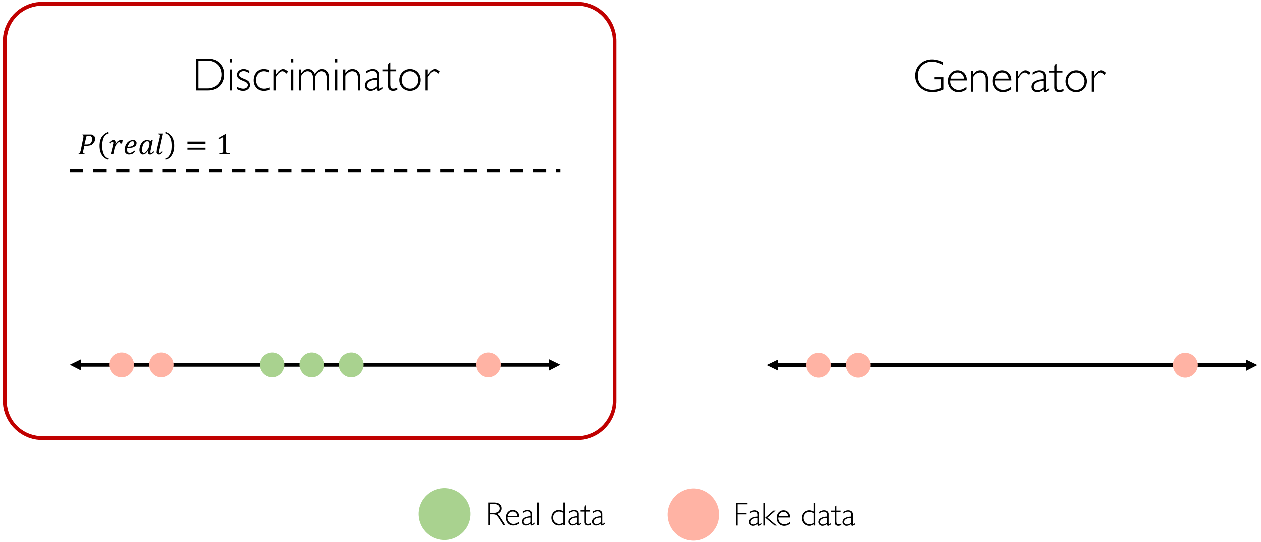
Intuition behind GANs

Discriminator looks at both real data and fake data created by the generator.



Intuition behind GANs

Discriminator tries to predict what's real and what's fake.



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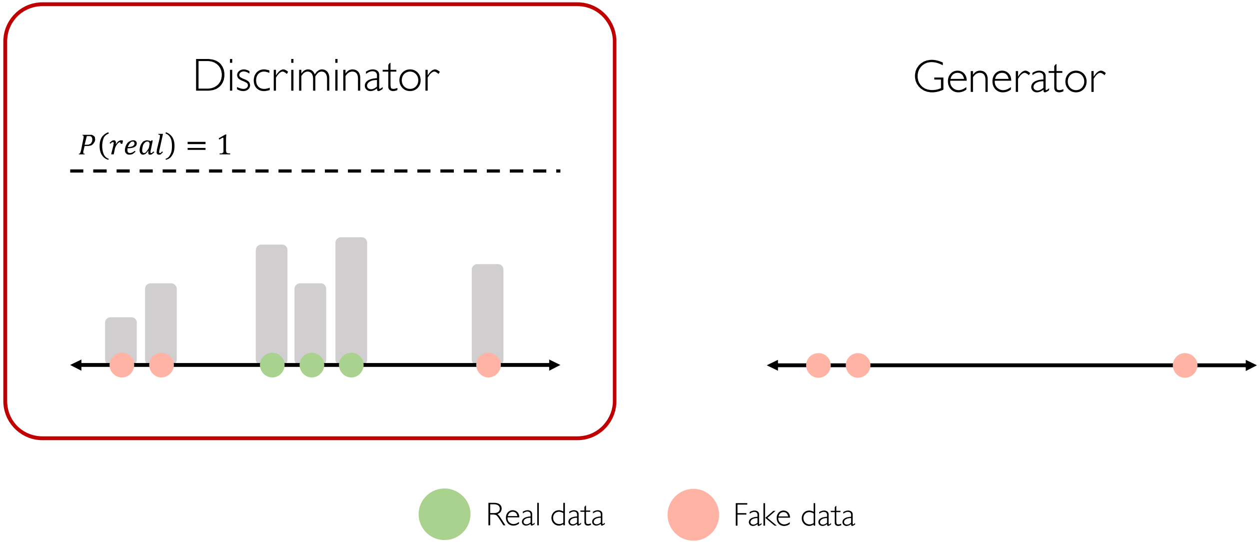

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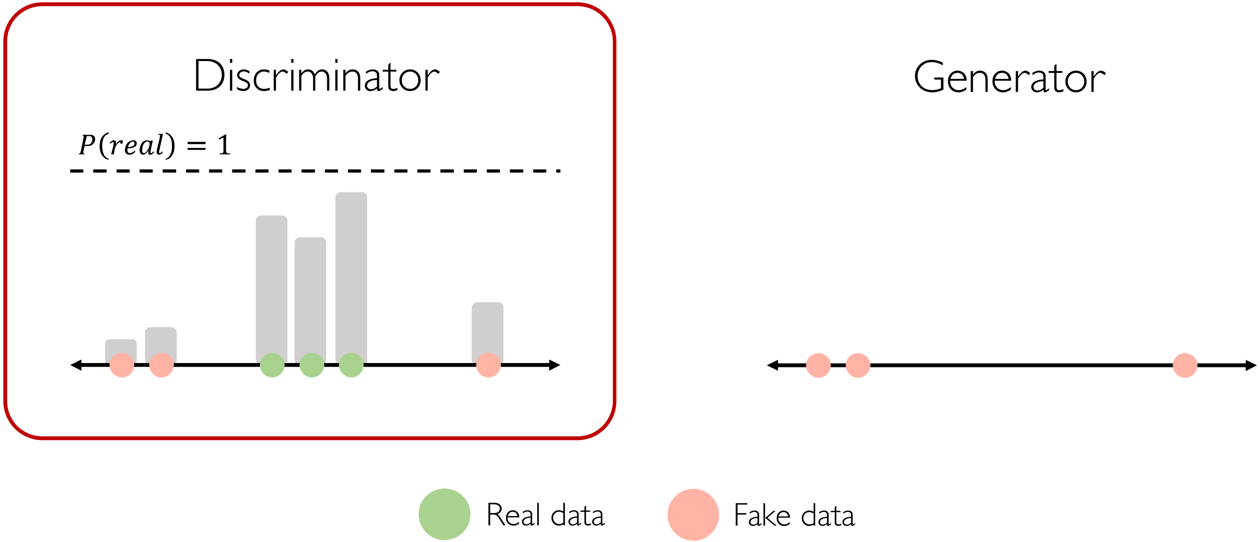

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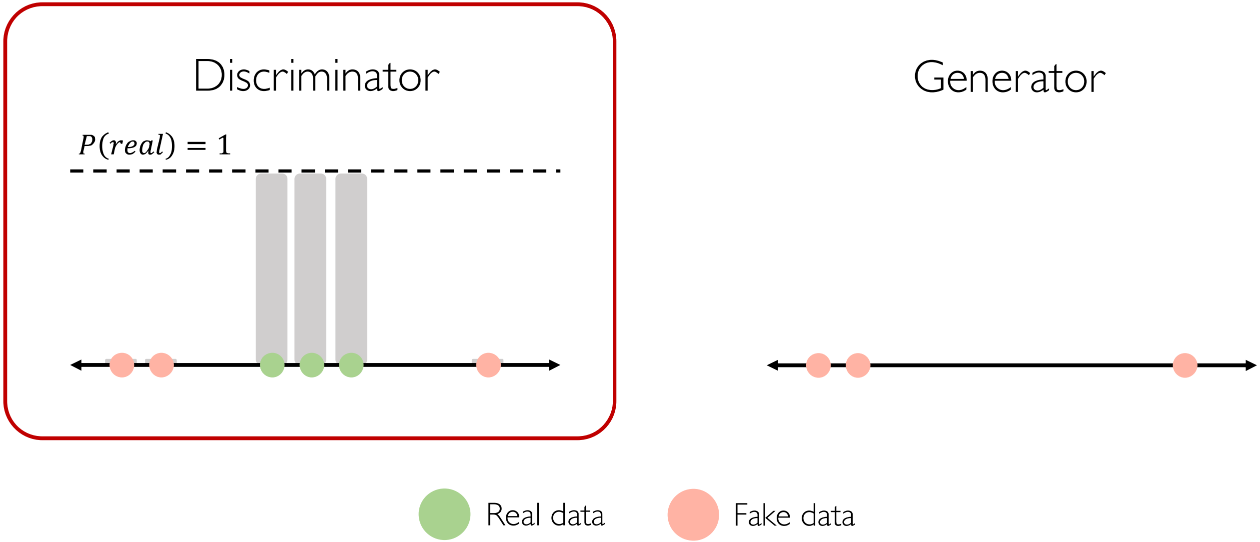
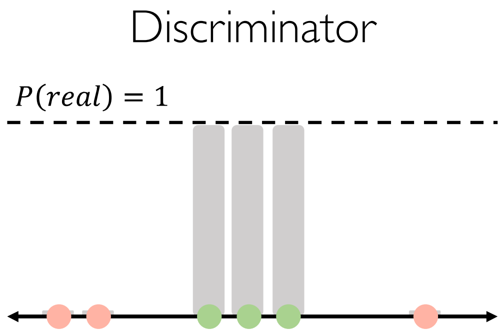
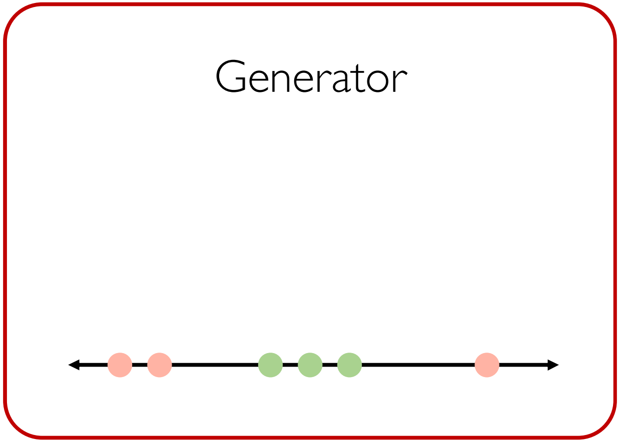


Intuition behind GANs

Generator tries to improve its imitation of the data.





Real data   Fake data

Intuition behind GANs

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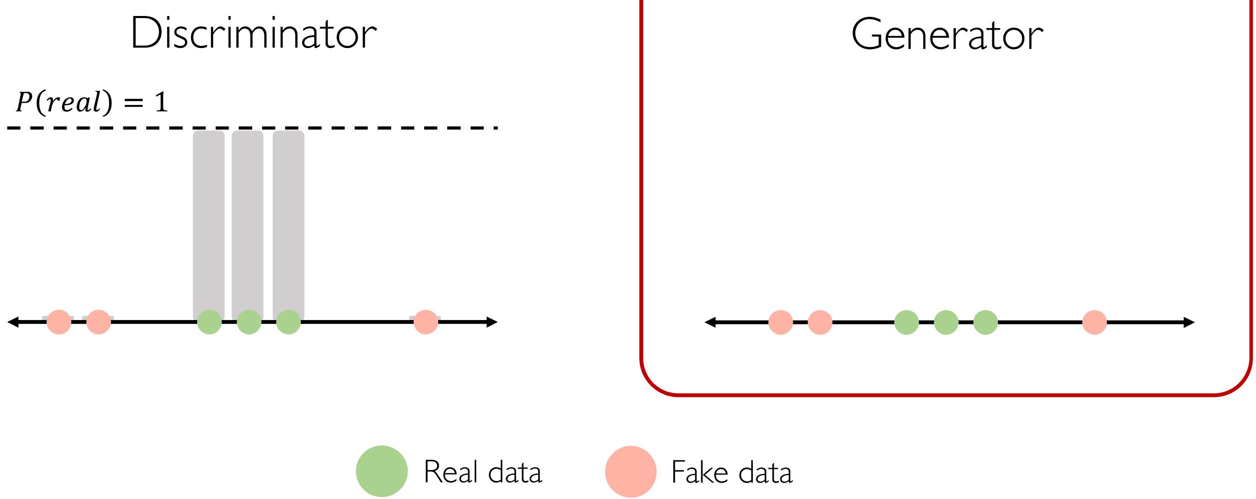

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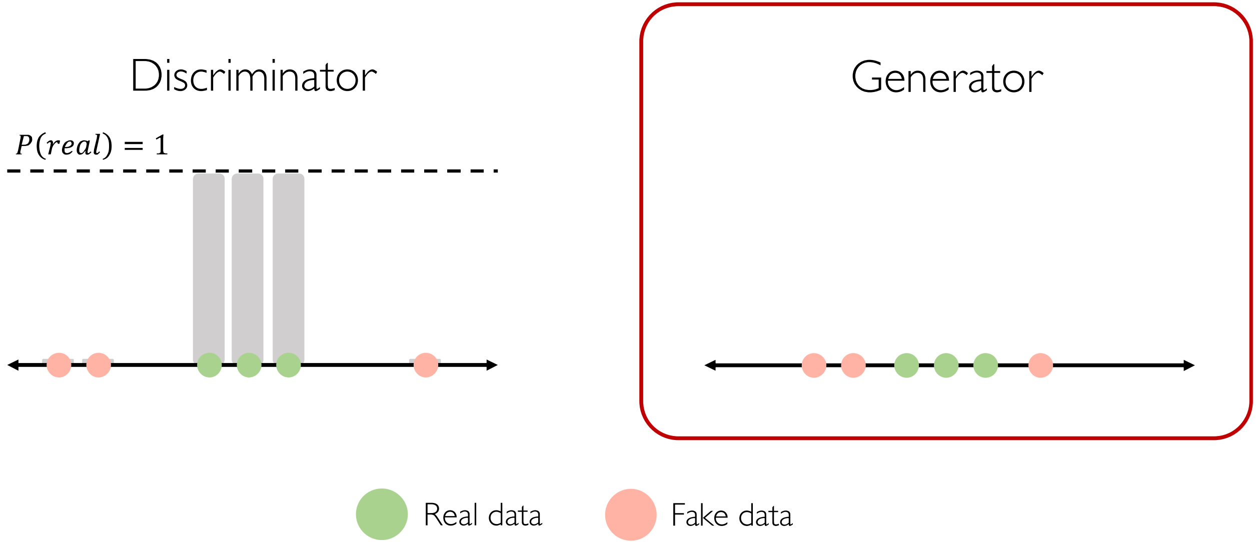

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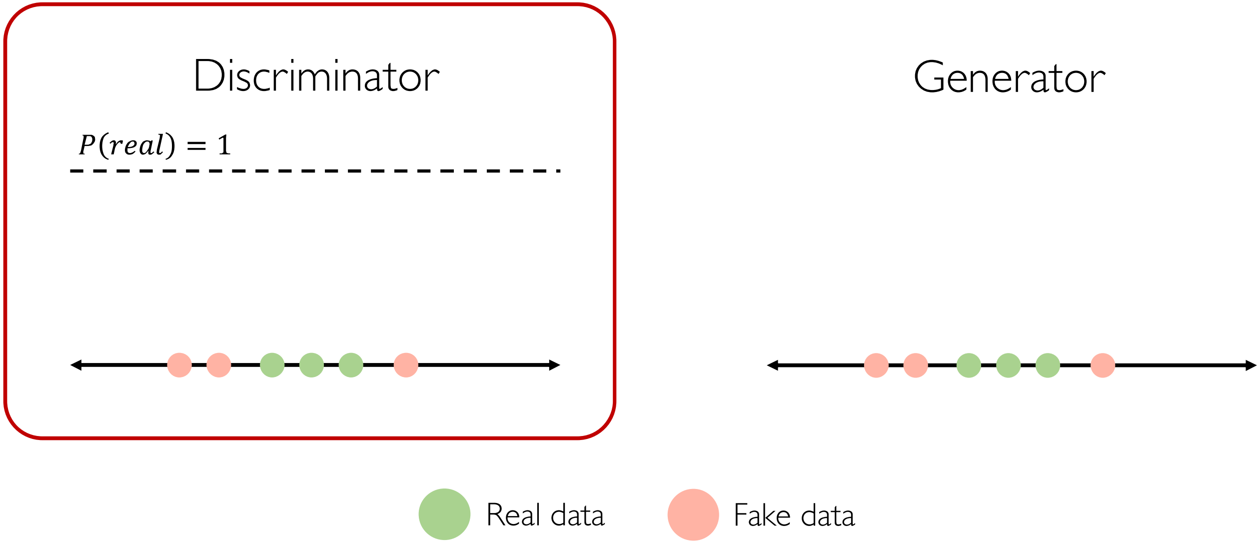

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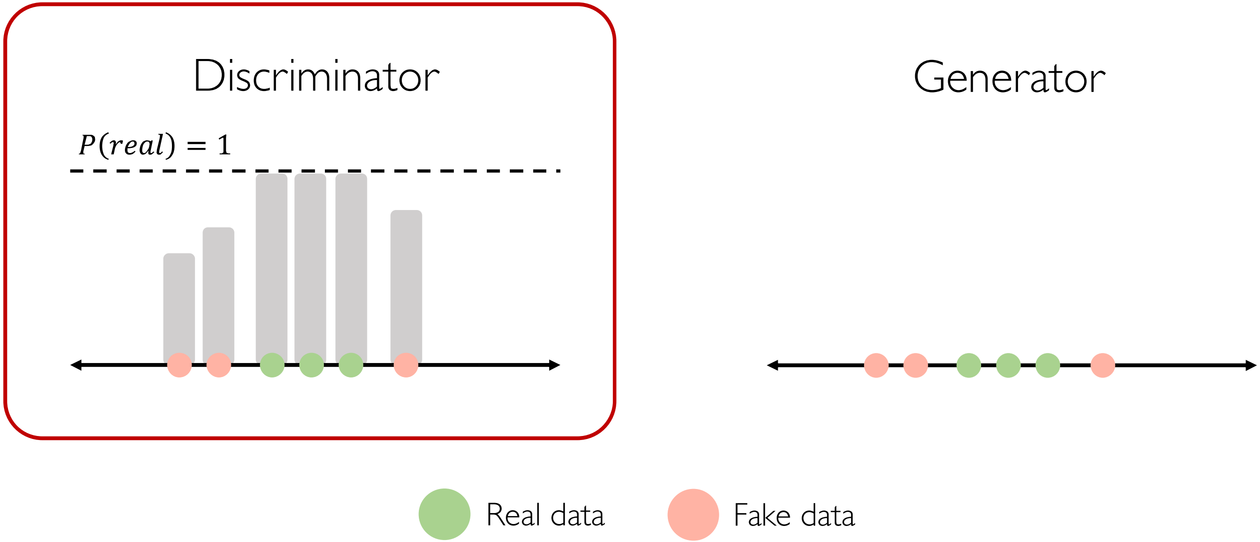

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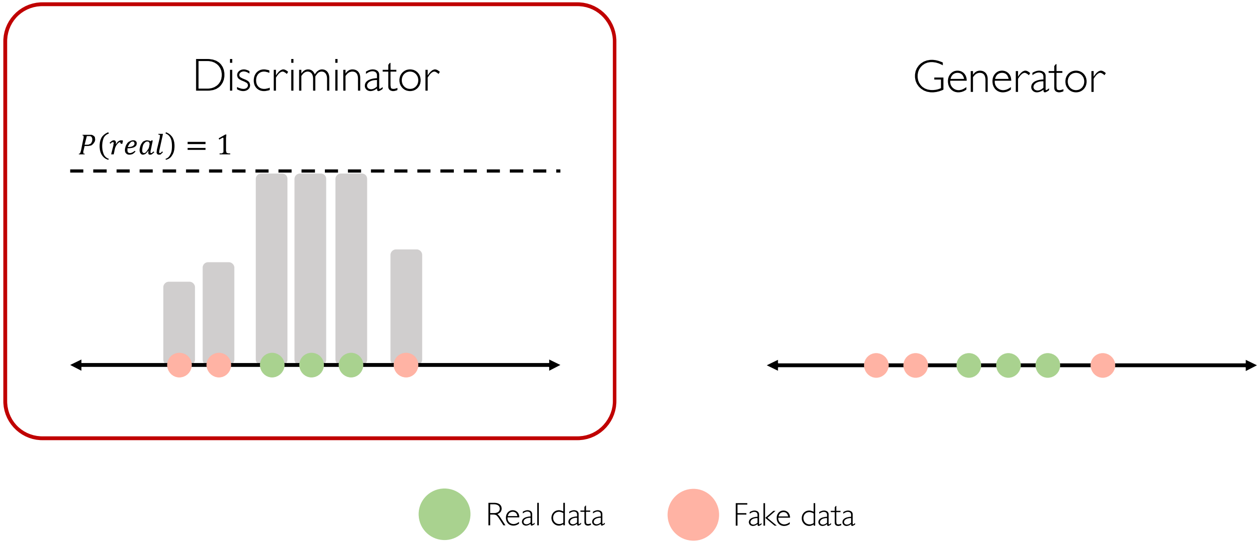

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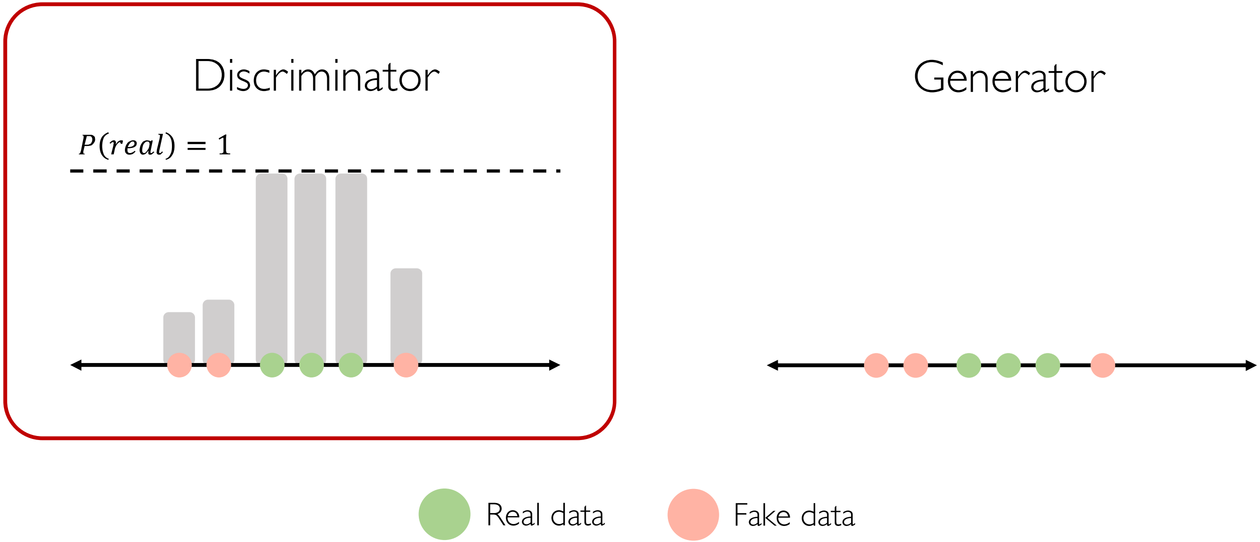

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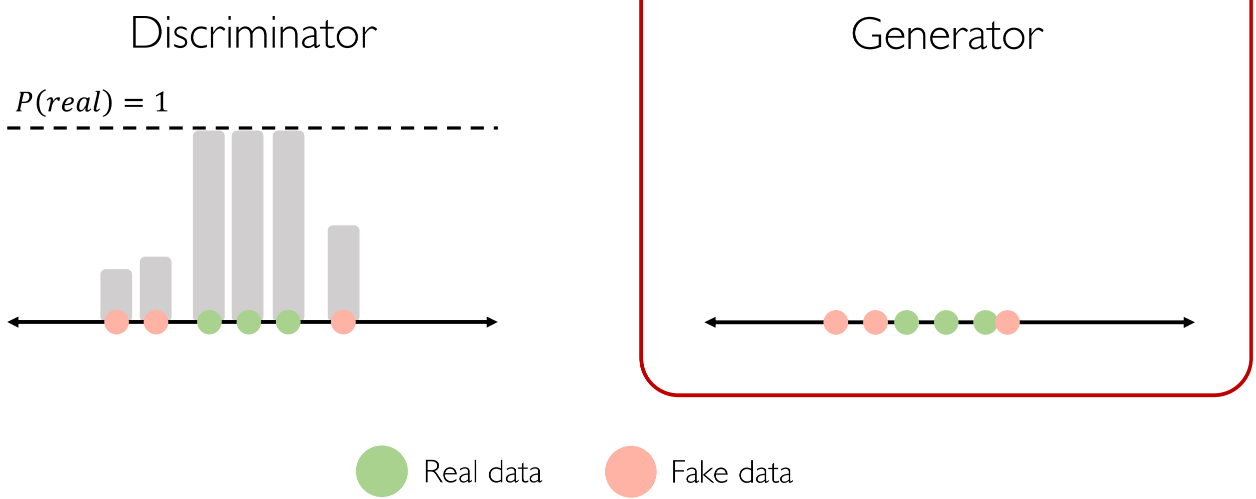

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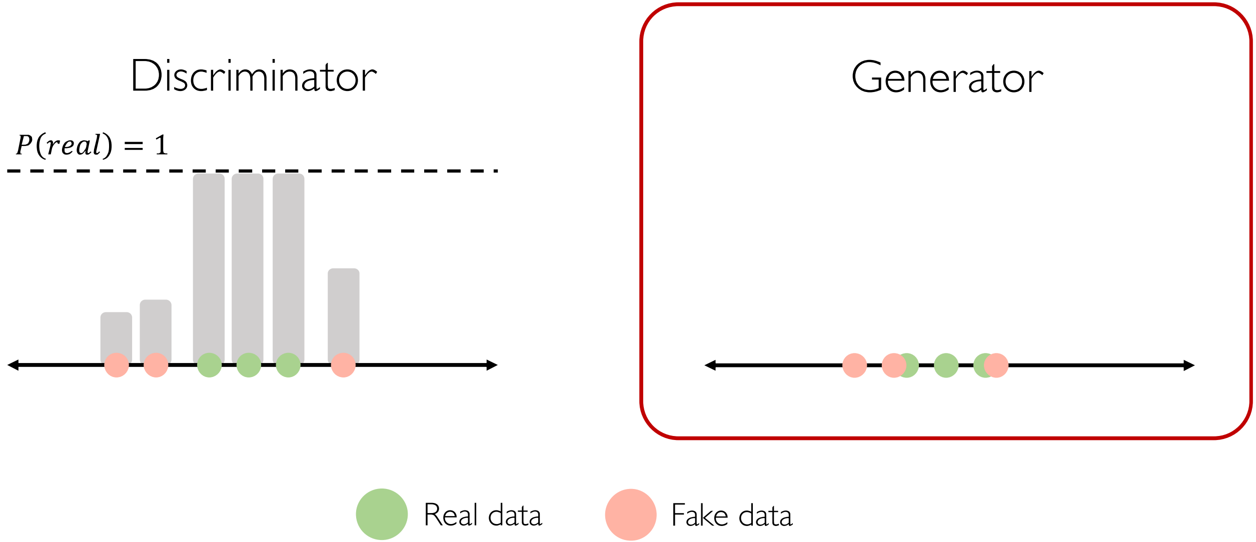

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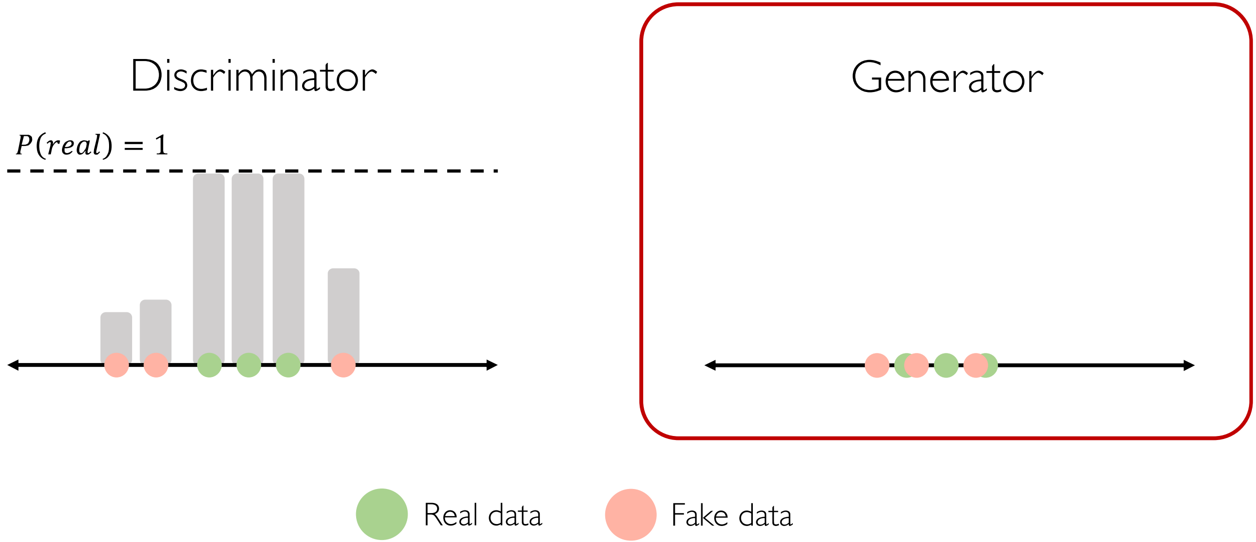
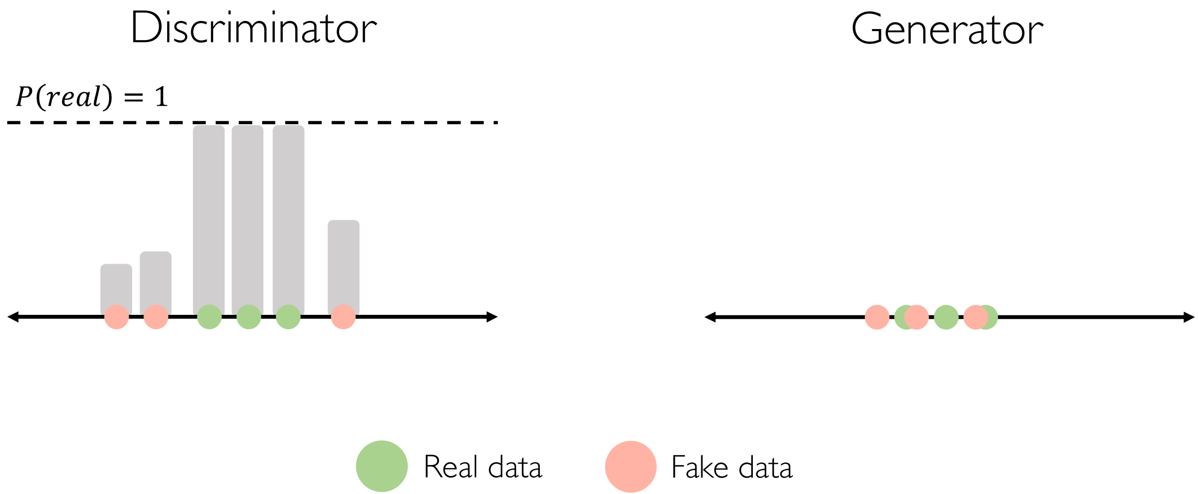


Intuition behind GANs

Discriminator tries to identify real data from fakes created by the generator.
Generator tries to create imitations of data to trick the discriminator.



Training GANs

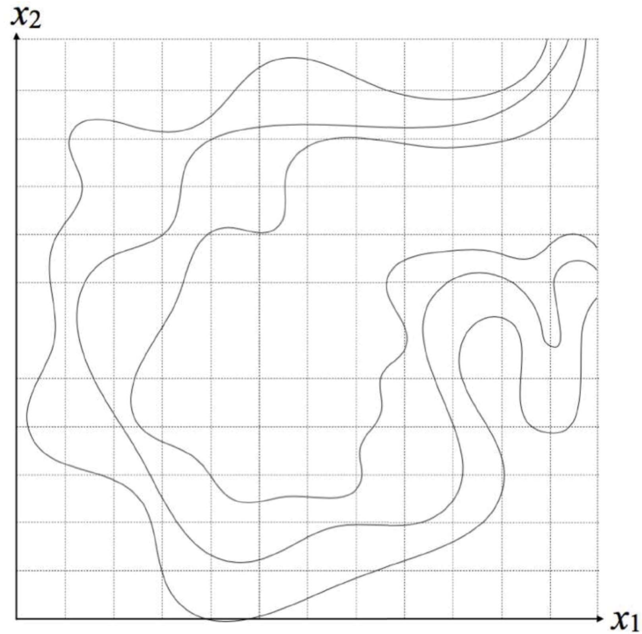
Discriminator tries to identify real data from fakes created by the generator.
Generator tries to create imitations of data to trick the discriminator.

Train GAN jointly via **minimax** game:

$$\min_{\theta_g} \max_{\theta_d} \left[\mathbb{E}_{x \sim p_{data}} \log D_{\theta_d}(x) + \mathbb{E}_{z \sim p(z)} \log\left(1 - D_{\theta_d}\left(G_{\theta_g}(z)\right)\right) \right]$$

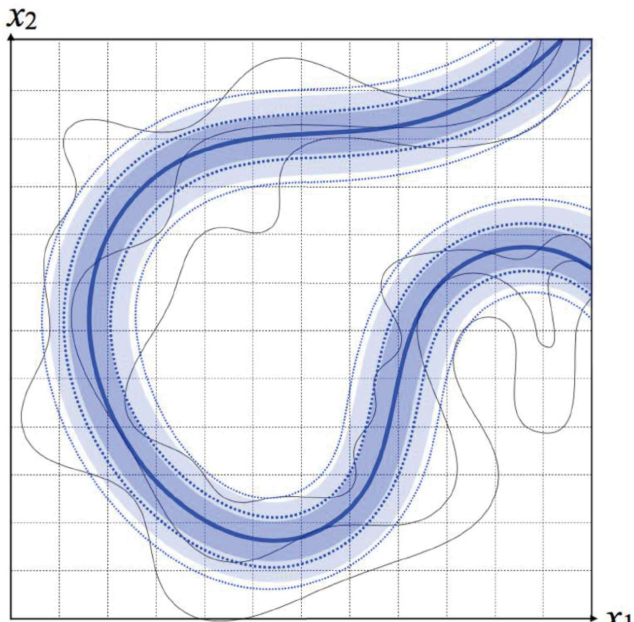
Discriminator wants to maximize objective s.t. $D(x)$ close to 1, $D(G(z))$ close to 0.
Generator wants to minimize objective s.t. $D(G(z))$ close to 1.

Why GANs?

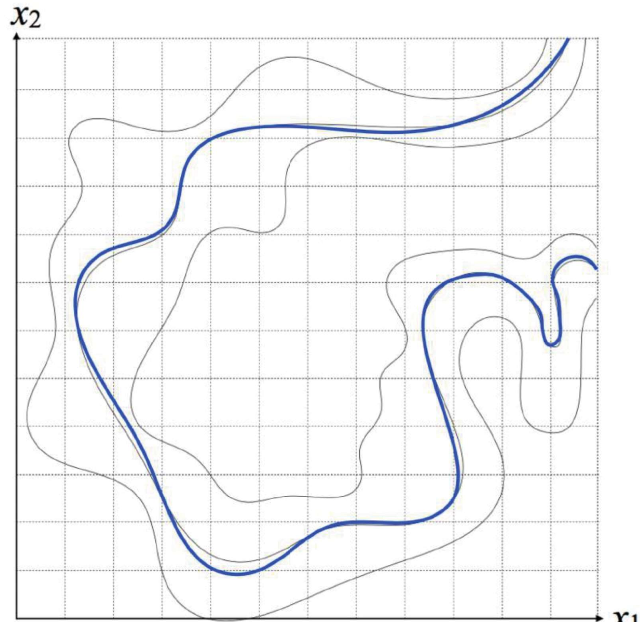


A. Courville, 6S191 2018.

Why GANs?



more traditional max-likelihood approach

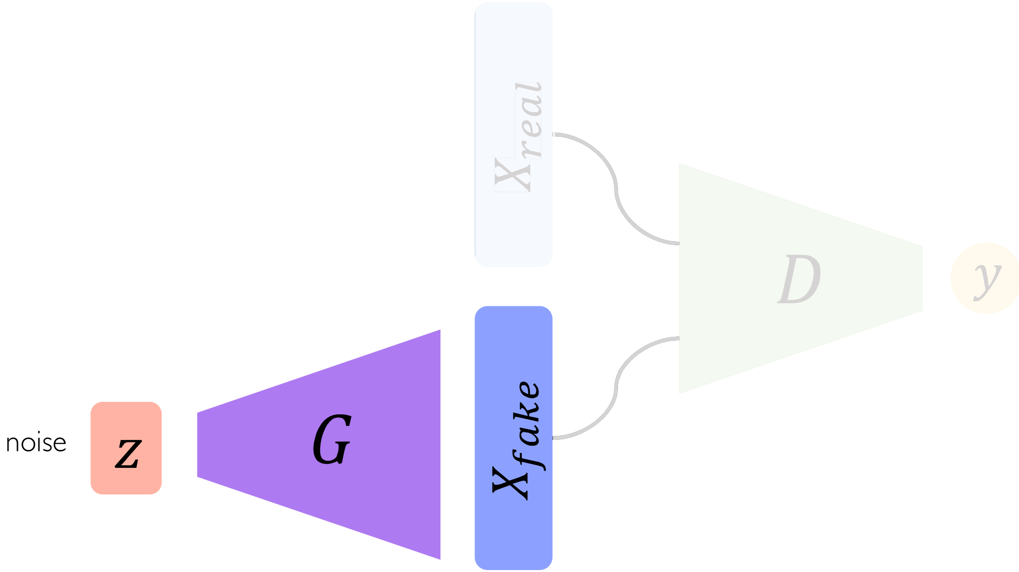


GAN

A. Courville, 6S191 2018.

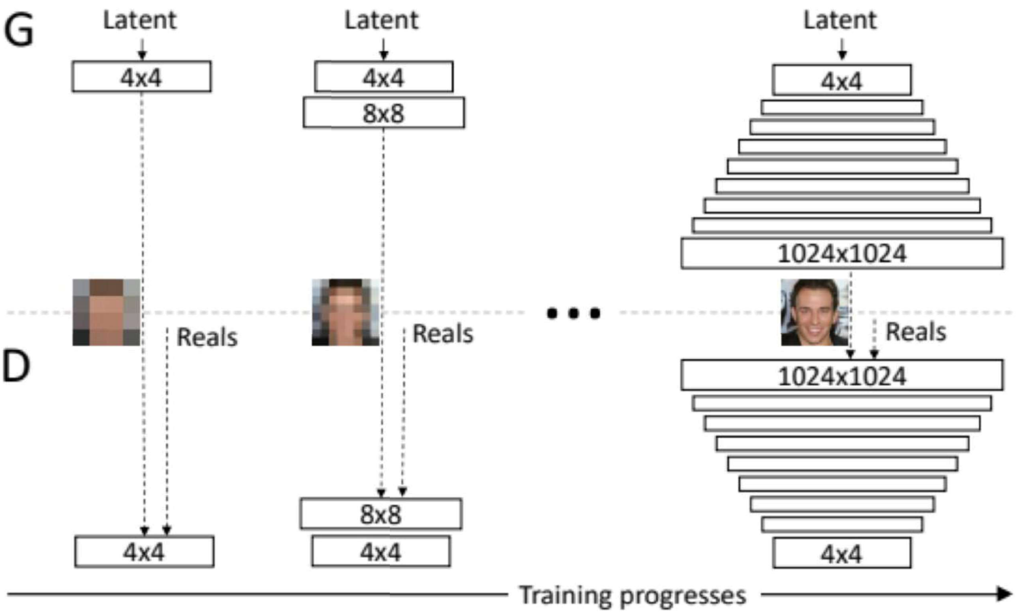
Generating new data with GANs

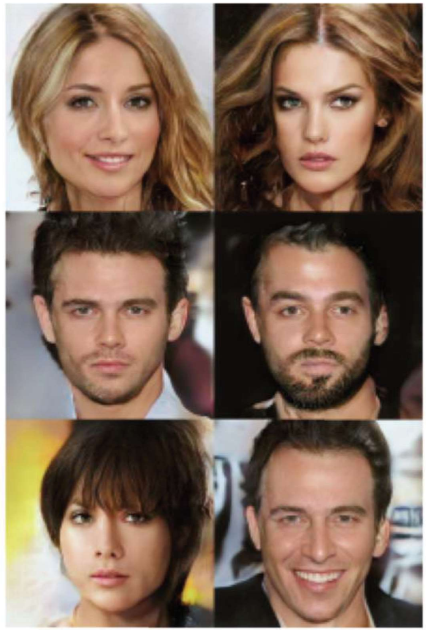
After training, use generator network to create **new data** that's never been seen before.



GANs: Recent Advances

Progressive growing of GANs (NVIDIA)





Karras et al., ICLR 2018.

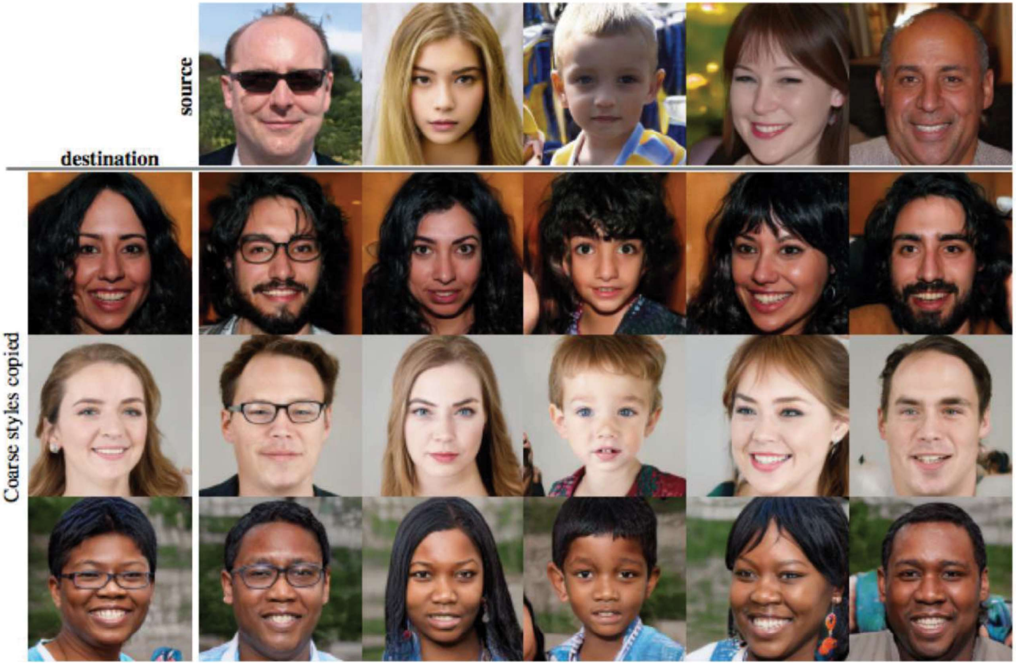
Progressive growing of GANs: results

Karras et al., ICLR 2018.

Style-based generator: results

Karras et al., Arxiv 2018.

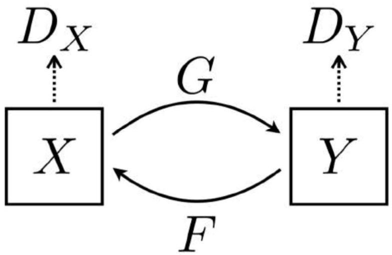
Style-based transfer: results



Karras et al., Arxiv 2018.

CycleGAN: domain transformation

CycleGAN learns transformations across domains with unpaired data.

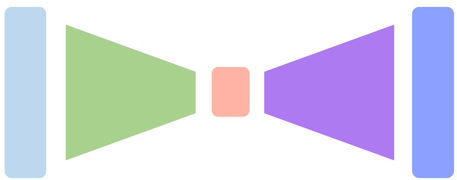


Zhu et al., ICCV 2017.

Deep Generative Modeling: Summary

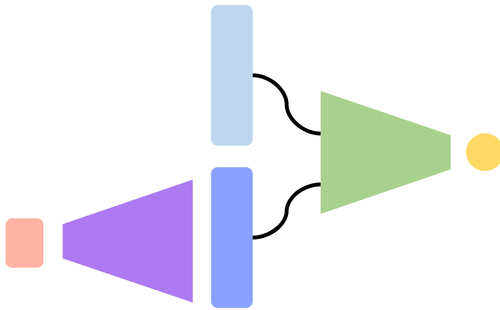
Autoencoders and Variational Autoencoders (VAEs)

Learn **lower-dimensional** latent space and **sample** to generate input reconstructions



Generative Adversarial Networks (GANs)

Competing **generator** and **discriminator** networks



References:

https://goo.gl/ZuBkGx9