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Pattern Analysis & Machine Intelligence

Praktikum: MLP-R-WS19

Week 11: Generative Adversarial Networks (GANs)



We have already seen VAEs, why should we look at GANs?



Yann LeCun
@ylecun



Apparently, GANs are used to create fake profile pictures on LinkedIn for international industrial espionage.

apnews.com/bc2f19097a4c4f...

1,172 6:29 AM - Jun 13, 2019



Experts: Spy used AI-generated face to connect with targets

LONDON (AP) — Katie Jones sure seemed plugged into Washingt...

apnews.com



We have already seen VAEs, why should we look at GANs?



All images created by BigGAN

Image taken from: https://cdn-images-1.medium.com/max/2600/1*Yw2KxjmIkj8yqS-ykLCQCQ.png

How do GANs work?

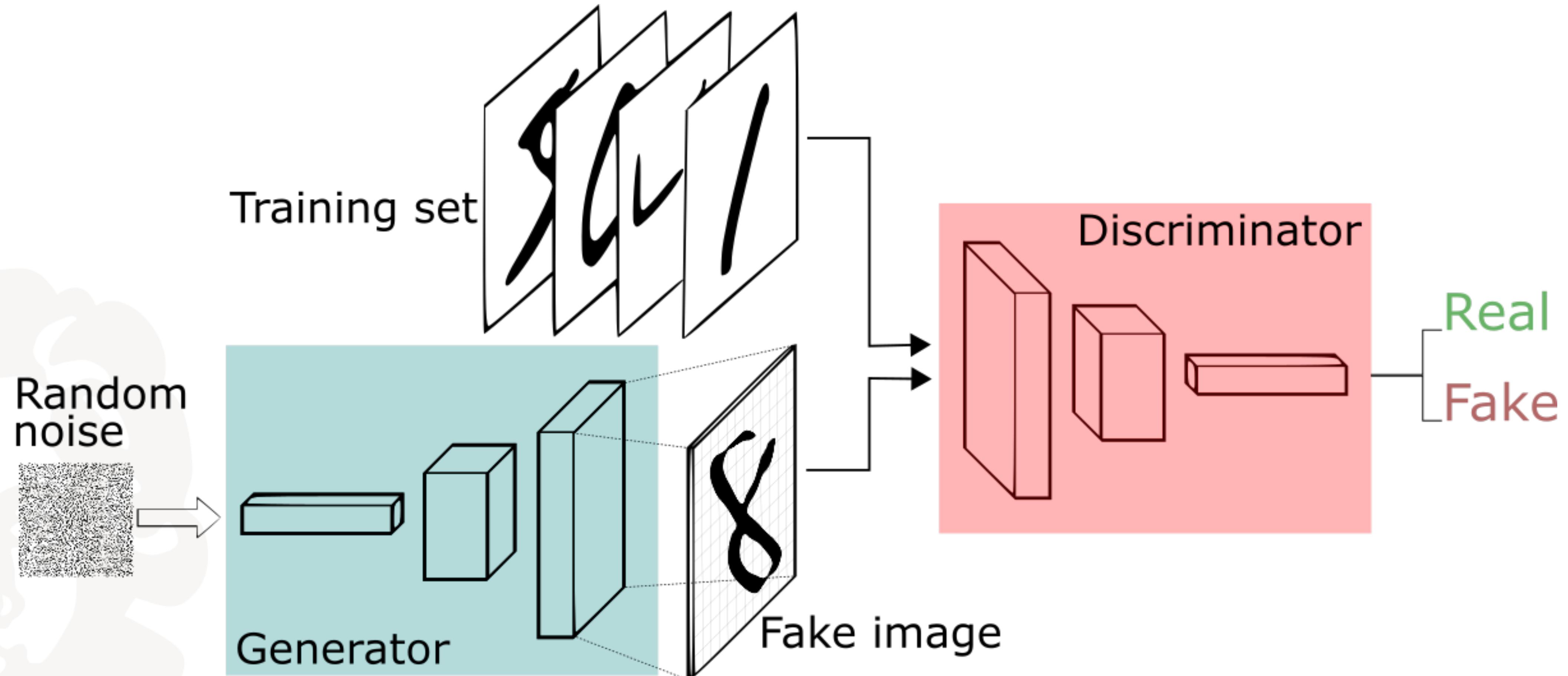


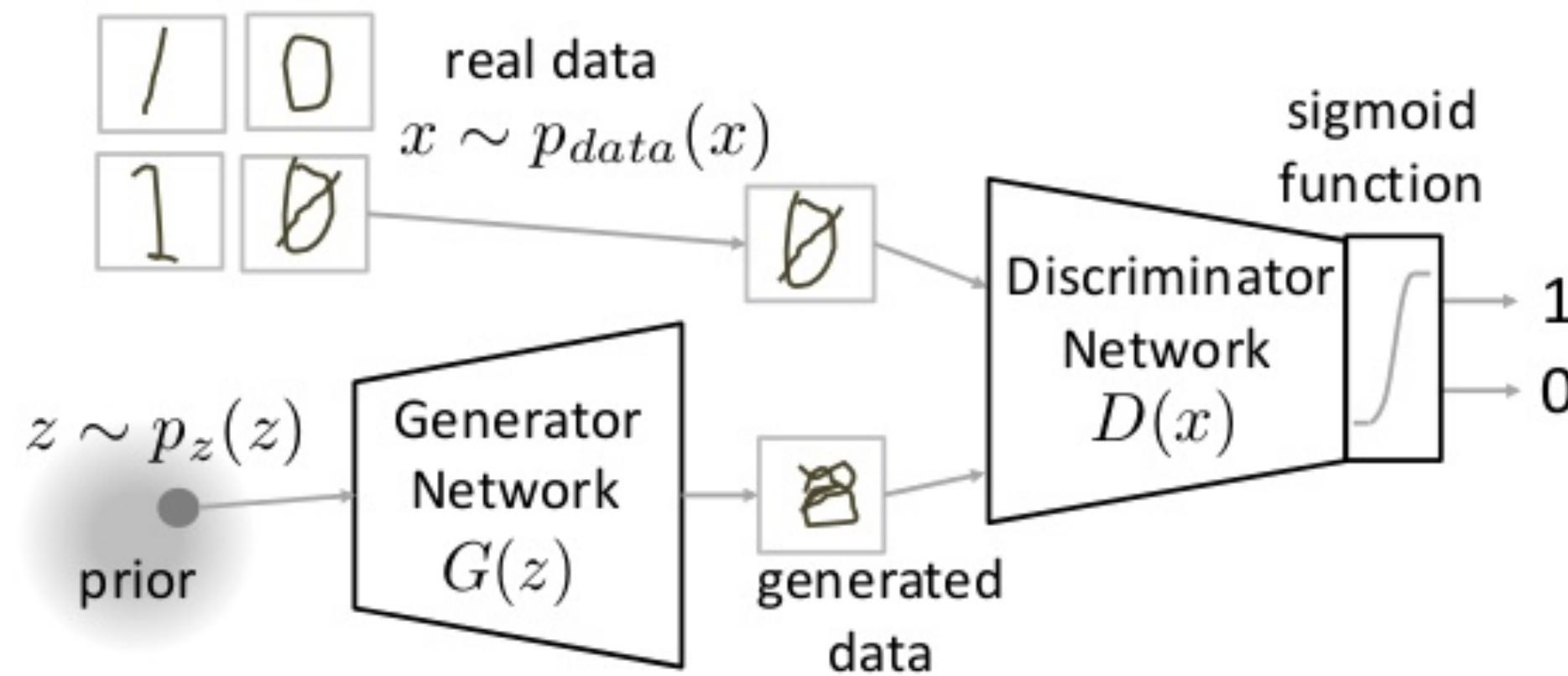
Image taken from: <https://skymind.ai/images/wiki/GANs.png>

How do GANs work? Alternating training

Generative Adversarial Networks

$$\min_G \max_D V(D, G)$$

$$V(D, G) = \mathbb{E}_{x \sim p_{\text{data}}(x)}[\log D(x)] + \mathbb{E}_{z \sim p_z(z)}[\log(1 - D(G(z)))]$$



Algorithm 1 Minibatch stochastic gradient descent training of generative adversarial nets. The number of steps to apply to the discriminator, k , is a hyperparameter. We used $k = 1$, the least expensive option, in our experiments.

for number of training iterations **do**

for k steps **do**

- Sample minibatch of m noise samples $\{\mathbf{z}^{(1)}, \dots, \mathbf{z}^{(m)}\}$ from noise prior $p_g(\mathbf{z})$.
- Sample minibatch of m examples $\{\mathbf{x}^{(1)}, \dots, \mathbf{x}^{(m)}\}$ from data generating distribution $p_{\text{data}}(\mathbf{x})$.
- Update the discriminator by ascending its stochastic gradient:

$$\nabla_{\theta_d} \frac{1}{m} \sum_{i=1}^m \left[\log D(\mathbf{x}^{(i)}) + \log (1 - D(G(\mathbf{z}^{(i)}))) \right].$$

end for

- Sample minibatch of m noise samples $\{\mathbf{z}^{(1)}, \dots, \mathbf{z}^{(m)}\}$ from noise prior $p_g(\mathbf{z})$.
- Update the generator by descending its stochastic gradient:

$$\nabla_{\theta_g} \frac{1}{m} \sum_{i=1}^m \log (1 - D(G(\mathbf{z}^{(i)}))).$$

end for

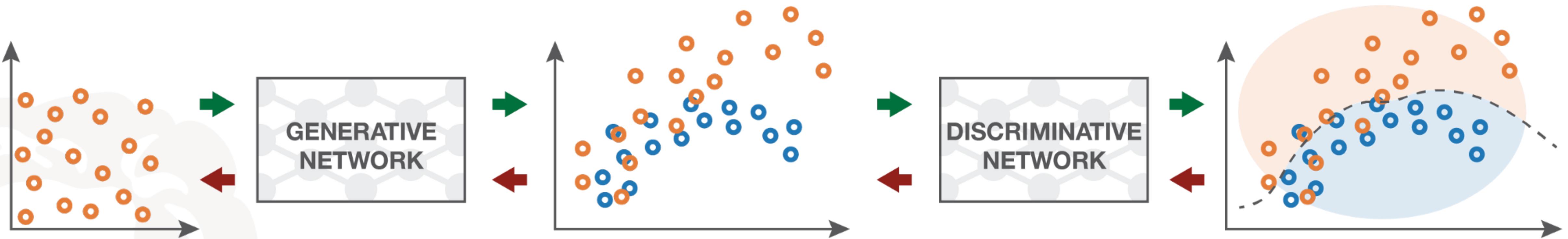
The gradient-based updates can use any standard gradient-based learning rule. We used momentum in our experiments.

Taken from: <https://image.slidesharecdn.com/generativeadversarialnetworks-161121164827/95/generative-adversarial-networks-11-638.jpg?cb=1480242452>

From original 2014 NeurIPS paper by Goodfellow et. Al.
<https://arxiv.org/pdf/1406.2661.pdf>

How do GANs work? Alternating training

■ Forward propagation (generation and classification) ■ Backward propagation (adversarial training)



Input random variables.

The generative network is trained to **maximise** the final classification error.

The **generated distribution** and the **true distribution** are not compared directly.

The discriminative network is trained to **minimise** the final classification error.

The classification error is the basis metric for the training of both networks.

Taken from: <https://towardsdatascience.com/understanding-generative-adversarial-networks-gans-cd6e4651a29>

Variants of GANs

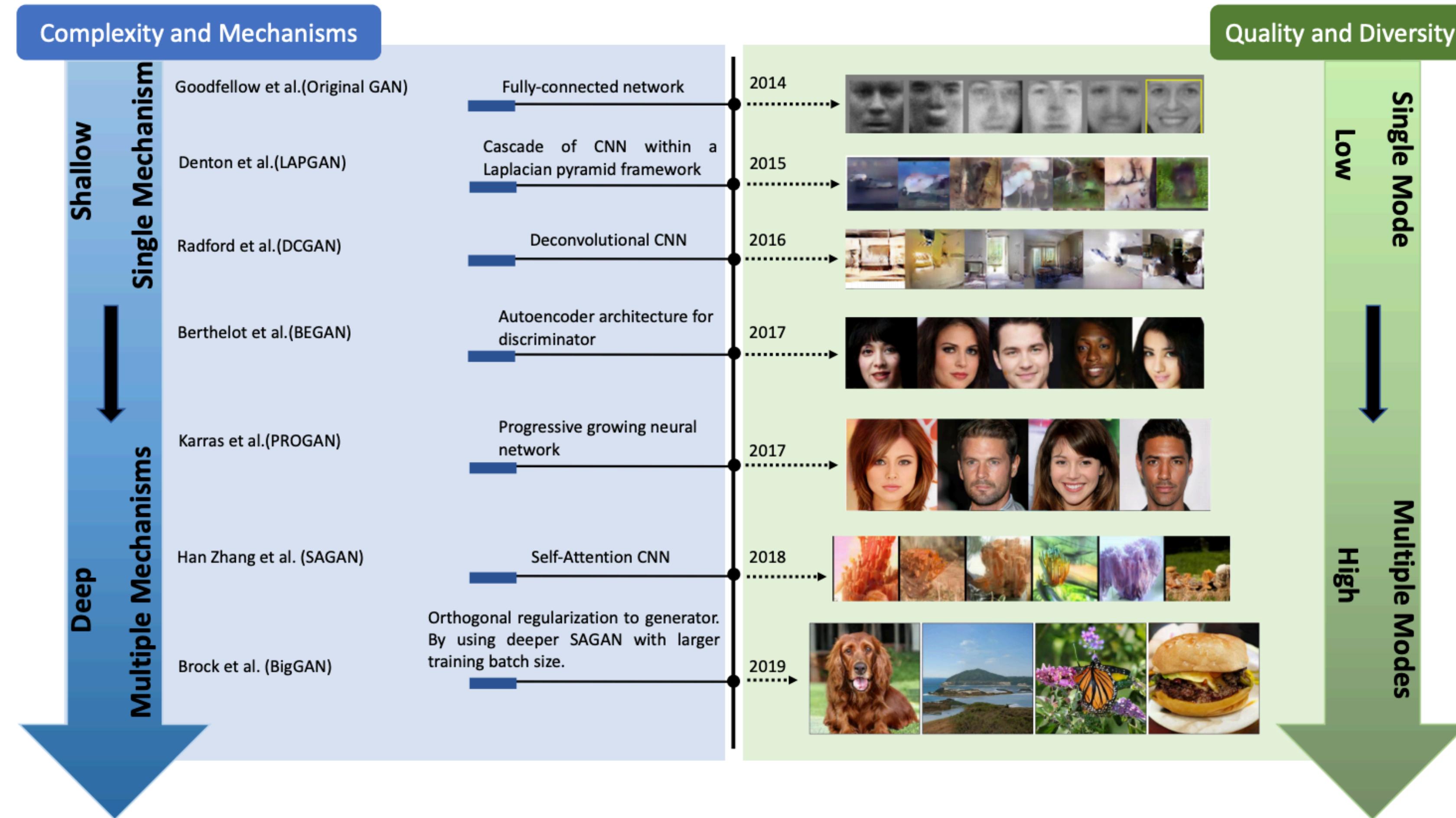


Fig. 2. Timeline of architecture-variant GANs. Complexity in blue stream refers to size of the architecture and computational cost such as batch size. Mechanisms refer to the number of types of models used in the architecture (e.g., BEGAN uses an autoencoder architecture for its discriminator while a deconvolutional neural network is used for the generator. In this case, two mechanisms are used).

Taken from Wang et. al 2019 "Generative Adversarial Networks: A Survey and Taxonomy": <https://arxiv.org/pdf/1906.01529.pdf>

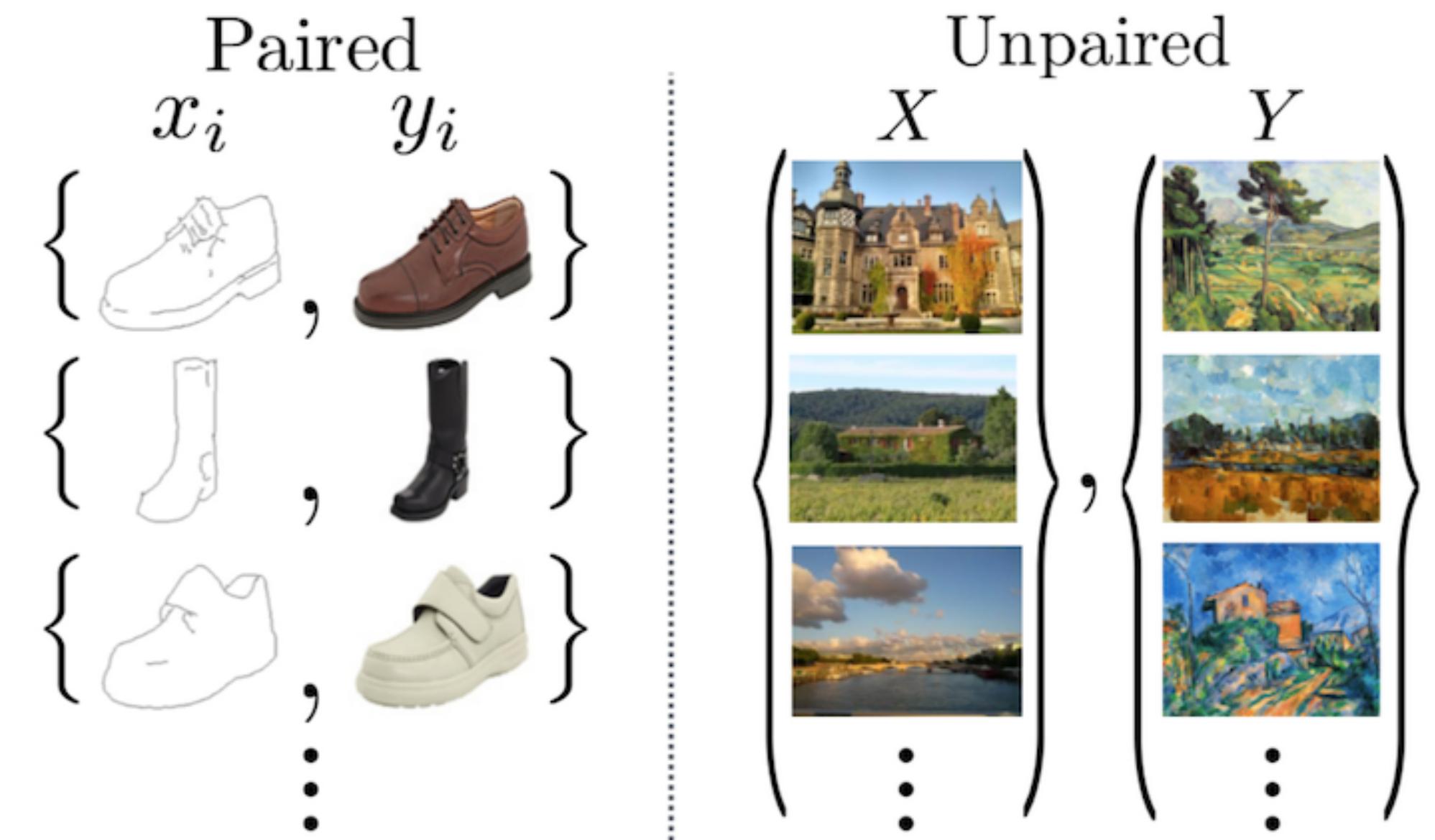
GAN examples



Taken from: <https://medium.com/datadriveninvestor/432-000-painting-by-ai-sold-at-christies-my-thoughts-4a33cd94f782>



Taken from: https://cdn-images-1.medium.com/max/1600/1*5DG4hHjxAyWTfV1J3mRH_A.png



Taken from: https://cdn-images-1.medium.com/max/1200/1*oZsw1JaGkKPxWKKvVUWlyg.png



Taken from: <https://machinelearningmastery.com/what-are-generative-adversarial-networks-gans/>