

ALMA MATER STUDIORUM Università di Bologna



## What about generating?

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### What?

Given training data, generate new samples from the same distribution

This has several applications and we will see some of them...



Andrej Karpathy 🤣 @karpathy

One day we'll be talking about good old "hand-crafted" films and instead the norm will be watching AI-generated (infinite) content on demand

6:28 AM · Mar 29, 2016



Is artificial intelligence set to become art's next medium?

Al artwork sells for \$432,500 — nearly 45 times its high estimate — as Christie's becomes the first auction house to offer a work of art created by an algorithm

https://obvious-art.com



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#### **Taxonomy of Generative Models**



Credits: Ian Goodfellow, Tutorial on Generative Adversarial Networks, 2017

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#### Autoencoder

Learn a mapping from the data, x, to a low-dimensional latent space, z





Credits: Alexander Amini, Deep Generative Models MIT 6.S191

#### Autoencoder

Learn a mapping from the data, x, to a low-dimensional latent space, z

How can we learn this latent space? Train the model to use these features to reconstruct the original data (self-supervised)



## Variational Autoencoder

Variational autoencoders are a probabilistic twist on autoencoders!

Sample from the mean and standard dev. to compute latent sample



Credits: Alexander Amini, Deep Generative Models MIT 6.S191

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## Variational Autoencoder

Different elements of z encode interpretable factors of variation

6666666666666666 6 n O0 9 9 9 777 7



Expression





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## Generative Adversarial Network [Goodfellow et al., Generative Adversarial Nets, NeurIPS2014]

Instead of explicitly modelling the density, directly sample to generate new instances

It's a two player game and both network are trained by alternating between them in a minimax game (game-theory)



### **Generative Adversarial Network**

The original GAN exploited simple MLP networks for both the encoder and the decoder

DCGAN (Radford et al. 2015)

- CNN
- Possibility to perform arithmetic \_ in the latent space
- Generated images still a bit noisy \_





Radford et al., Unsupervised Representation Learning with Deep Convolutional Generative Adversarial Networks

### **Generative Adversarial Network**

#### Image-to-Image Translation





Learns a mapping between two domains Requires paired images

Isola et al. Image-to-Image Translation with Conditional Adversarial Networks



Monet  $\rightarrow$  photo





MA-r

photo →Monet

Zhu et al., Unpaired Image-to-Image Translation using Cycle-Consistent Adversarial Networks



Ledig et al., Photo-Realistic Single Image Super-Resolution Using a Generative Adversarial Network

#### SRGAN







Karras et al., A Style-Based Generator Architecture for Generative Adversarial Networks Karras et al., Analyzing and Improving the Image Quality of StyleGAN



#### **Generative Adversarial Network**



Lee et al. MaskGAN: Towards Diverse and Interactive Facial Image Manipulation https://github.com/switchablenorms/CelebAMask-HQ



Han et al. CookGAN: Meal Image Synthesis from Ingredients



# Is "Generating" just about VAE and GAN?



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#### Median Free-Modelling Accuracy



CASP





Senior, Andrew W., et al. "Improved protein structure prediction using potentials from deep learning."



Yet in a circle pallid as it flow, by this bright sun, that with his light display, roll'd from the sands, and half the buds of snow, and calmly on him shall infold away

captures language, rhyme and meter for sonnet modelling.

generated poems are largely indistinguishable from human-written poems

Expert evaluation: machine-generated poems still underperform in terms of readability and emotion

Lau et al., Deep-speare: A joint neural model of poetic language, meter and rhyme



Gatys et al. Image Style Transfer Using Convolutional Neural Networks



### Which one is fake?





Galteri et al. Deep 3D Morphable Model Refinement



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