

# Generative Models

## Unsupervised Learning (无监督学习)

Data:  $x$  Just data, no labels

Goal: Learn some underlying hidden structure of the data

Ex. Clustering, dimensionality reduction, feature learning, etc.  
autoencoder

generative models  $\Rightarrow$  realistic samples for artwork, super-resolution  
time-series  $\rightarrow$  simulation and planning  
enable inference of latent representations

### Pixel RNN (2016)

Generate image pixels starting from corner

Dependency on previous pixels modeled using an RNN (LSTM)

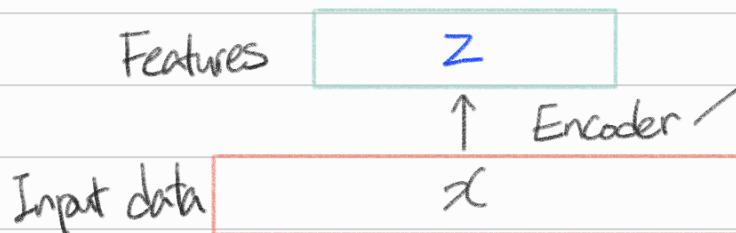
### Pixel CNN (2016)

Still generate image starting from corner

Dependency on previous pixels now modeled using a CNN over context

### Variational Autoencoder

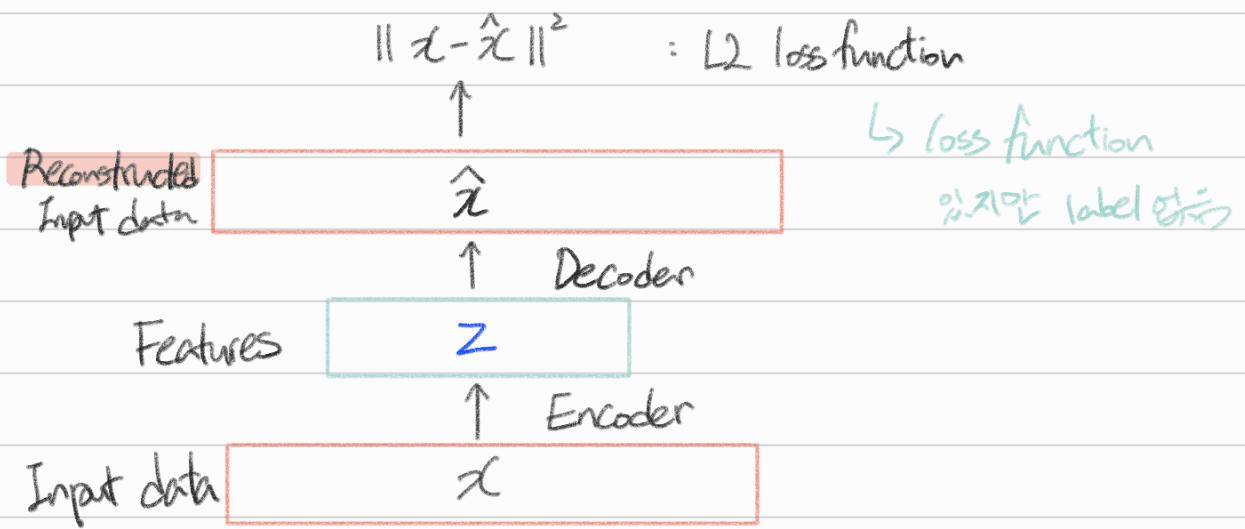
defines intractable density function with latent  $z$



Originally: Linear + nonlinearity

Later: Deep, fully-connected

Later: ReLU CNN



How to learn this feature representation?

Train such that features can be used to **reconstruct** original data, "Autoencoding" - encoding itself

VAE intuition:  $x$  is an image,  $z$  is latent factors used to generate  $x$

Probabilistic generation of data 3023 0103

encoder & decoder = probabilistic  
recognition inference

GAN doesn't work with any explicit function

Instead, take game-theoretic approach, learn to generate from training distribution 2-player game

Generative Adversarial Networks

Prob: Want to sample from complex, high dimensional training distribution

Sol: Sample from a simple distribution, e.g. random noise  
Learn transformation to training distribution

# Training GANs : Two-players game

Generator network: try to fool discriminator

Discriminator network: try to distinguish btw. real & fake img.

Train jointly in "minimax game"

Discriminator wants to maximize object  $\Rightarrow$  Gradient ascent

Generator wants to minimize object  $\Rightarrow$  Gradient descent

Pros:

- Beautiful, state-of-the-art samples

Cons:

- Trickier, more unstable to train
- Can't solve inference queries such as  $p(z)$ ,  $p(z|z)$

Active areas of research