Diffusion

Plan

Review

GANs

Diffusion

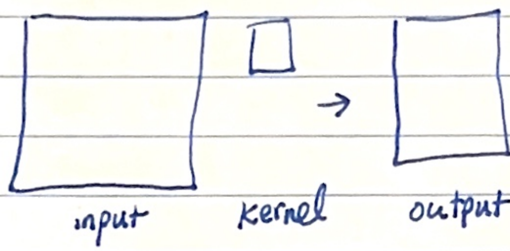
Logistics

Scribe notes - all should have feedback

Zoom

Extra credit check in

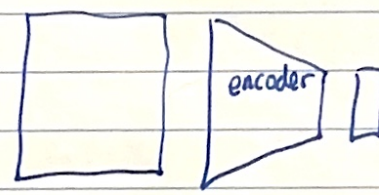
Motivation: Process images locally and efficiently



weights can
- ↳ average
- ↳ detect edges
- ↳ be learned!

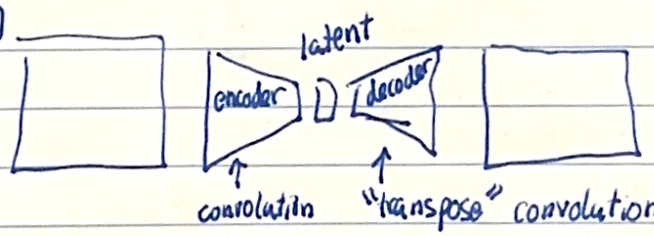
Motivation: Meaningfully embed images in smaller space

Contrastive learning



- positive close
- negative far

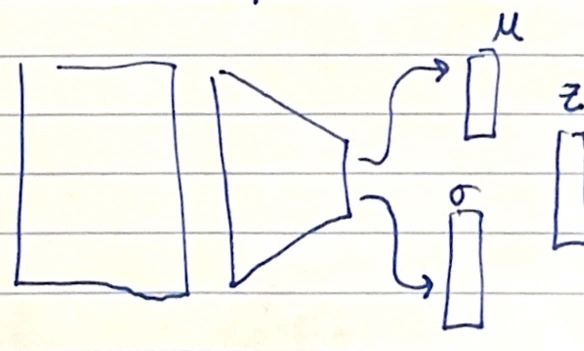
Auto encoders



- Reconstruct via MSE

Variational Autoencoders

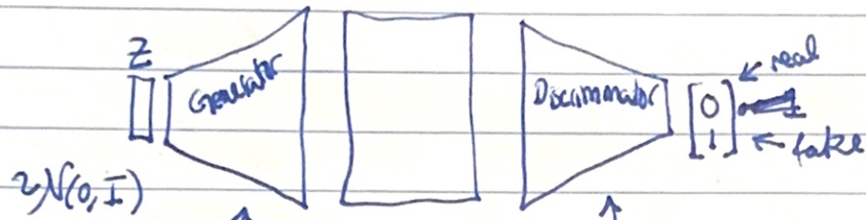
evenly distribute latent space via probabilistic encodings



$z = \mu + \sigma \epsilon$

Generative Adversarial Networks

Motivation: Generate <u>new</u> images! e.g, animals, mountains, etc.



$\boxed{\text{Activity: What losses?}}$

Train to generate realistic images from noise

Train to identify real images

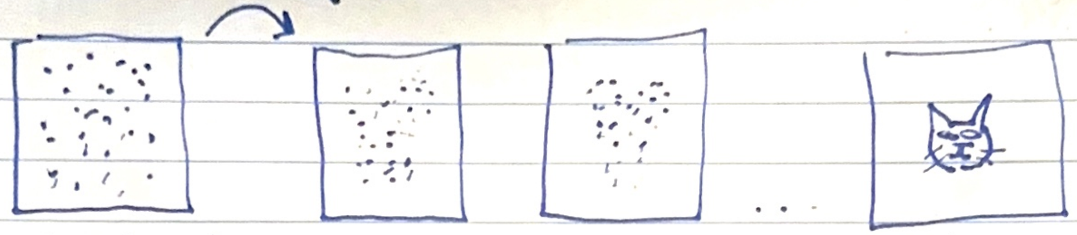
Problem: mode collapse :(

z latent $\qquad\qquad x$ real

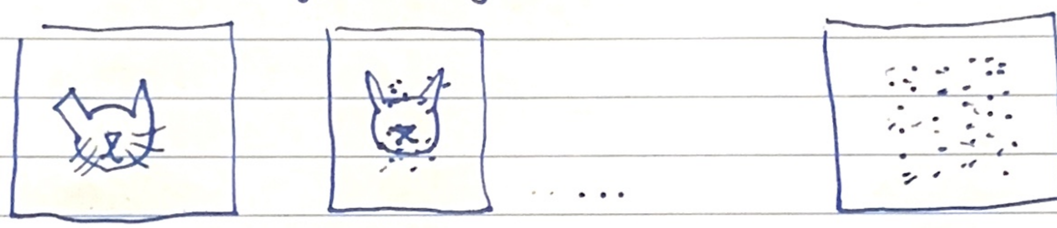
$$\mathcal{L}_G = -\text{dist}\left(D(G(z)), \begin{bmatrix}0\\1\end{bmatrix}\right)$$

$$\mathcal{L}_D = \text{dist}\left(D(G(z)), \begin{bmatrix}0\\1\end{bmatrix}\right) + \text{dist}\left(D(x), \begin{bmatrix}1\\0\end{bmatrix}\right)$$

Diffusion



How do we get training data?



Tension: slowly add noise vs. reaching final noise state

$$x_t = \sqrt{\alpha}\, x_{t-1} + \sqrt{1-\alpha}\, z$$

for $z \sim N(0, I)$

$\Rightarrow \sqrt{\alpha}\, z \sim N(0, \alpha I)$

$$= \sqrt{\alpha}\left(\sqrt{\alpha}\, \cancel{x}_{t-2} + \sqrt{1-\alpha}\, z'\right) + \sqrt{1-\alpha}\, z$$

$$= \sqrt{\alpha^t}\, x_0 + \underline{\sigma}\, z''$$

since linear combination of Gaussian stays Gaussian

$$\sigma^2 = \sum_{l=0}^{t-1} (1-\alpha)\alpha^l = (1-\alpha)\,\frac{(1-\alpha^t)}{1-\alpha}$$

$y_1 \sim N(\mu_1, \sigma_1^2 I)$

$y_2 \sim N(\mu_2, \sigma_2^2 I)$

$y_1 + y_2 \sim N(\mu_1 + \mu_2, (\sigma_1^2 + \sigma_2^2) I)$

$$= \sqrt{\alpha^t}\, x_0 + \sqrt{1-\alpha^t}\, z'''$$

$$z''' = \frac{x_t - \sqrt{\alpha^t}\, x_0}{\sqrt{1-\alpha^t}} \qquad x_0 = \frac{x_t - \sqrt{1-\alpha^t}\, z'''}{\sqrt{\alpha^t}}$$

Diffusion (continued)

Training:

Sample $t \sim \text{Unif}([0, T])$

Sample $z \sim N(0, I)$

Compute $x_t = \sqrt{\alpha^t}\, x_0 + \sqrt{1-\alpha^t}\, z$

Train f to minimize $\| f(x_t) - z \|_2^2$

Evaluation:

$\cancel{x^{(0)} \sim N(0, I)}$

~~for~~ $\cancel{t}$ ~~in~~ $\cancel{\{0, \ldots, \text{num\_steps}\}}$:

$\cancel{z\_pred = f(x^{(i)})}$

$\cancel{x^{(i+1)} = \dfrac{x^{(i)} - \sqrt{\alpha^T}\, z\_pred}{\sqrt{1-\alpha^T}}}$

$x_T \sim N(0, I)$

for i in $\{1, \ldots, \text{num\_steps}\}$:

$z\_pred = f(x_T)$

¡very important! $x_0 = \dfrac{x_T - \sqrt{1-\alpha^t}\, z\_pred}{\sqrt{\alpha^t}}$

$x_T \neq \sqrt{\alpha^T}\, x_0 + \sqrt{1-\alpha^t}\, z$ for $z \sim N(0, I)$