

Denoising Diffusion Probabilistic Models

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ECNU

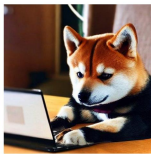
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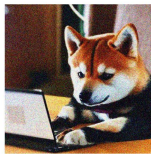
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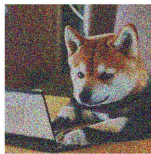
Our Team



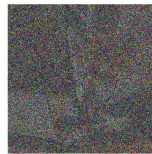
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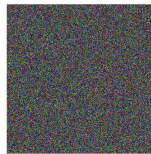
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What is generative model?

Regardless of precise definition, the terminology is constitutional because a generative model can be used to "generate" random instances

Deep generative models

With the rise of deep learning, a new family of methods, called deep generative models (DGMs)

- Generative adversarial networks (GANs)
- Variational autoencoders (VAEs)
- Flow Based Model

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What is Diffusion Model?

We can say...

In machine learning, diffusion models, also known as diffusion probabilistic models, are a class of latent variable models.

Intuitive understanding

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The Process of DDPM

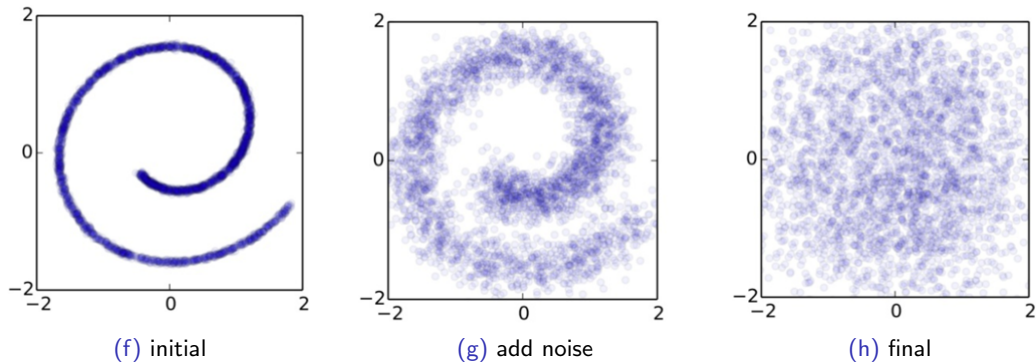


Figure: how the figure tranform to a Gaussian Distribution

Formula

Forward

$$q(x_t|x_{t-1}) = N(x_t; x_{t-1}\sqrt{1-\beta_t}, I\beta_t) \quad (1)$$

$$x_t = x_{t-1}\sqrt{1-\beta_t} + z_t\sqrt{\beta_t} \quad (2)$$

Backward

$$p(x_t|x_{t-1}) = N(x_{t-1}; f_\mu(x_t, t), f_\sigma(x_t, t)) \quad (3)$$

Forward Equation

$$x_t = x_{t-1}\sqrt{1-\beta_t} + z_t\sqrt{\beta_t} \quad (\text{let } 1-\beta_t = \alpha_t) \quad (1a)$$

$$= x_{t-2}\sqrt{\alpha_t}(\sqrt{\alpha_{t-1}} + z_{t-2}\sqrt{1-\alpha_{t-1}}) + z_{t-1}\sqrt{1-\alpha_t} \quad (2a)$$

$$= x_{t-2}\sqrt{\alpha_t\alpha_{t-1}} + z_{t-2}\sqrt{\alpha_t - \alpha_t\alpha_{t-1}} + z_{t-1}\sqrt{1-\alpha_t} \quad (3a)$$

$$= x_{t-2}\sqrt{\alpha_t\alpha_{t-1}} + z\sqrt{1-\alpha_t\alpha_{t-1}} \quad (4a)$$

$$= \dots$$

$$= x_0\sqrt{\bar{\alpha}_t} + z\sqrt{1-\bar{\alpha}_t} \quad (5a)$$

Backward Equation

$$\begin{aligned}
 q(x_{t-1}|x_t, x_0) &= q(x_t|x_{t-1}, x_0) \frac{q(x_{t-1}|x_0)}{q(x_t|x_0)} \\
 &\propto \exp \left(-\frac{1}{2} \left(\left(\frac{\alpha_t}{\beta_t} + \frac{1}{1 - \bar{\alpha}_{t-1}} \right) x_{t-1}^2 - \left(\frac{2\sqrt{\alpha_t}}{\beta_t} x_t + \frac{2\sqrt{\bar{\alpha}_{t-1}}}{1 - \bar{\alpha}_{t-1}} \right) x_{t-1} + C(x_t, x_0) \right) \right) \\
 &= \exp \left(-\frac{1}{2} (A x_{t-1}^2 + B x_{t-1} + C) \right) \\
 E(x_{t-1}) &= -\frac{B}{2A}, \text{Var}(x_{t-1}) = \frac{1}{A}
 \end{aligned} \tag{4}$$

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DDPM Advantage

Name.	Quality	Likelihood	Speed	Gradually or One-time	Stability
GAN	++	Uncertain	fast	One-time	Unstable
VAE	++	Uncertain	fast	One-time	-
Flow Model	+	Certain	fast	Gradually	-
DDPM	+++	-	slow	Gradually	Stable

Table: cons and pros of generative model

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Text2Image

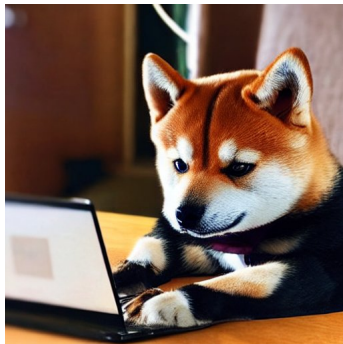
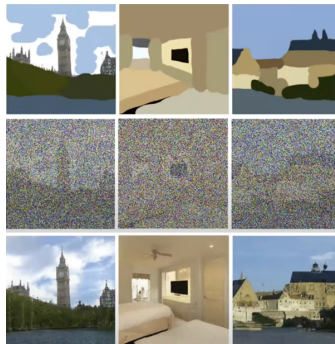
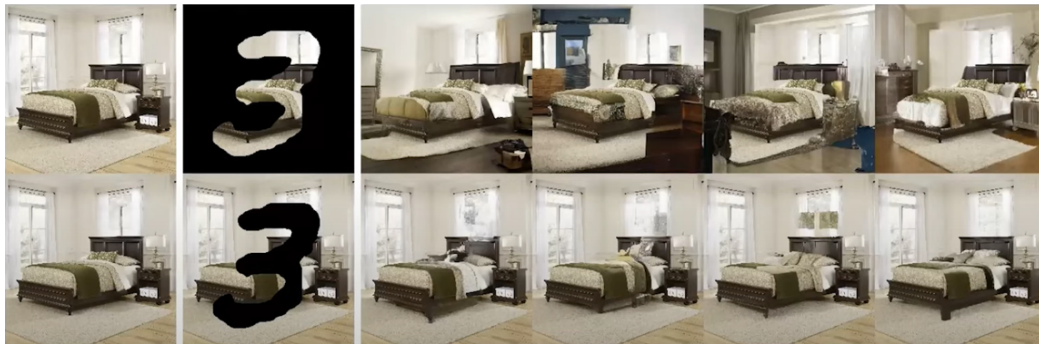


Image refinement



Inpainting



Colorization



Conclusion

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Reference

Thanks
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