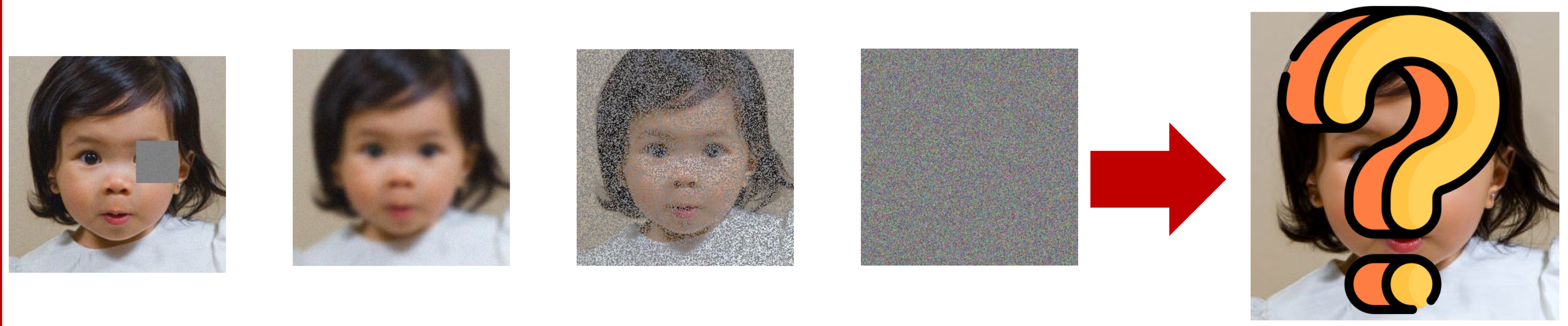
Diffusion Models for Image Generation and Inverse Problems

Yue Qi
Stanford Online

Motivation

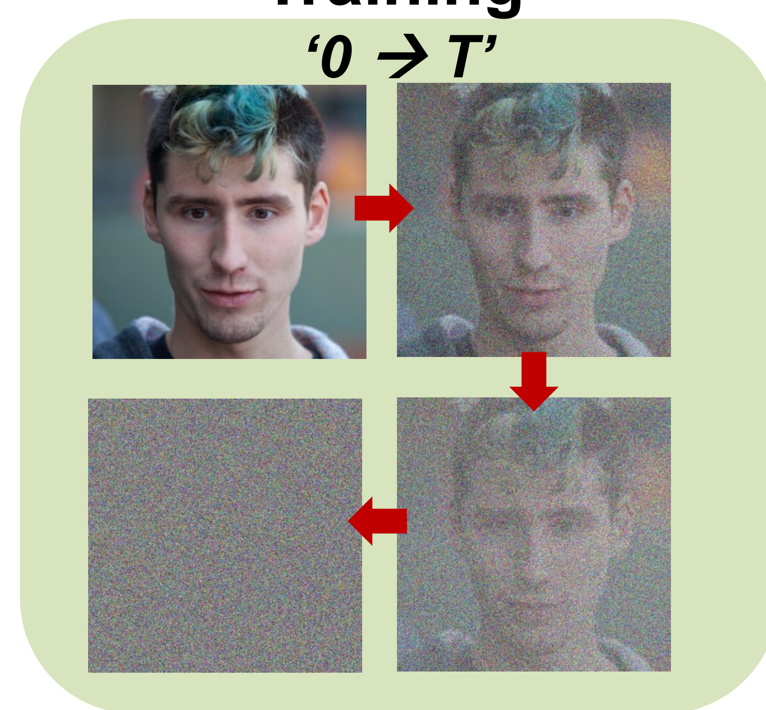


Diffusion model for image restoration and generation

- The straightforward structure and efficient training process of diffusion models have made them a popular choice for generative modeling.
- In this work, we implemented several diffusion model approaches utilizing a pre-trained score predictor for image denoising, unconditional image generation, and tackling inverse problems, including inpainting and deconvolution.

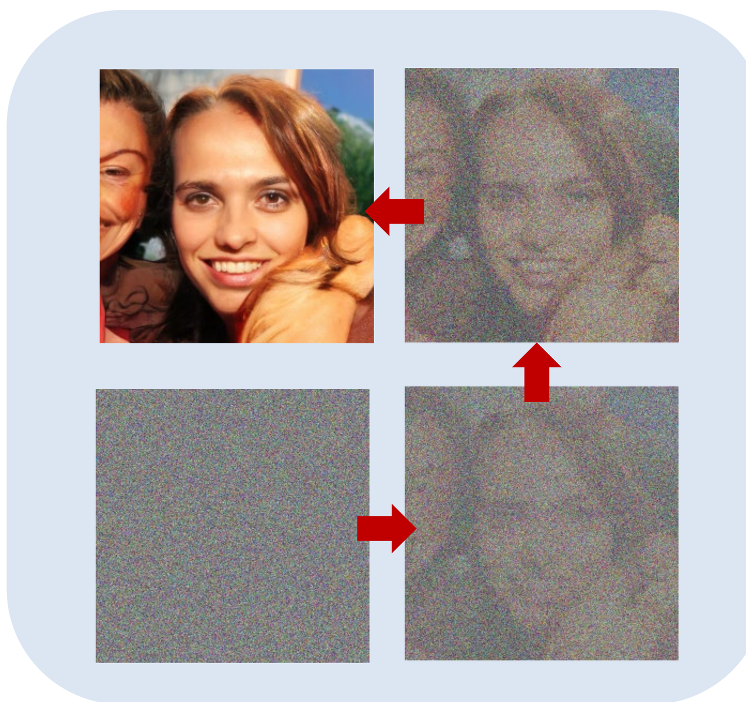
Methods

Training
'0 → T'



Pre-trained score ($s_\theta(x_t, t)$) predictor

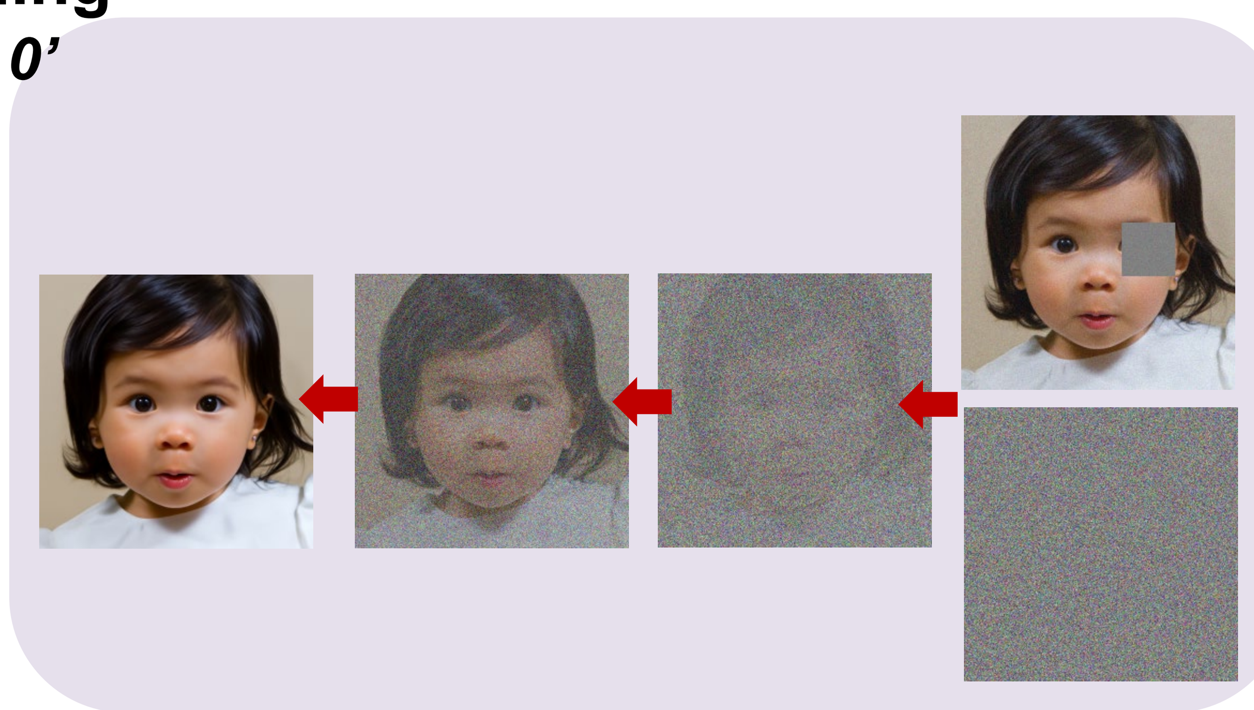
Sampling
'T → 0'



Reverse Diffusion: DDPM

$$\hat{x}_0 = \frac{1}{\sqrt{\bar{\alpha}_t}}(x_t + (1-\bar{\alpha}_t)s_\theta(x_t, t))$$

$$x_{t-1} = \frac{\sqrt{\bar{\alpha}_t}(1-\bar{\alpha}_{t-1})}{1-\bar{\alpha}_t}x_t + \frac{\sqrt{\bar{\alpha}_{t-1}}(1-\alpha_t)}{1-\bar{\alpha}_t}\hat{x}_0 + \sqrt{1-\alpha_t}z$$



Posterior Sampling: ScoreALD, DPS

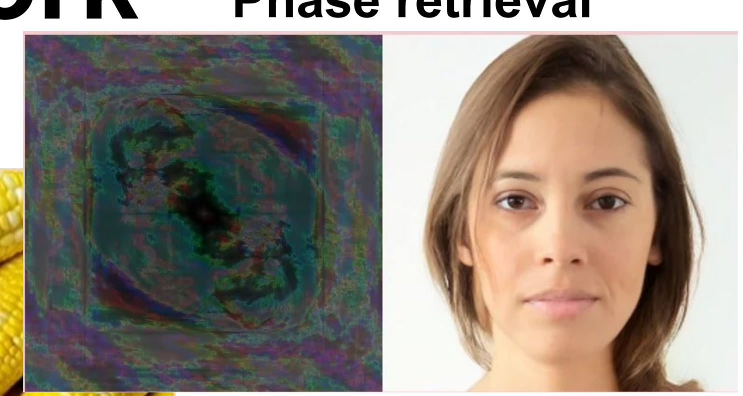
$$\hat{x}_0 = \frac{1}{\sqrt{\bar{\alpha}_t}}(x_t + (1-\bar{\alpha}_t)s_\theta(x_t, t))$$

$$x_{t-1}' = \frac{\sqrt{\bar{\alpha}_t}(1-\bar{\alpha}_{t-1})}{1-\bar{\alpha}_t}x_t + \frac{\sqrt{\bar{\alpha}_{t-1}}(1-\alpha_t)}{1-\bar{\alpha}_t}\hat{x}_0 + \sqrt{1-\alpha_t}z$$

$$x_{t-1} = x_{t-1}' - \frac{1}{\sigma^2 + \gamma_t^2}\nabla_{x_t}\|\mathcal{A}(x_t) - y\|^2$$

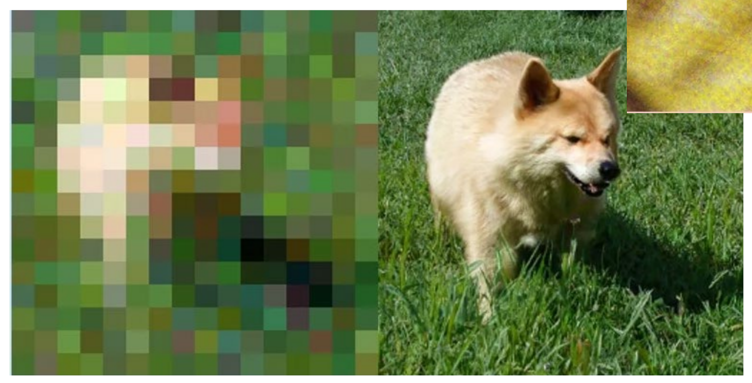
Related Work

Phase retrieval



Non-uniform deblur

Super-resolution



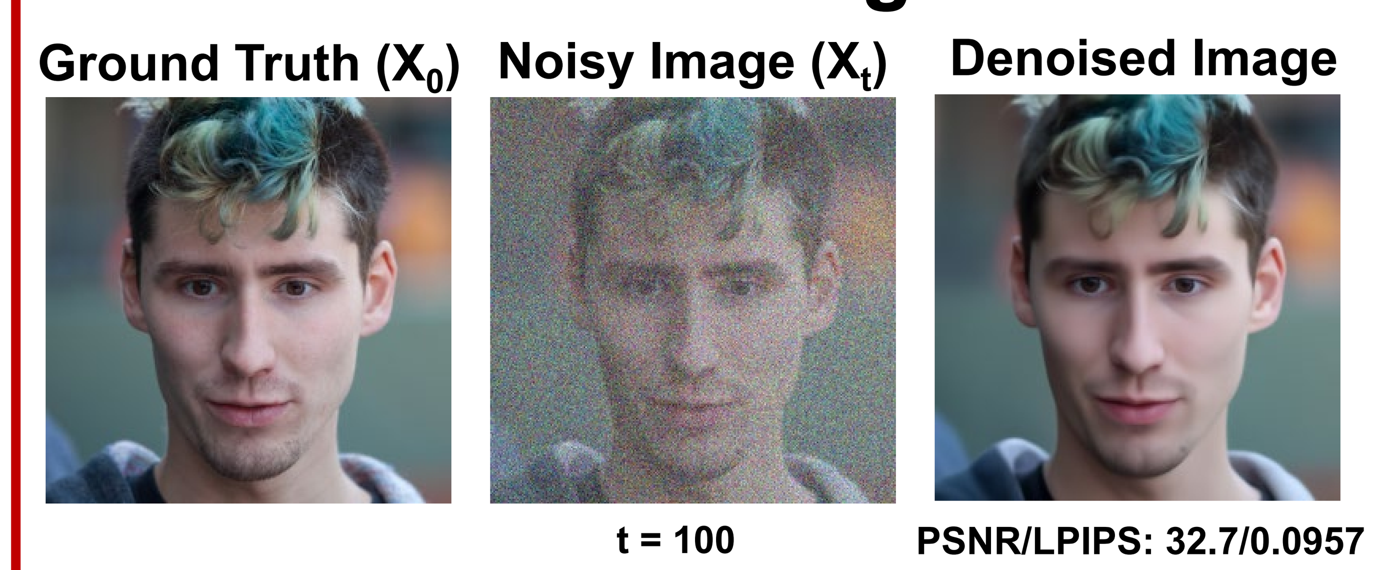
- Diffusion posterior sampling has enabled to solve many other linear/ nonlinear inverse problems with noise[3].

References

[1] C. Meng, Y. He, Y. Song, J. Song, J. Wu, J.Y. Zhu, S. Ermon, "SDEdit: Guided Image Synthesis and Editing with Stochastic Differential Equations", ICLR 2022
[2] J. Ho, et al, "Denoising Diffusion Probabilistic Models",NeurIPS 2020
[3] H.Chung, et al, "Diffusion posterior sampling for general noisy inverse problems", ICLR 2023

Experimental Results

Denoising



Unconditional Image Generation

Deconvolution & Inpainting