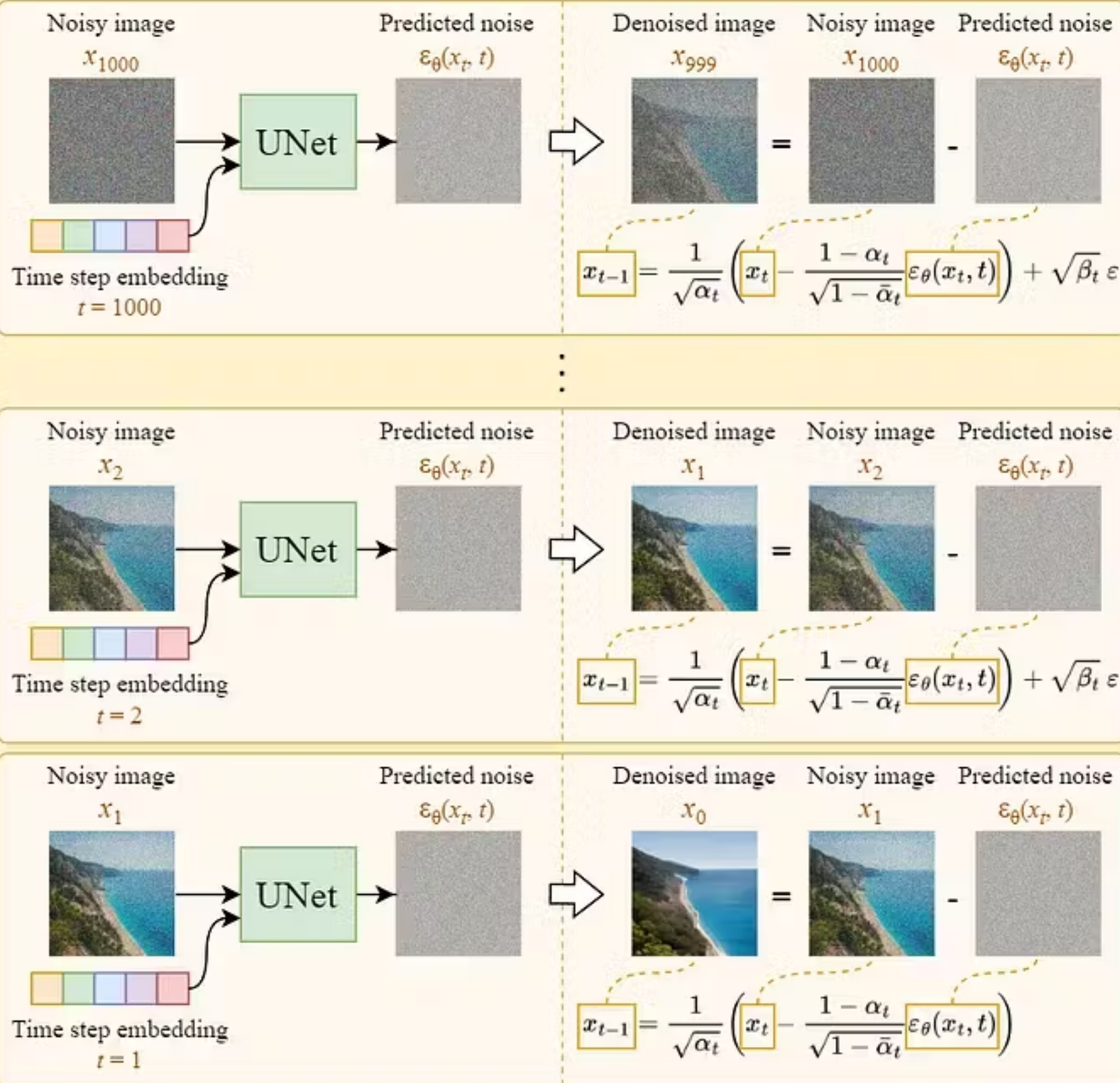# Reverse Diffusion / Denoising / Sampling

1. Sample a Gaussian noise

$$x_T \sim N(0, \mathbf{I})$$

E.g. $T = 1000$

$$x_{1000} \sim N(0, \mathbf{I})$$

2. Iteratively denoise the image

Noisy image x_{1000}

UNet

Time step embedding $t = 1000$

Predicted noise $\varepsilon_\theta(x_t, t)$

Denoised image x_{999}

Noisy image x_{1000}

Predicted noise $\varepsilon_\theta(x_t, t)$

$$x_{t-1} = \frac{1}{\sqrt{\alpha_t}}\left(x_t - \frac{1-\alpha_t}{\sqrt{1-\bar{\alpha}_t}}\varepsilon_\theta(x_t, t)\right) + \sqrt{\beta_t}\,\varepsilon$$

$\vdots$

Noisy image x_2

UNet

Time step embedding $t = 2$

Predicted noise $\varepsilon_\theta(x_t, t)$

Denoised image x_1

Noisy image x_2

Predicted noise $\varepsilon_\theta(x_t, t)$

$$x_{t-1} = \frac{1}{\sqrt{\alpha_t}}\left(x_t - \frac{1-\alpha_t}{\sqrt{1-\bar{\alpha}_t}}\varepsilon_\theta(x_t, t)\right) + \sqrt{\beta_t}\,\varepsilon$$

Noisy image x_1

UNet

Time step embedding $t = 1$

Predicted noise $\varepsilon_\theta(x_t, t)$

Denoised image x_0

Noisy image x_1

Predicted noise $\varepsilon_\theta(x_t, t)$

$$x_{t-1} = \frac{1}{\sqrt{\alpha_t}}\left(x_t - \frac{1-\alpha_t}{\sqrt{1-\bar{\alpha}_t}}\varepsilon_\theta(x_t, t)\right)$$

3. Output the denoised image

Denoised image x_0