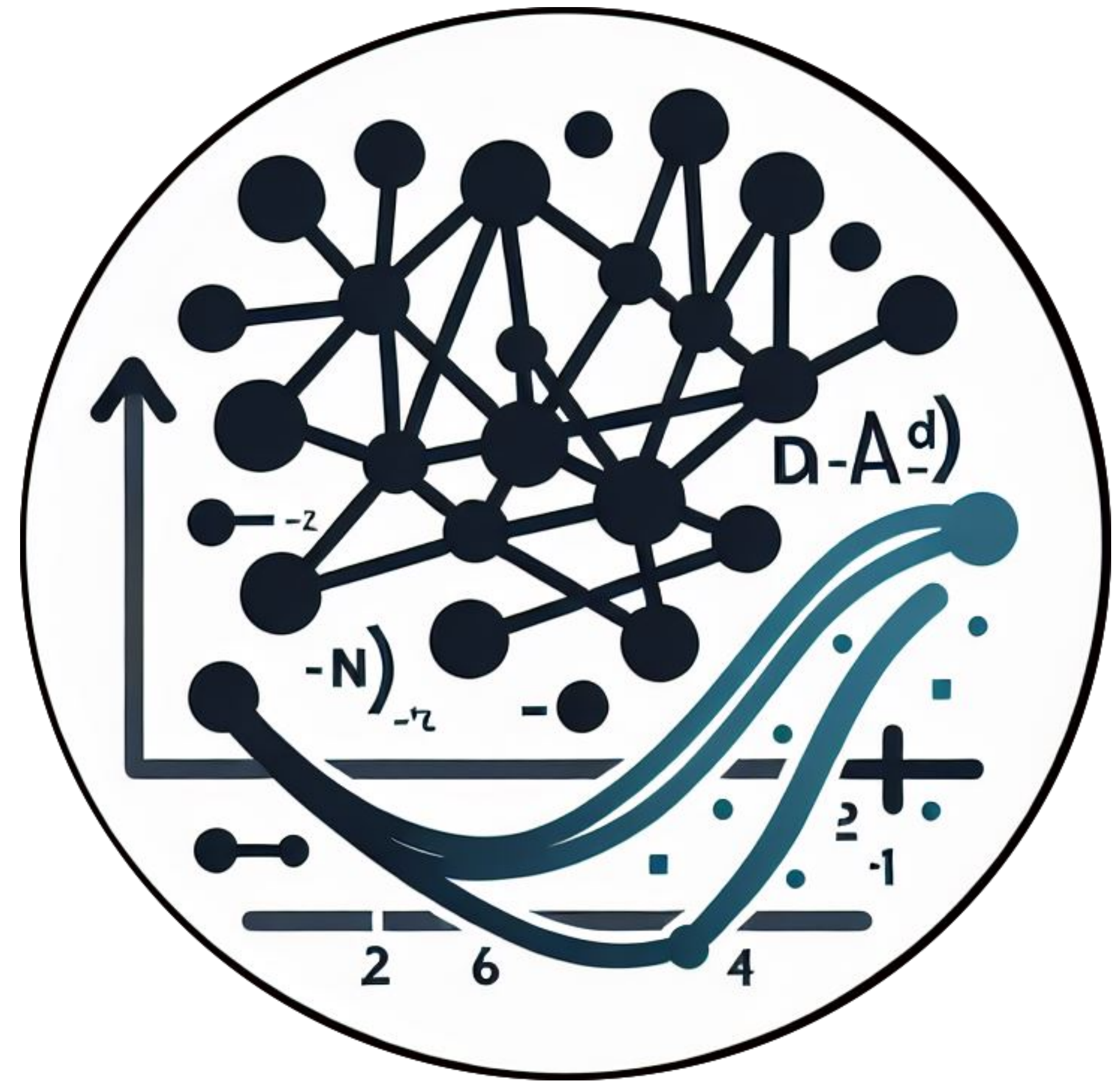


Diffusion Models

Deep Learning for Engineers

Andrew Ning

aning@byu.edu



Deep Unsupervised Learning using Nonequilibrium Thermodynamics

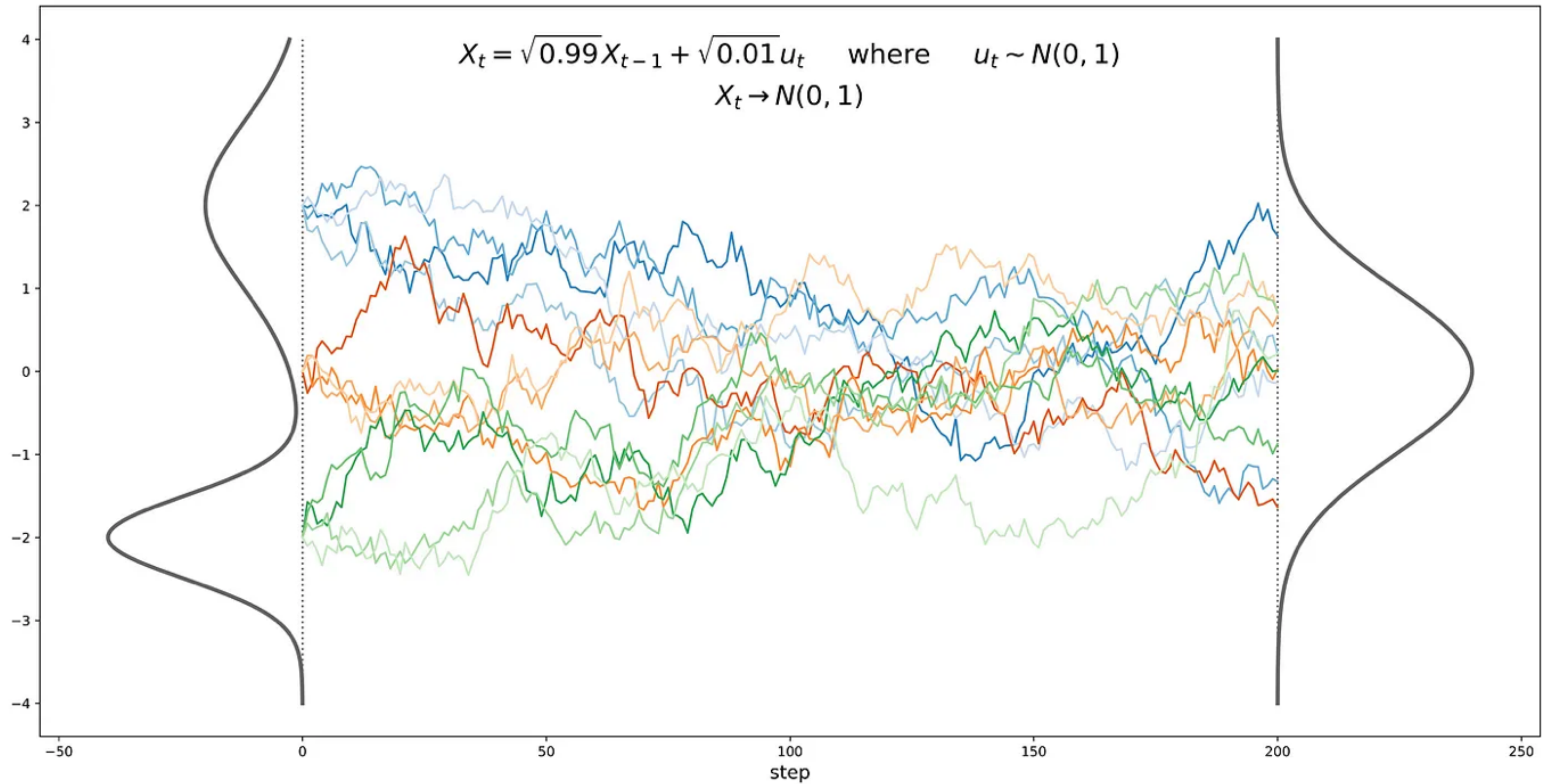
[Jascha Sohl-Dickstein](#), [Eric A. Weiss](#), [Niru Maheswaranathan](#), [Surya Ganguli](#)

Denoising Diffusion Probabilistic Models

[Jonathan Ho](#), [Ajay Jain](#), [Pieter Abbeel](#)

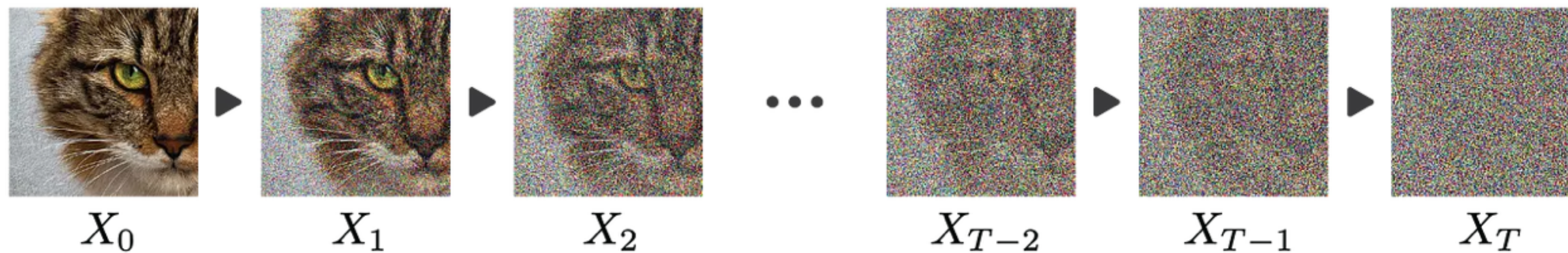
High-Resolution Image Synthesis with Latent Diffusion Models

[Robin Rombach](#), [Andreas Blattmann](#), [Dominik Lorenz](#), [Patrick Esser](#), [Björn Ommer](#)



Joseph Rocca

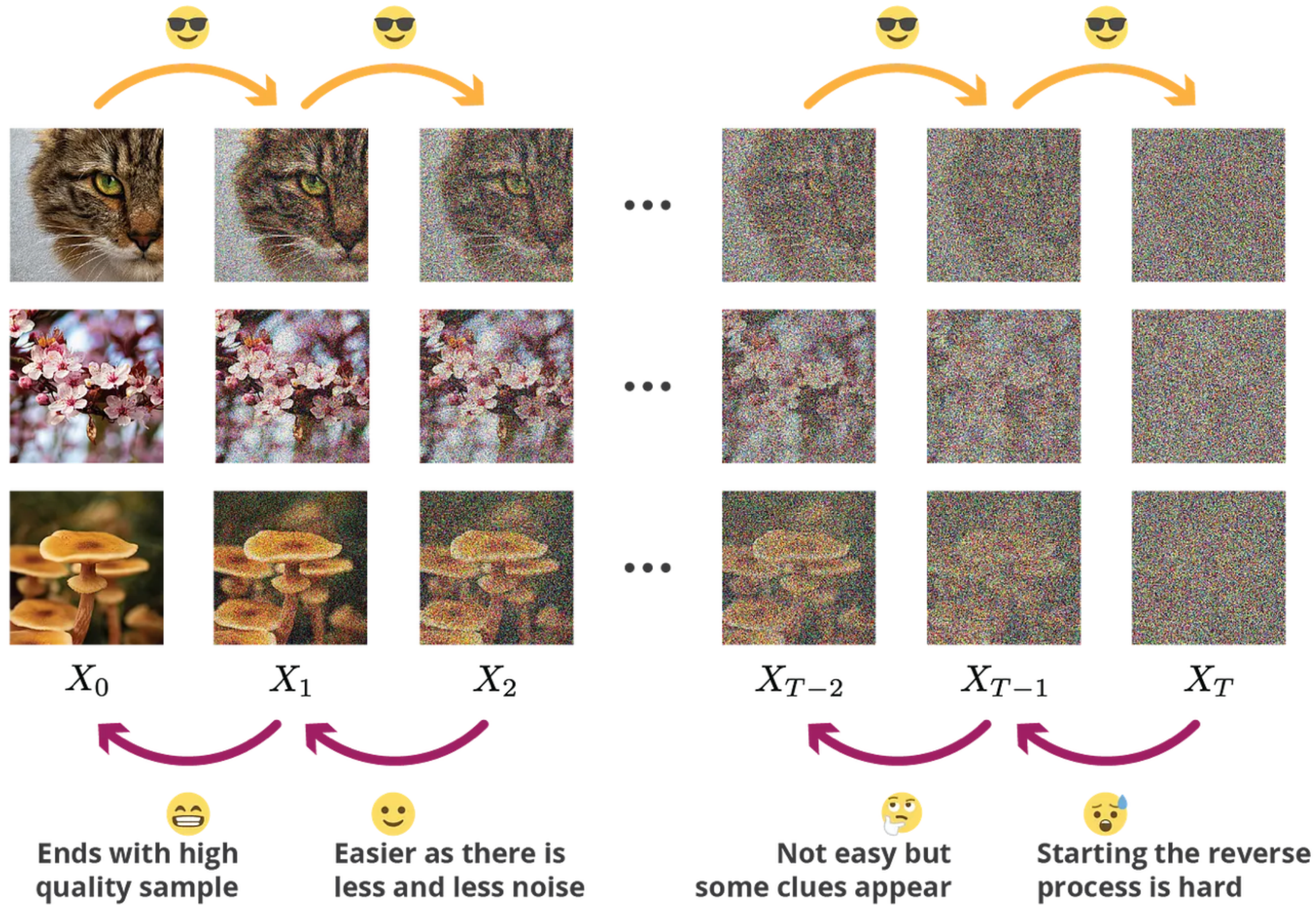
<https://medium.com/data-science/understanding-diffusion-probabilistic-models-dpms-1940329d6048>



$$\begin{array}{c}
 \text{[Noisy Cat Image]} \\
 X_1
 \end{array}
 = \sqrt{1-p} \begin{array}{c} \text{[Clear Cat Image]} \\ X_0 \end{array} + \sqrt{p} \begin{array}{c} \text{[Noise Image]} \\ u_1 \sim \mathcal{N}(0, I) \end{array}$$

Joseph Rocca

<https://medium.com/data-science/understanding-diffusion-probabilistic-models-dpms-1940329d6048>



Joseph Rocca

<https://medium.com/data-science/understanding-diffusion-probabilistic-models-dpms-1940329d6048>

Training examples are created by generating **noise** and adding an **amount** of it to the images in the training dataset (forward diffusion)

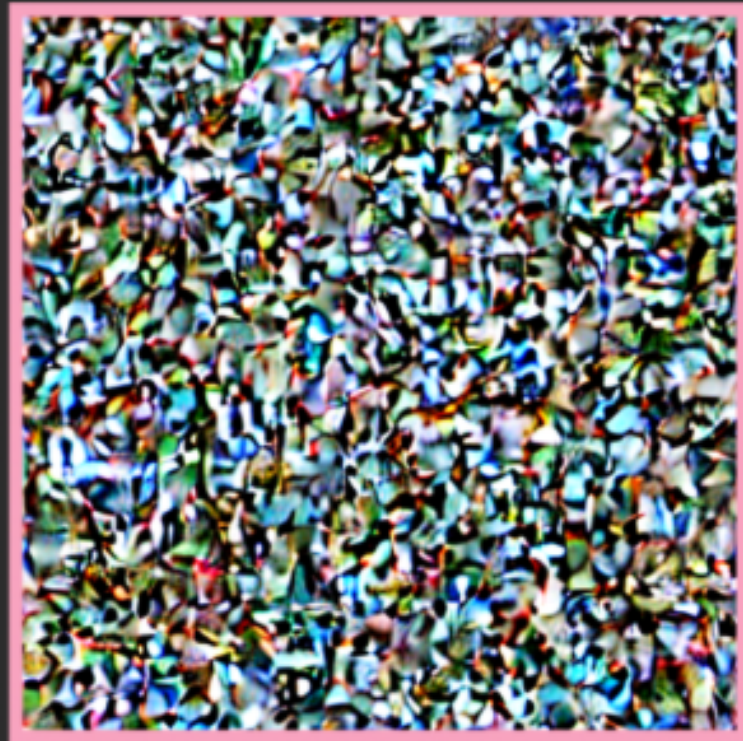
1

Pick an image



2

Generate some
random **noise**

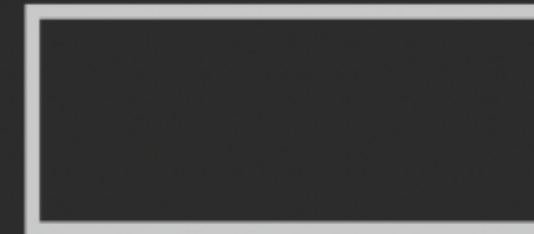


Noise sample 1

3

Pick an amount
of **noise**

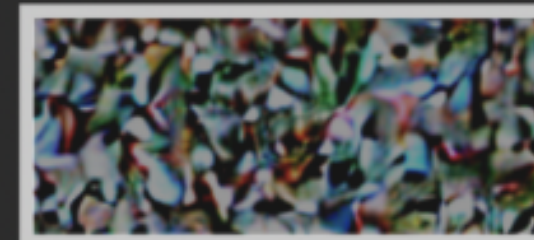
0



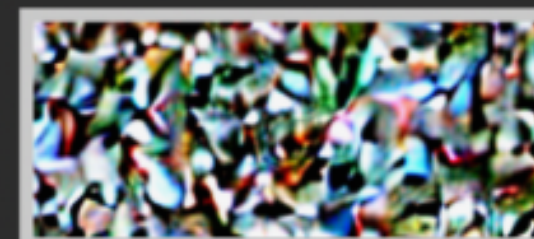
1



2

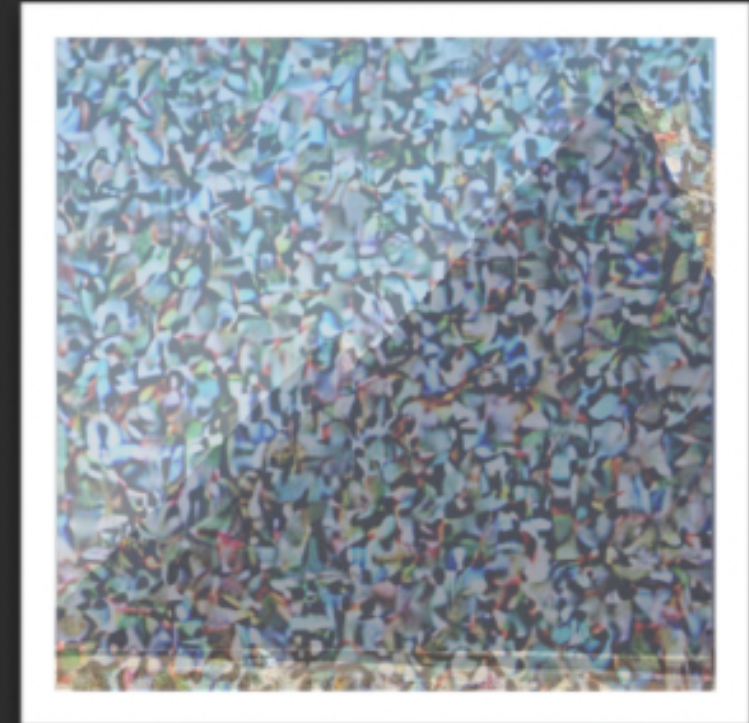


3



4

Add **noise** to
the image in
that **amount**



Generating a 2nd training example with a different image, **noise sample** and **noise amount** (forward diffusion)

1

Pick an image



2

Generate some random noise



Noise sample 2

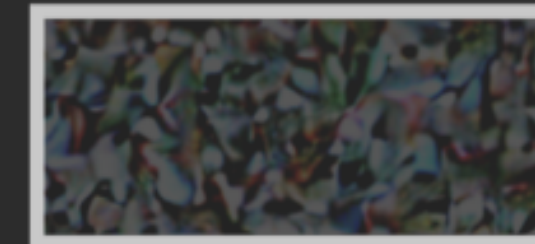
3

Pick an amount of noise

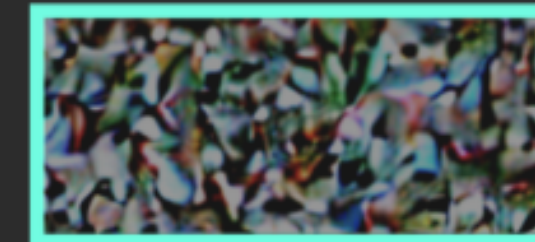
0



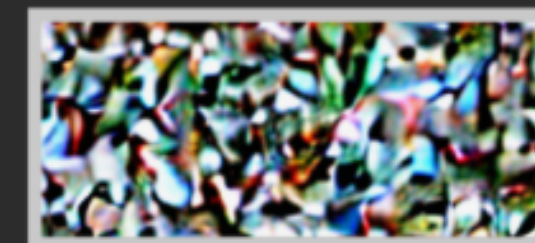
1



2



3



4

Add **noise** to the image in that **amount**



DATASET

MODEL

INPUT

Noise Amount Noisy Image

3



14



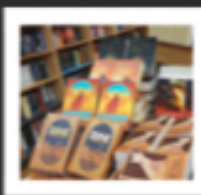
7



42



2

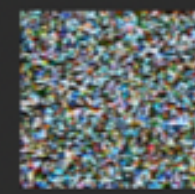
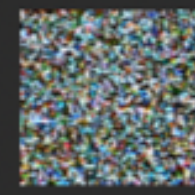
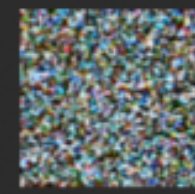
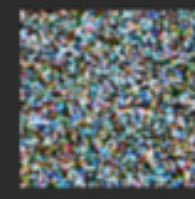


21

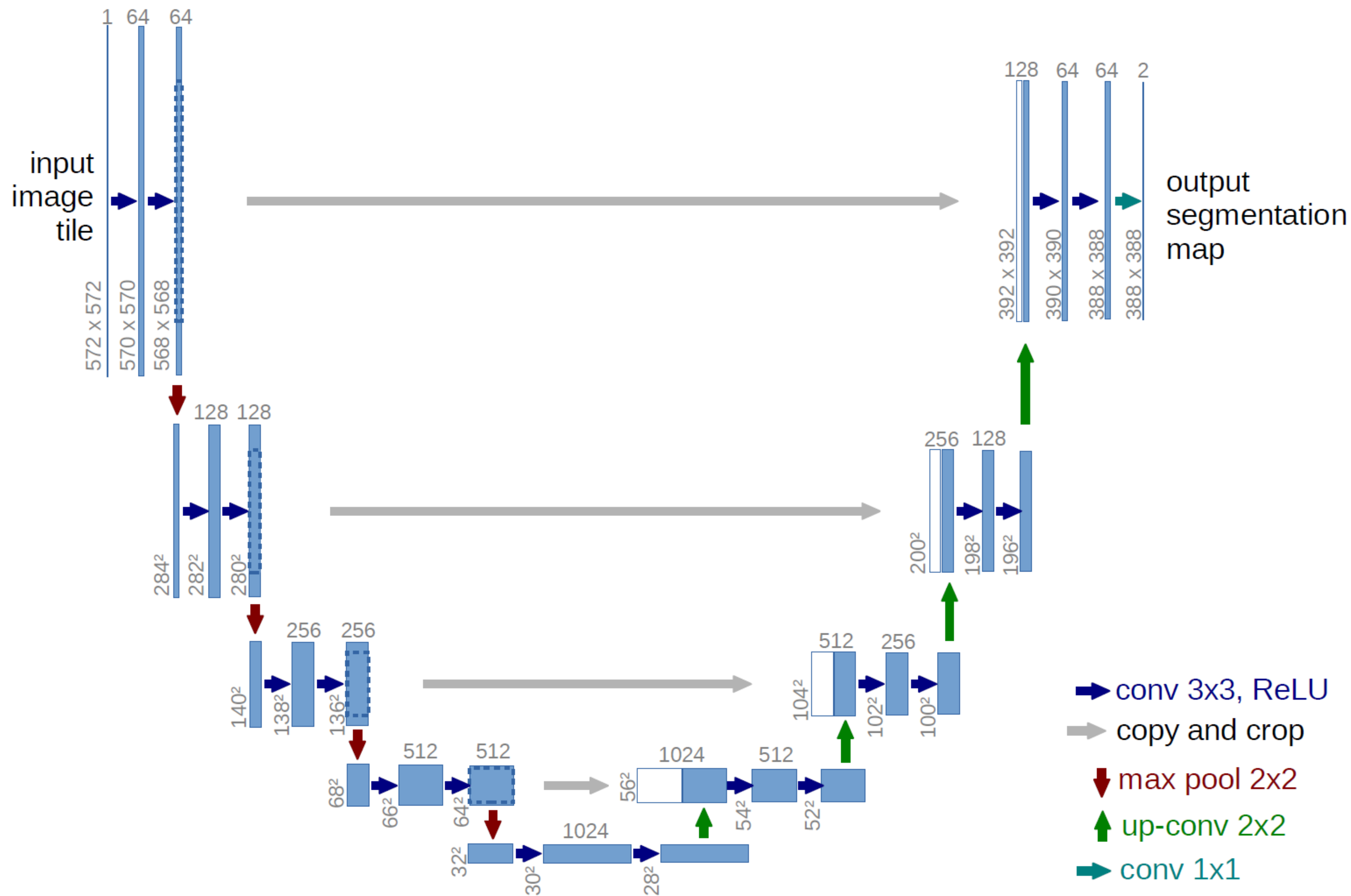


OUTPUT / LABEL

Noise sample



Noise
Predictor
(UNet)



UNet training step

1

Pick a training example from the training dataset

2

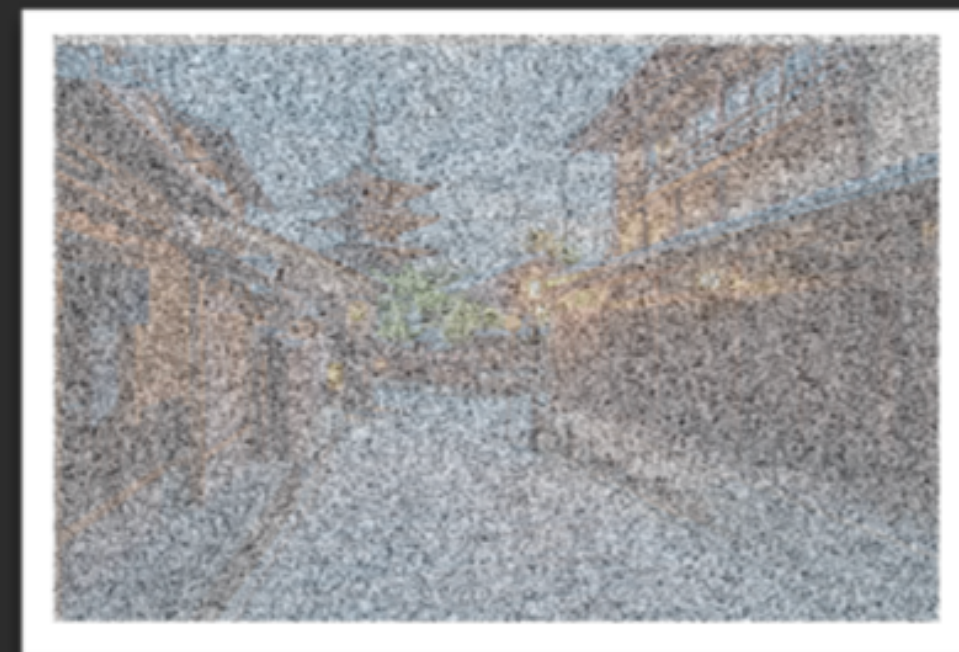
Predict the noise

3

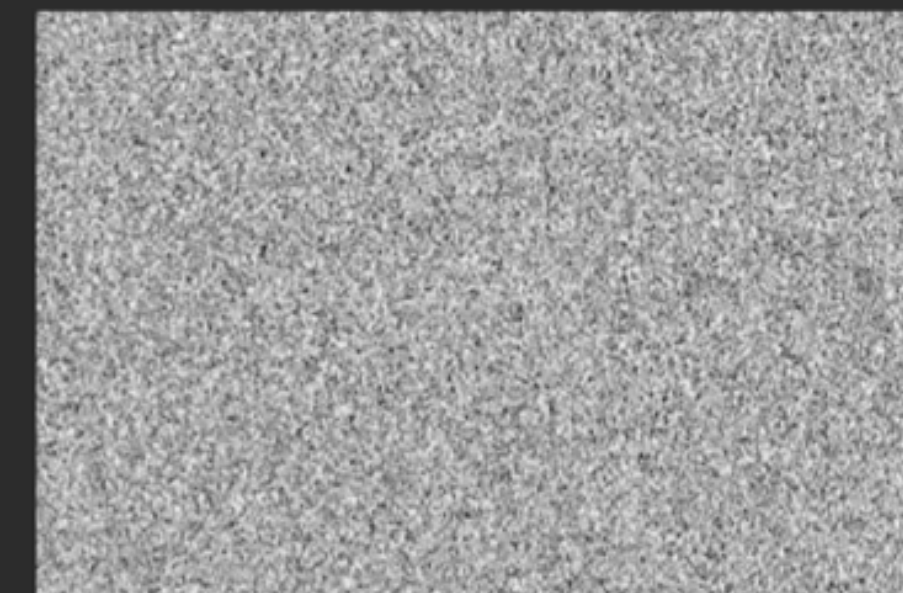
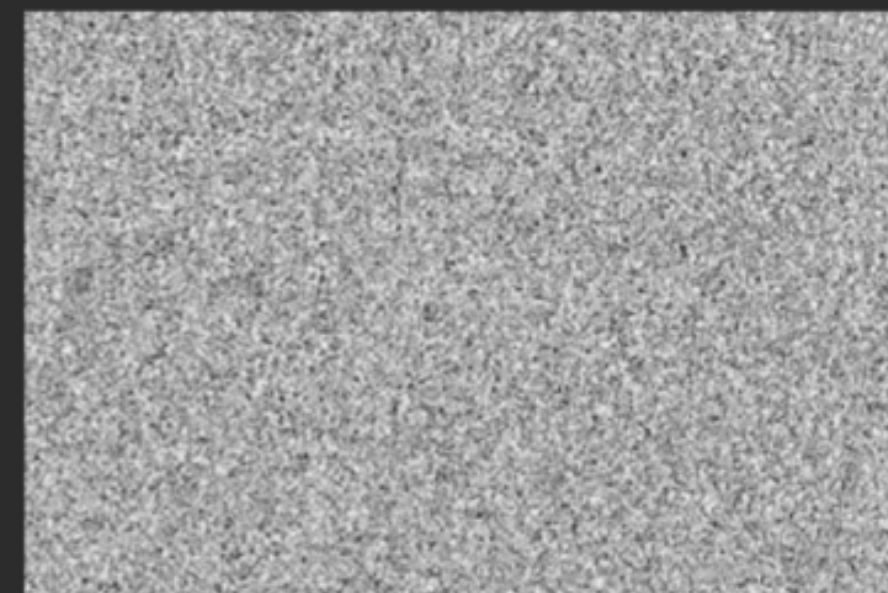
Compare to actual noise (calculate loss)

Unet Prediction

Actual noise (Label)



Noise
amount:
3

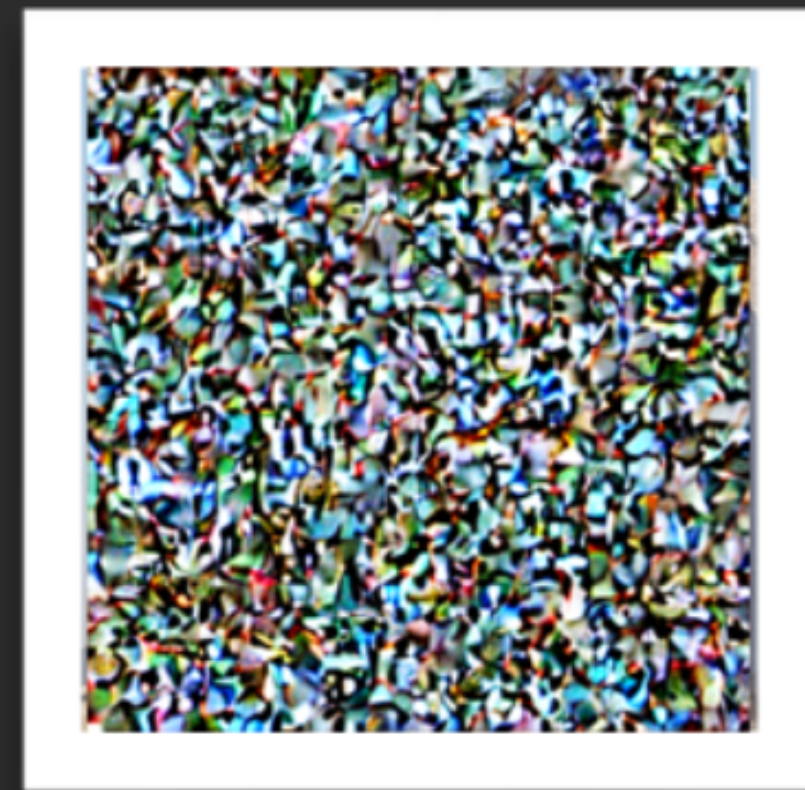


4

Update model
(backprop)

Predicted noise sample

Jay Alammam
<https://jalammar.github.io/illustrated-stable-diffusion/>



Noise amount:
3



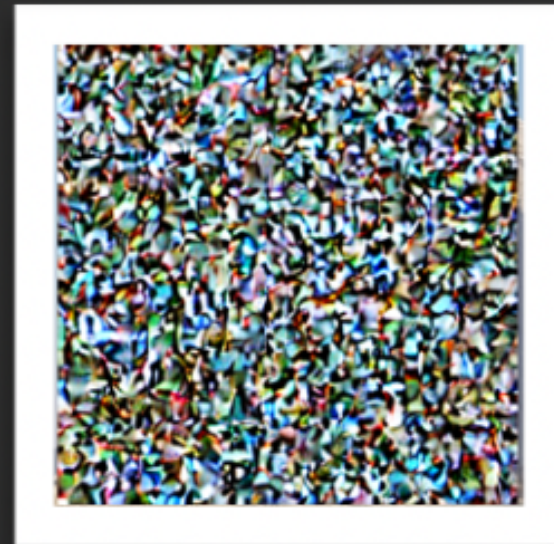
Trained
Noise
Predictor
(UNet)

Reverse Diffusion (Denoising) Step 1

Slightly
de-noised
image



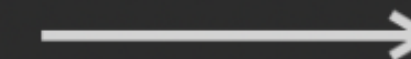
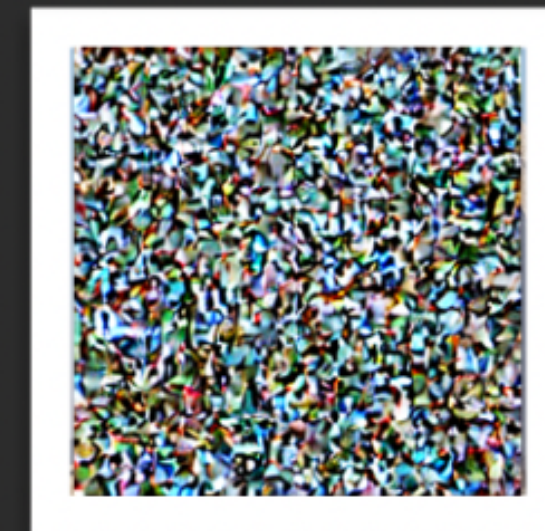
=



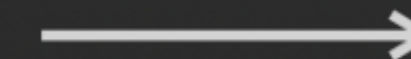
-

Subtract
predicted noise
from image

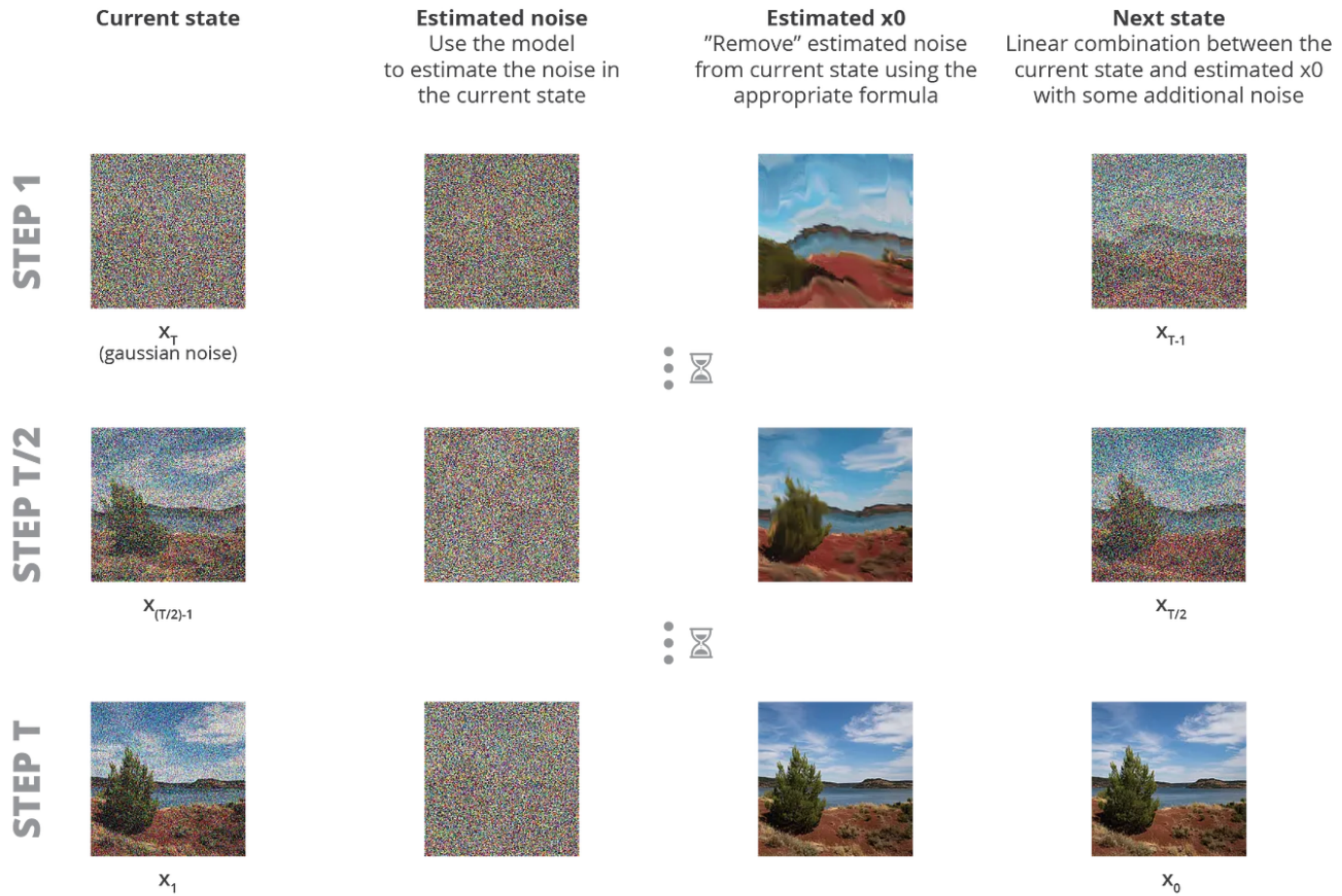
Predicted
noise sample



Noise amount:
3



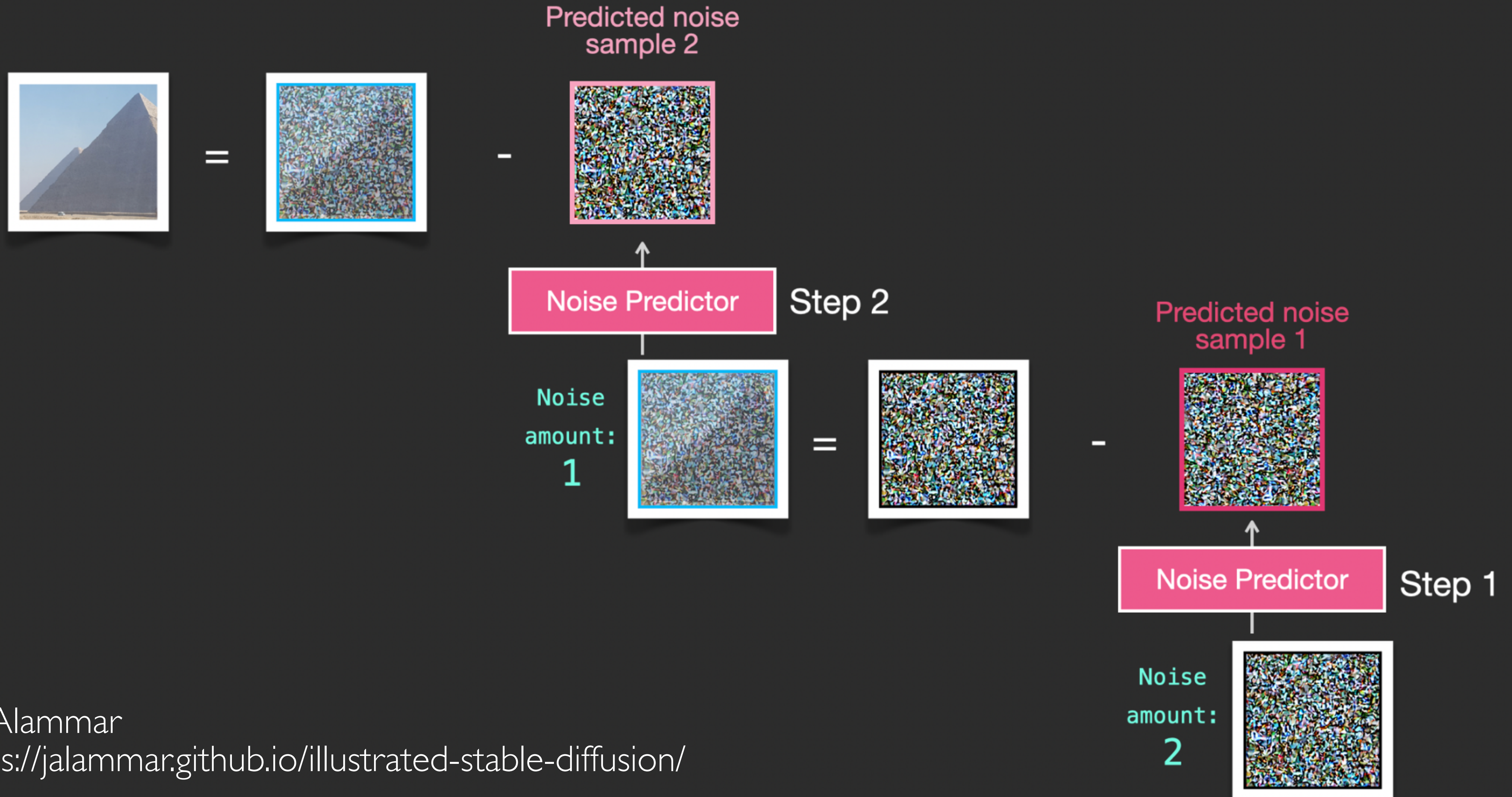
Trained
Noise
Predictor
(UNet)

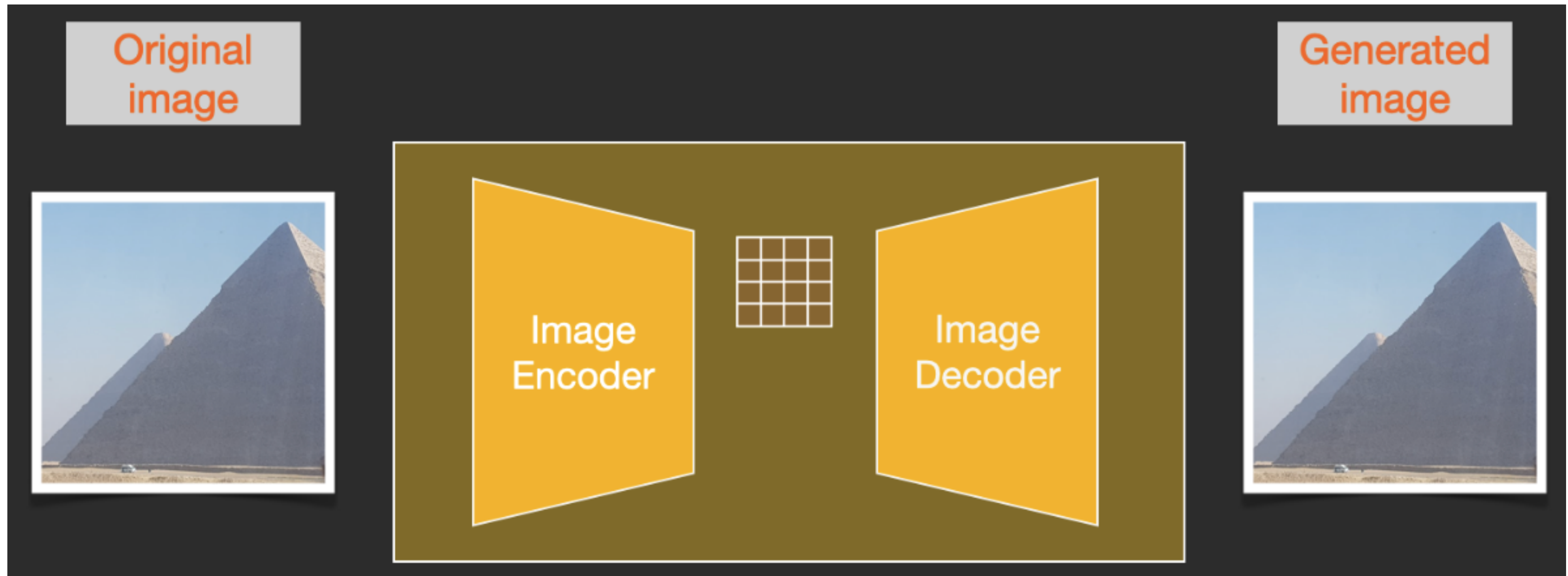


Joseph Rocca

<https://medium.com/data-science/understanding-diffusion-probabilistic-models-dpms-1940329d6048>

Image Generation by Reverse Diffusion (Denoising)





Jay Alammam

<https://jalammar.github.io/illustrated-stable-diffusion/>

High-Resolution Image Synthesis with Latent Diffusion Models, Robin Rombach, Andreas Blattmann, Dominik Lorenz, Patrick Esser, Björn Ommer, Dec 2021

Original image



Image
Encoder

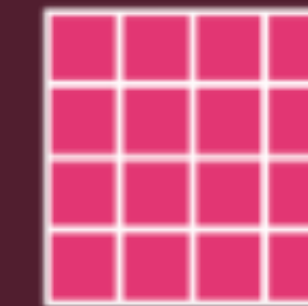
Generate training examples with different amounts of noise added to their compressed/latent version



Compressed
image (latent)



Latent + noise
sample 1 at
noise amount 1



Latent + noise
sample 2 at
noise amount 2



Latent + noise
sample 3 at
noise amount 3

Image Generation by Reverse Diffusion (Denoising)



Processed
Image
Information

UNet
Step
50



UNet
Step
2

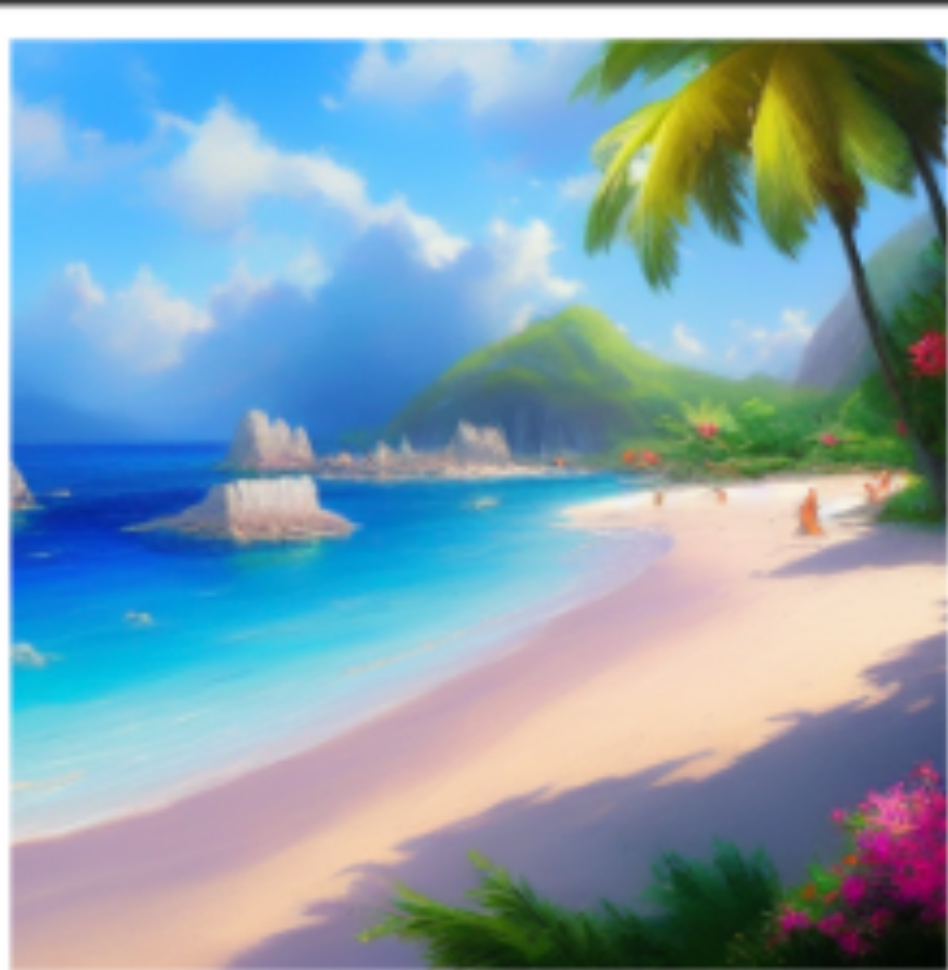


UNet
Step
1



Complete
noise

Image
Decoder

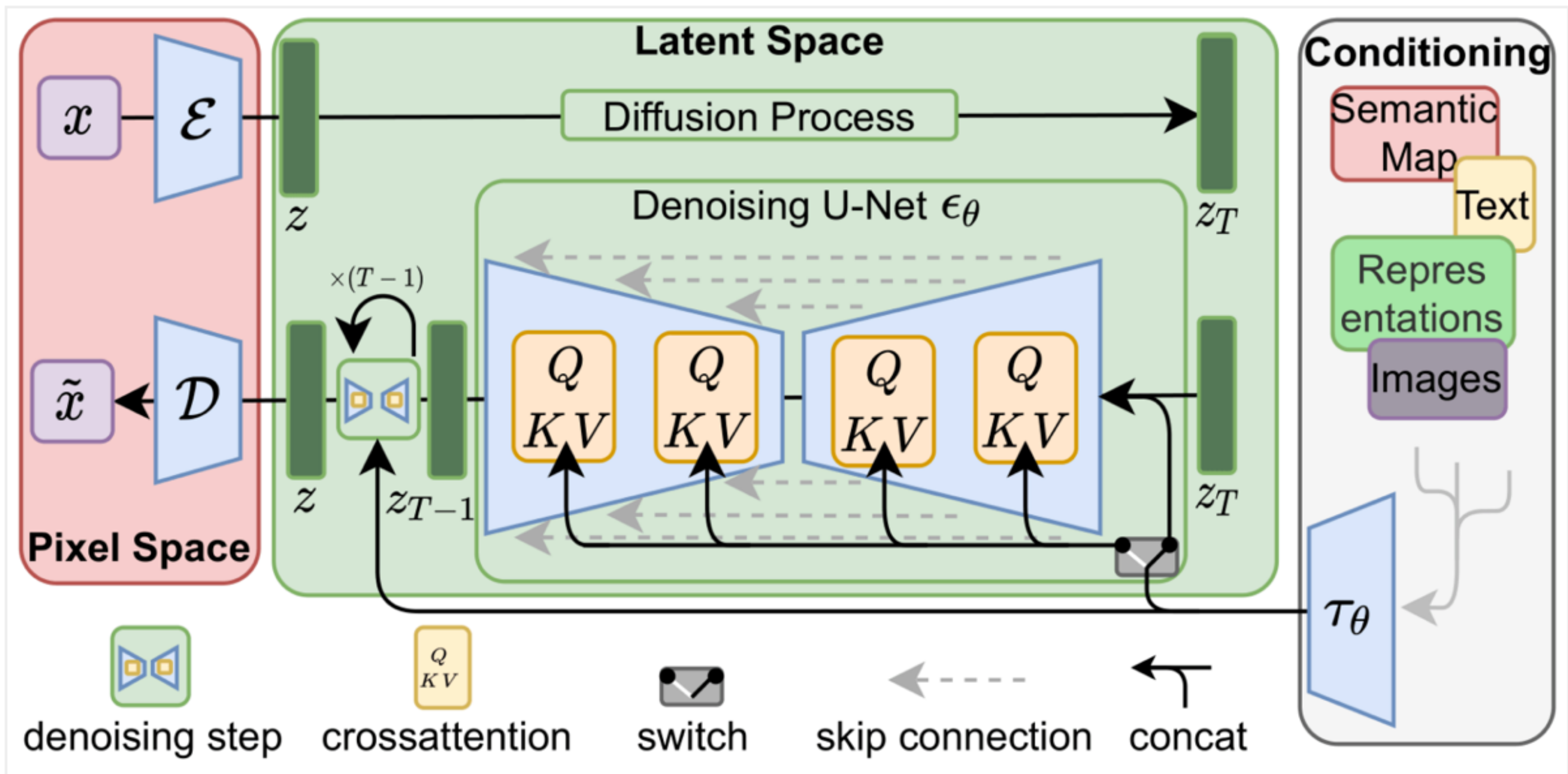


Generated image

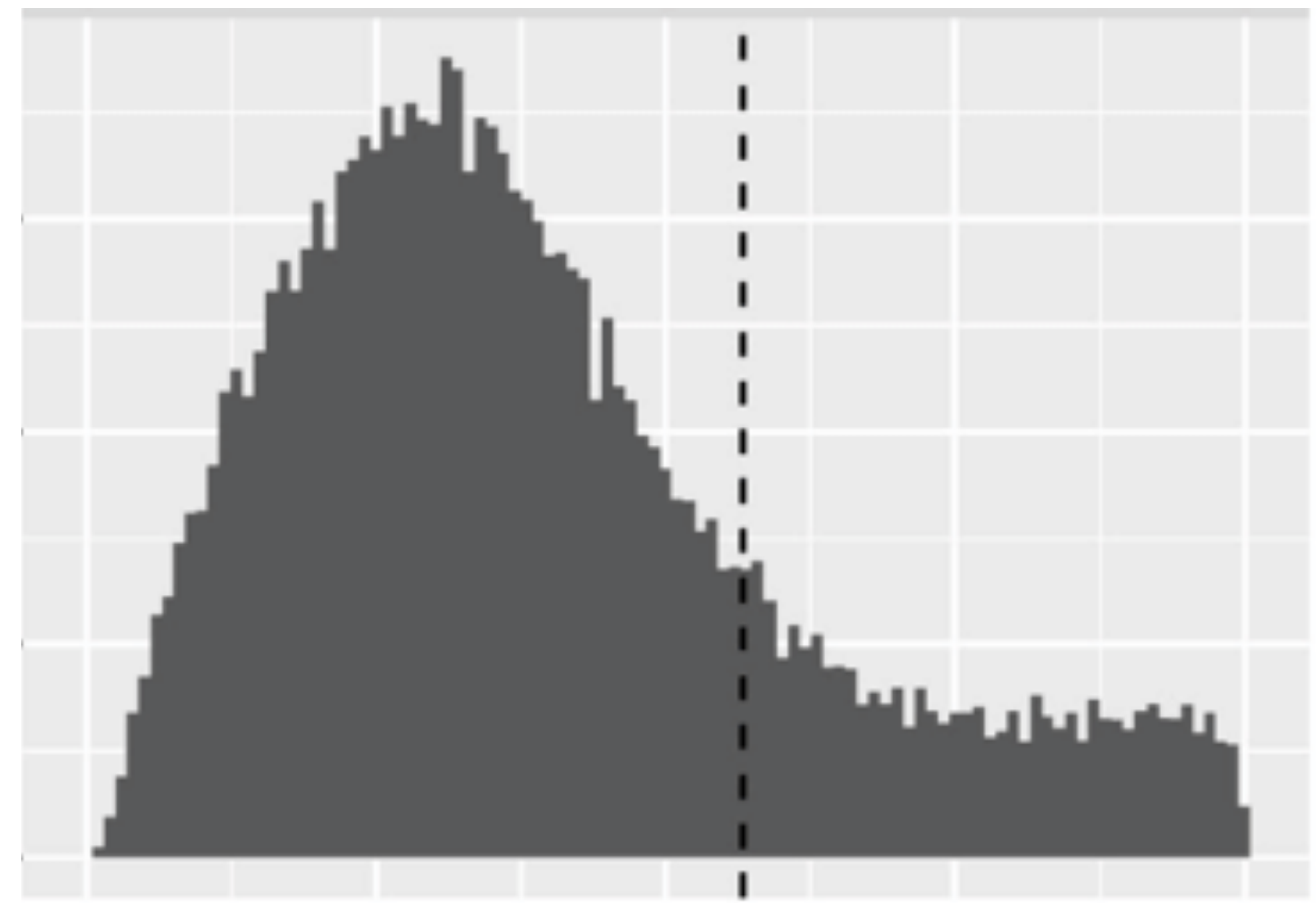
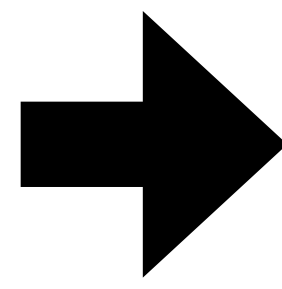
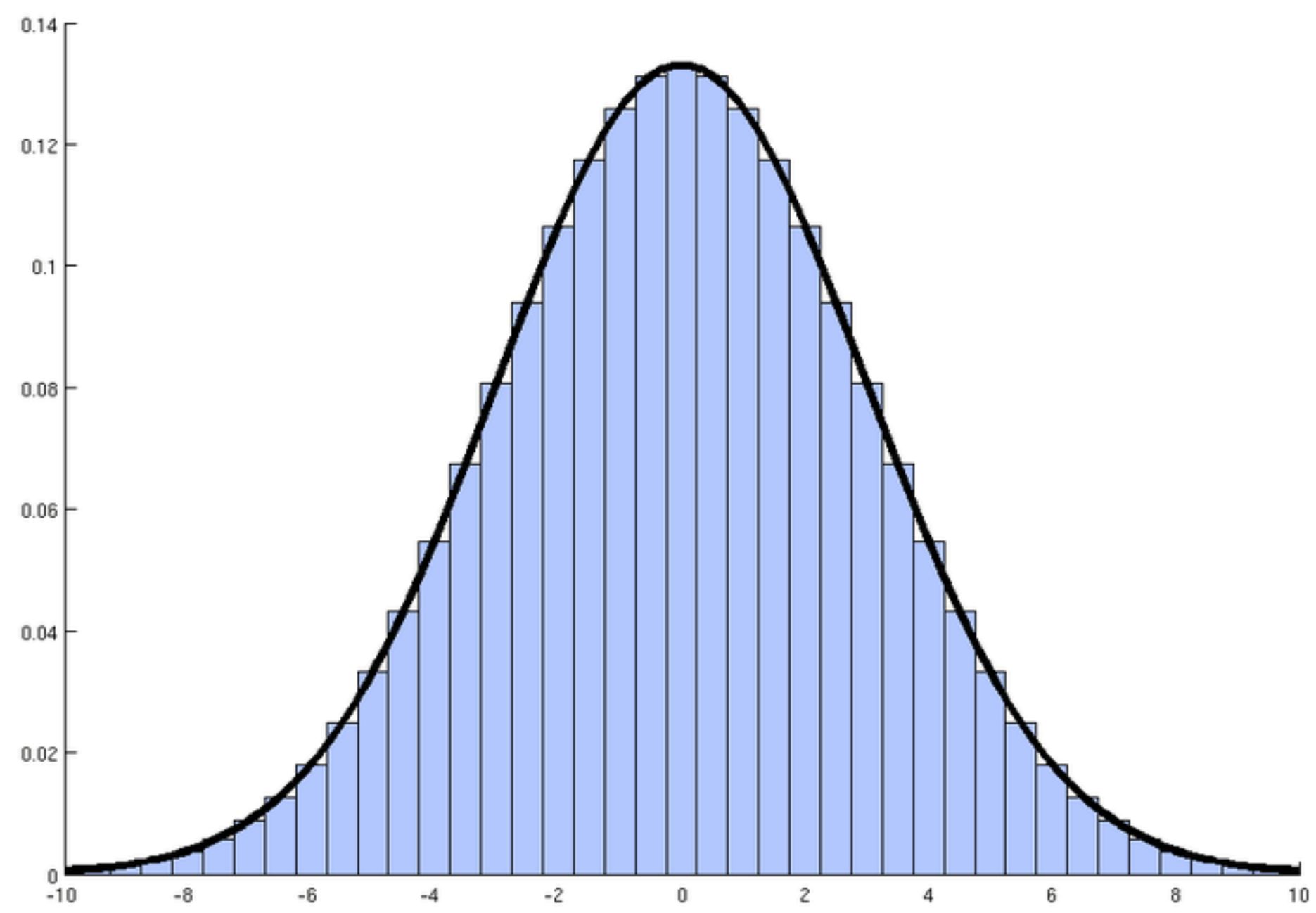
Jay Alammam

<https://jalammar.github.io/illustrated-stable-diffusion/>

Image Information Creator

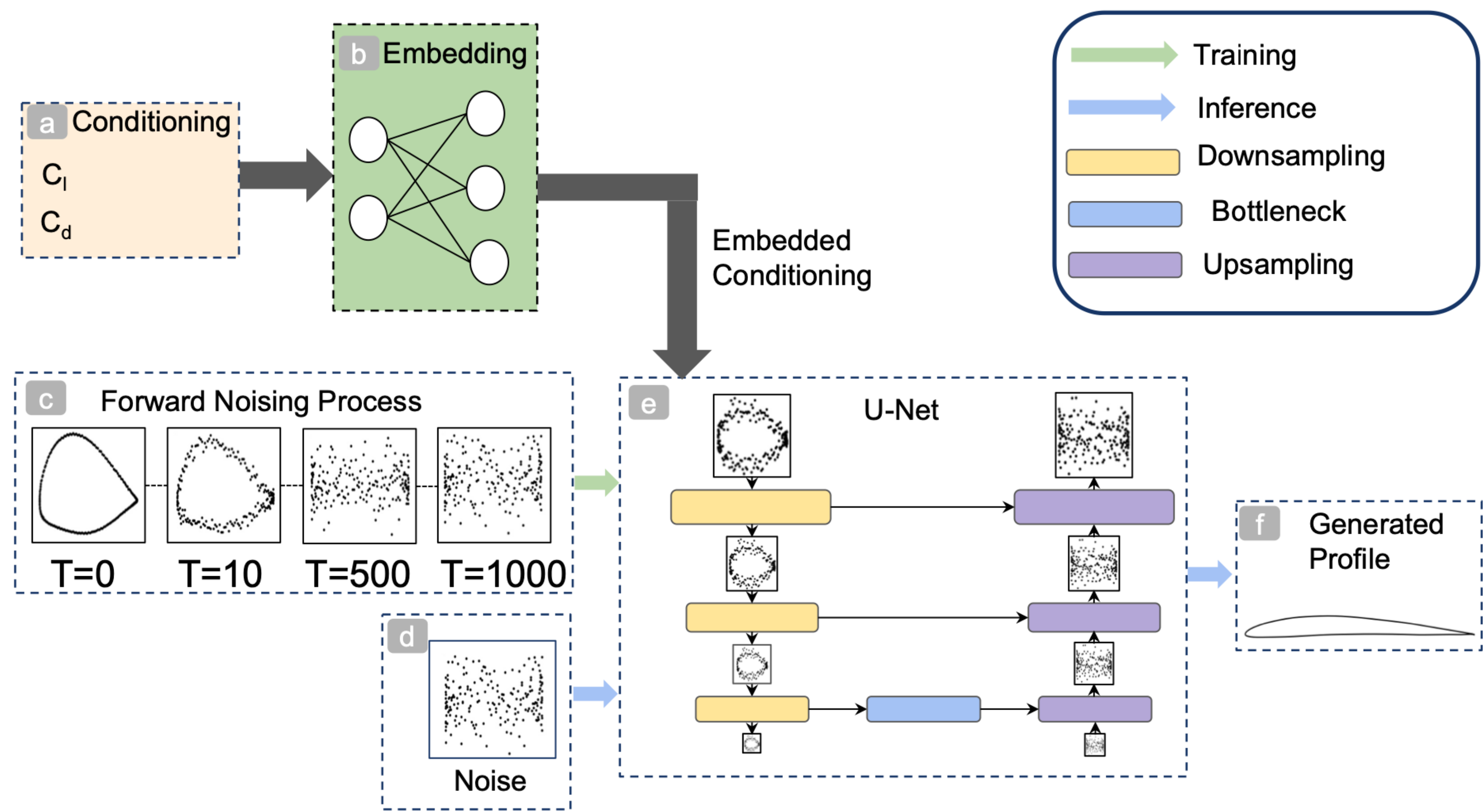


<https://openai.com/index/dall-e-2/>



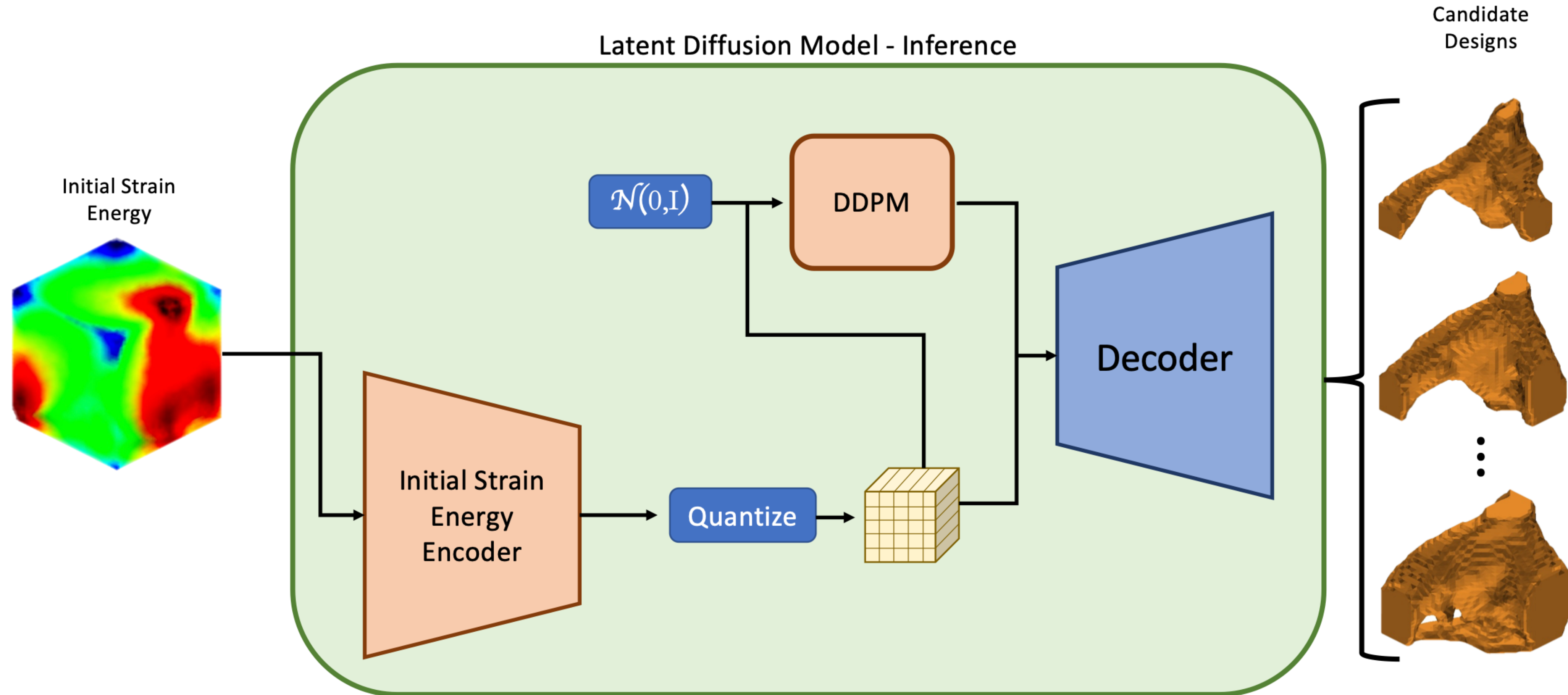
Airfoil Diffusion: Denoising Diffusion Model For Conditional Airfoil Generation

Reid Graves, Amir Barati Farimani



Latent Diffusion Models for Structural Component Design

Ethan Herron, Jaydeep Rade, Anushrut Jignasu, Baskar Ganapathysubramanian, Aditya Balu, Soumik Sarkar, Adarsh Krishnamurthy



PDE solvers

Diffusion-Based Failure Sampling for Cyber-Physical Systems

Harrison Delecki, Marc R. Schlichting, Mansur Arief, Anthony Corso, Marcell Vazquez-Chanlatte, Mykel J. Kochenderfer

