Image Generative Model

Stable Diffusion

What are Diffusion Models?

- It is generative deep learning model using noise reduction method
- It reverses the process of adding noise to an image
- Usually use for text-to-image, but also img-to-img and inpainting
- More stable than GAN (no mode collapse)

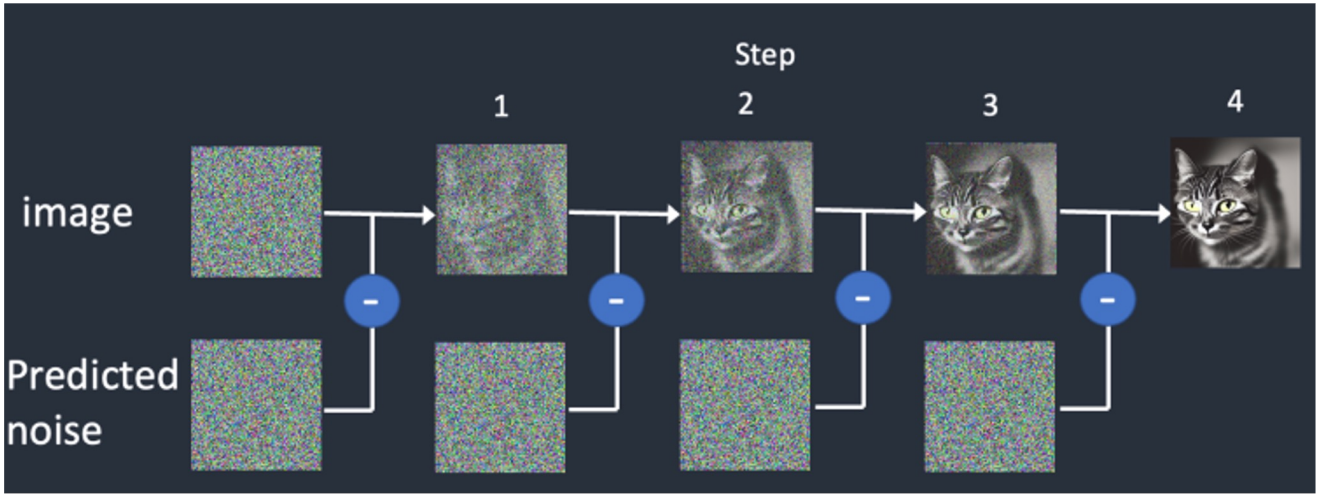

Figure 1 The Process of Noise Reduction

Stable diffusion

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- Text-to-Image (Image-to-Image in some pipeline)
- Latent diffusion model + Text encoder
- Open access
- Trained on 512 × 512 images from a subset of the LAION-5B database
- Uses a frozen CLIP ViT-L/14 text encoder

Outline

- How to train & generate image
- Finetuning Techniques
- Code Demo

How to Train & Generate Image

Stable Diffusion Model Comprises

1) Tokenizer → tokenize prompt
2) Text Encoder → encode tokens
3) Variational Auto-Encoder (vae) → map image to latent space
4) Noise Scheduler → generate noise
5) UNET → predict noise

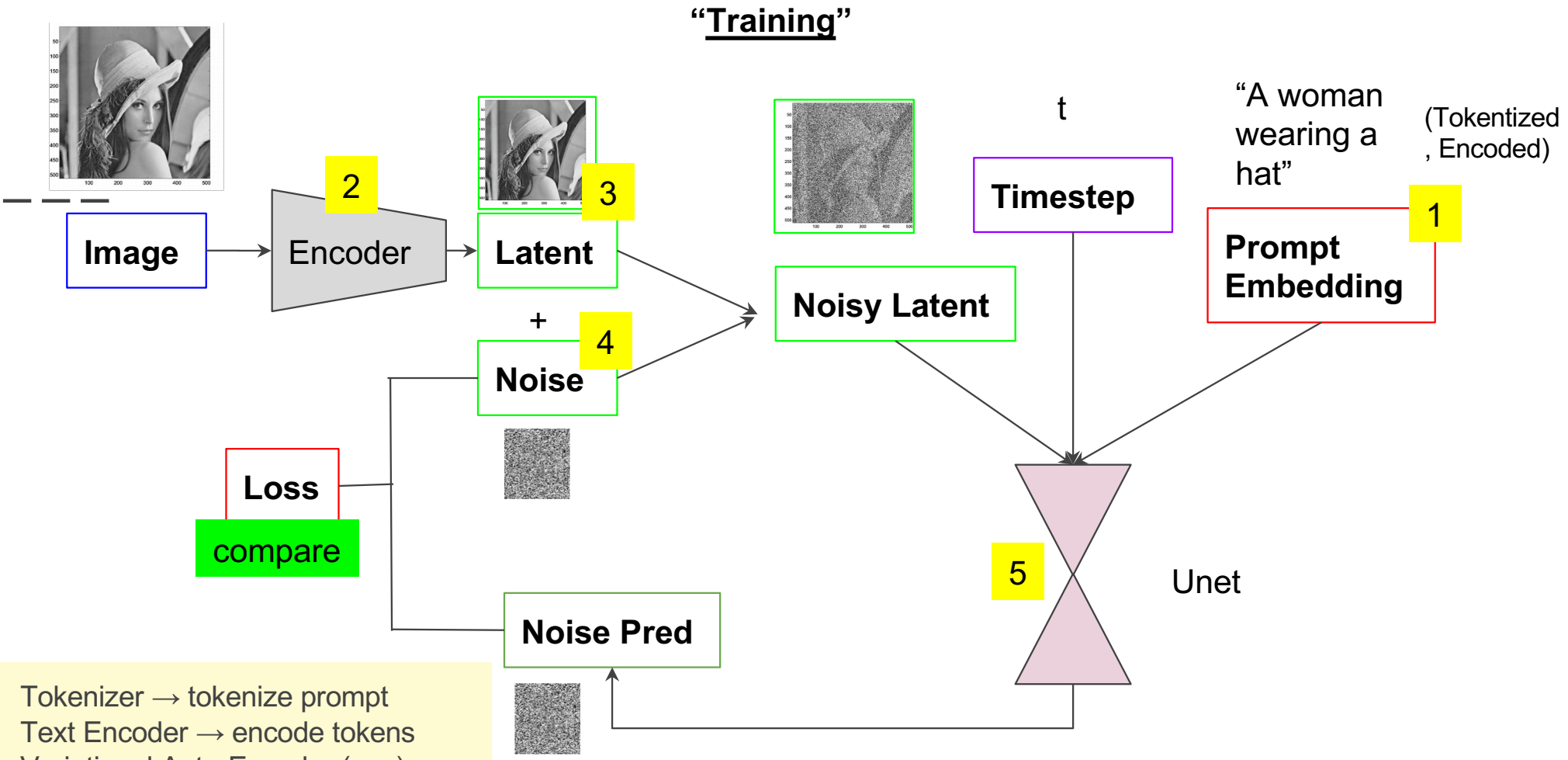

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Figure 4 Diffusion During Training

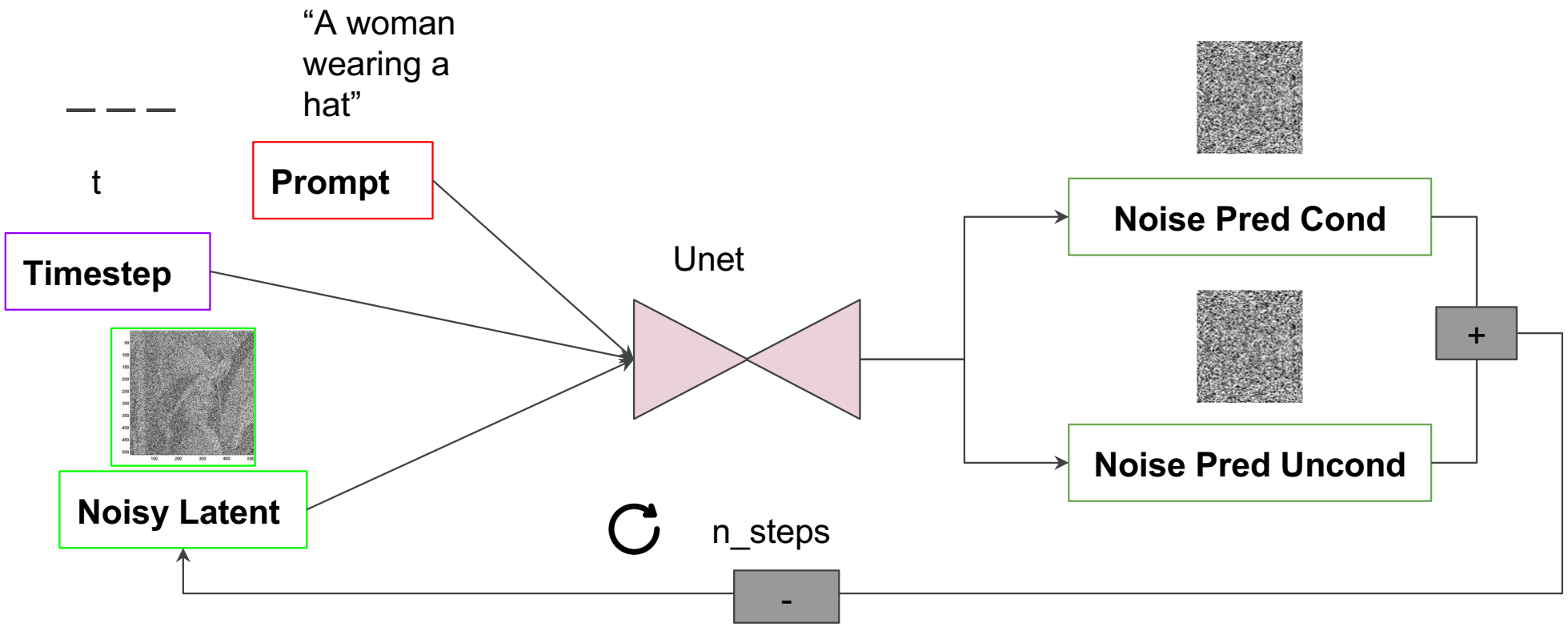

Figure 3 Diffusion Model During Inference

Finetuning Techniques

Finetuning Techniques

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- Textual Inversion
- DreamBooth
- ControlNet

Textual Inversion (paper)

- Use a small set of images (typically 3-5)
- The image depicts our target concept across multiple settings
- e.g. varied background or poses
- “We intervene in the embedding process and replace the vector associated with the rokenized string with a new, learning embedding”
- “In essence “injecting” the concept in to our vocabulary”
- Cons of Textual Inversion
  - This method only trains text encoder (Tokenizer)
  - It’s good when you want to give your “concept” a new style

Textual Inversion (paper)

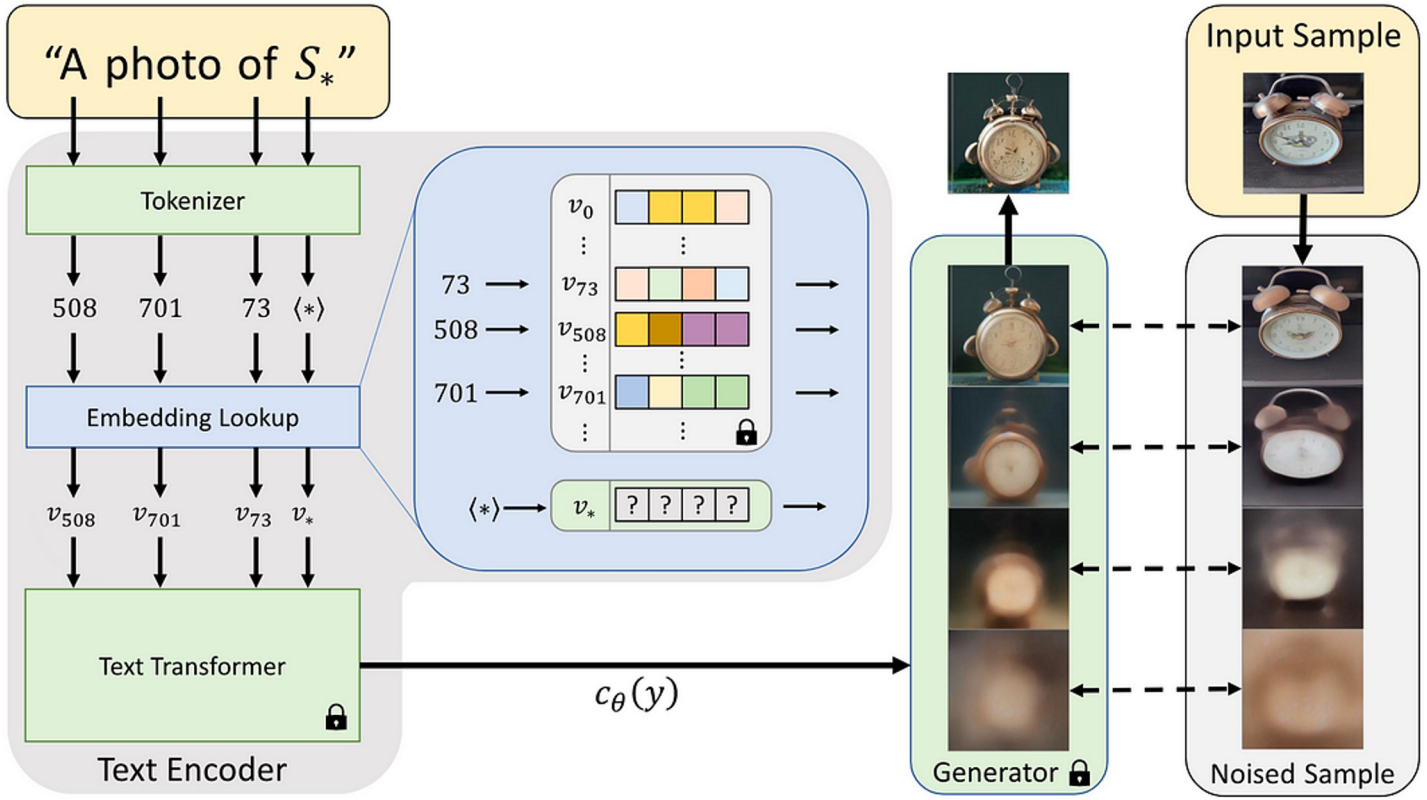


Figure 4 Outline for text embeddings and inversion process

DreamBooth (paper)

- trains unet (and text encoder if you want)
- only need 3-5 image per subject
- May overfit to training data
- Some subjects are easier to learn then others

DreamBooth (paper)

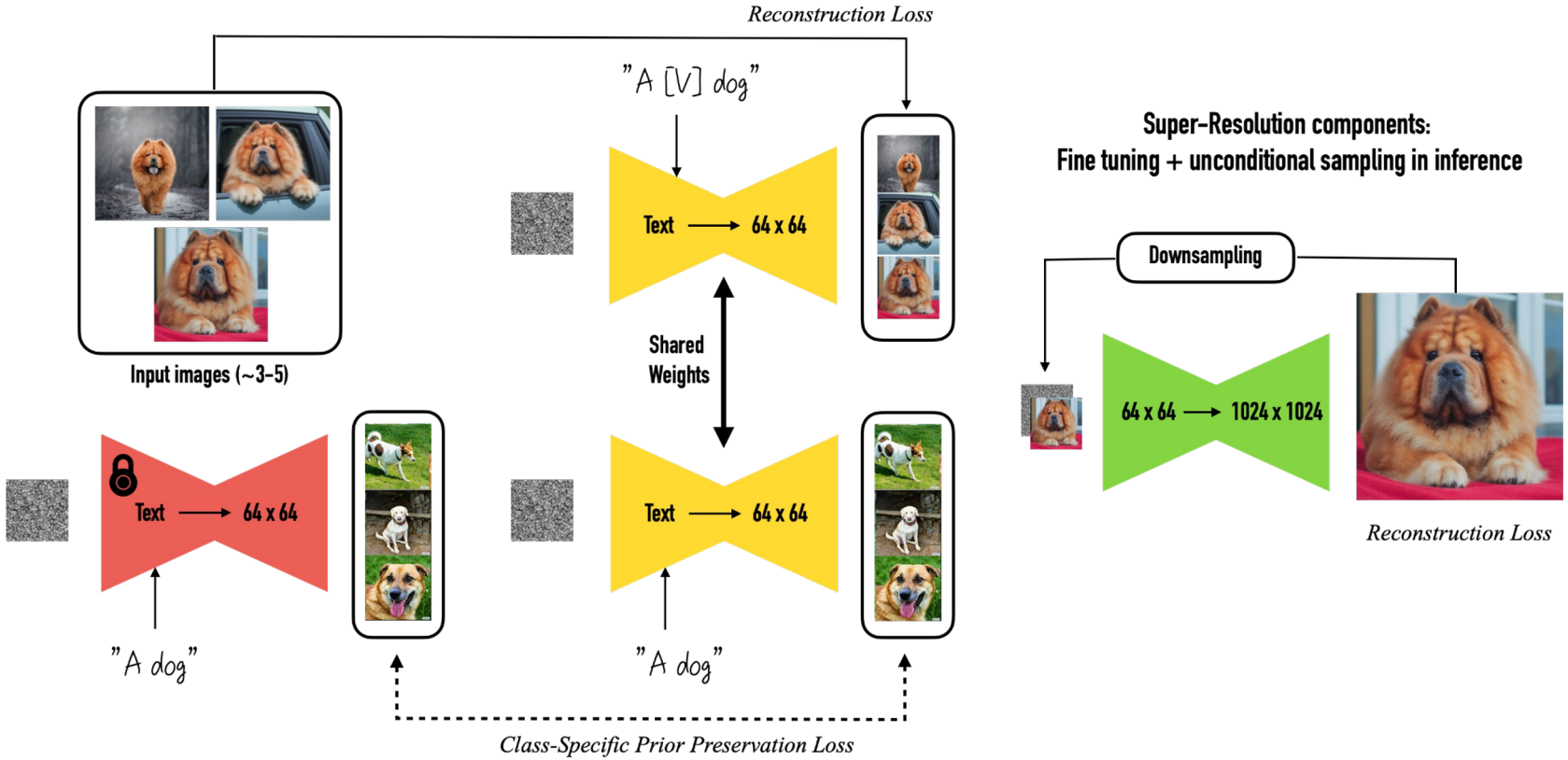


Figure 5 Architecture overview from the Breambooth

ControlNet (paper)

- ControlNet is model that add conditioning controls pretrained diffusion model
- Condition input to guide the content of the generated image usually is edge maps, pose key points, depth maps, segmentation maps, normal maps, etc

Figure 6: Control Stable Diffusion with Canny edge map

ControlNet Architecture

- ControlNet architecture is based on copying the structure and weights from the encoder part of the U-net architecture.
- For the decoder, the “zero convolution” is an 1 × 1 convolution layer with both weight and bias initialized as zeros.

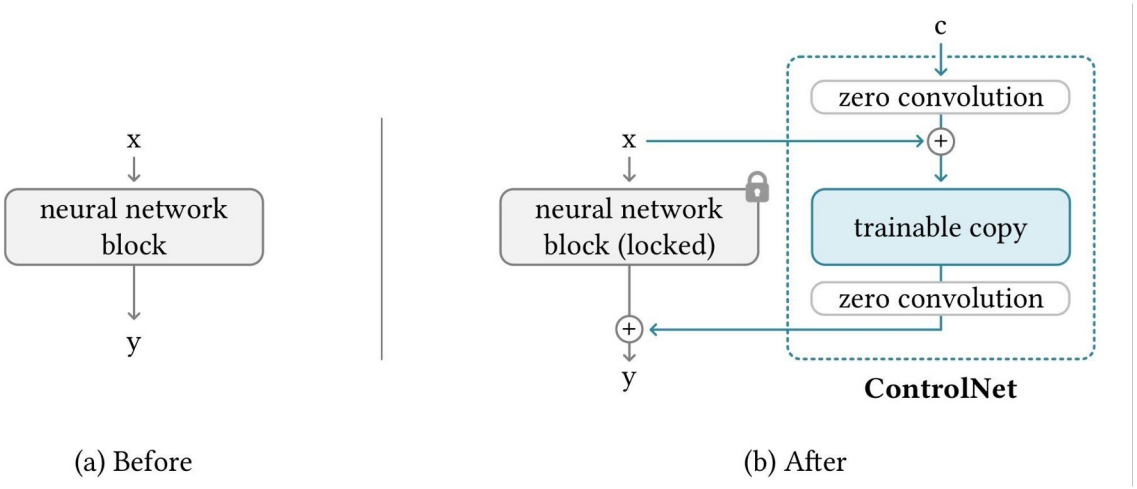
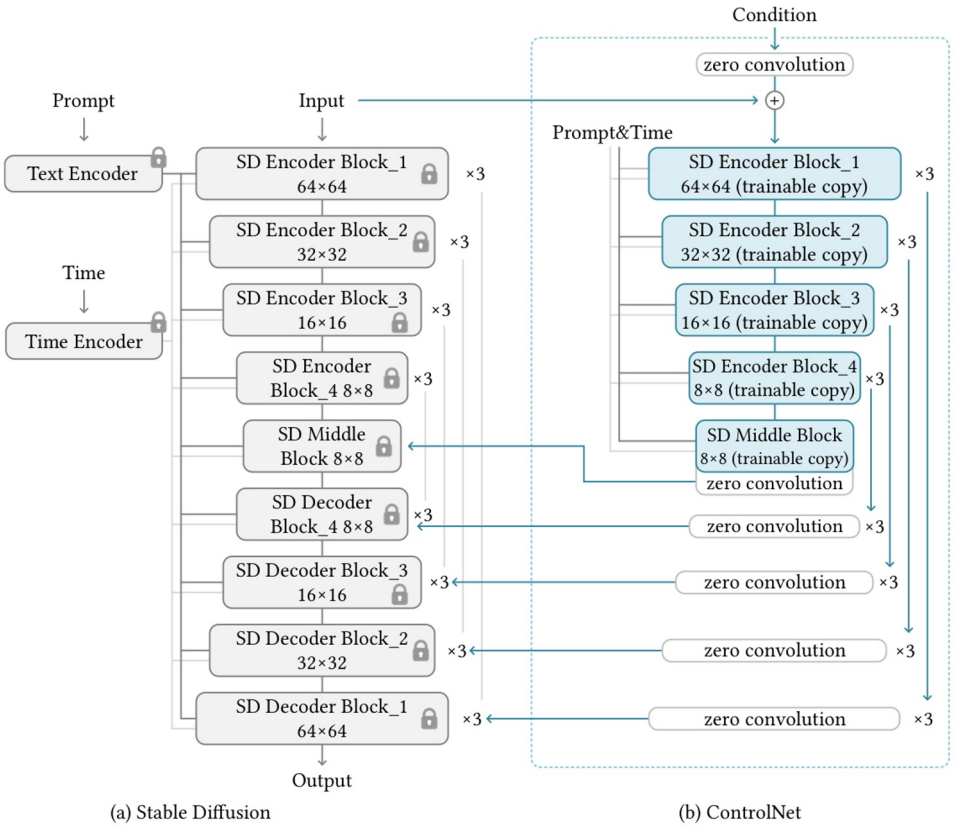


Figure 7: ControlNet. We show the approach to apply a ControlNet to an arbitrary neural network block. The x, y are deep features in neural networks. The “+” refers to feature addition. The “c” is an extra condition that we want to add to the neural network. The “zero convolution” is an 1 × 1 convolution layer with both weight and bias initialized as zeros.

Training a ControlNet for Diffusion



- In the training step, all parameters in the Diffusion part are locked, but only the ControlNet part is trained.

Figure 8: ControlNet in Stable Diffusion.

Code Demo

Text-to-Image

StableDiffusionPipeline

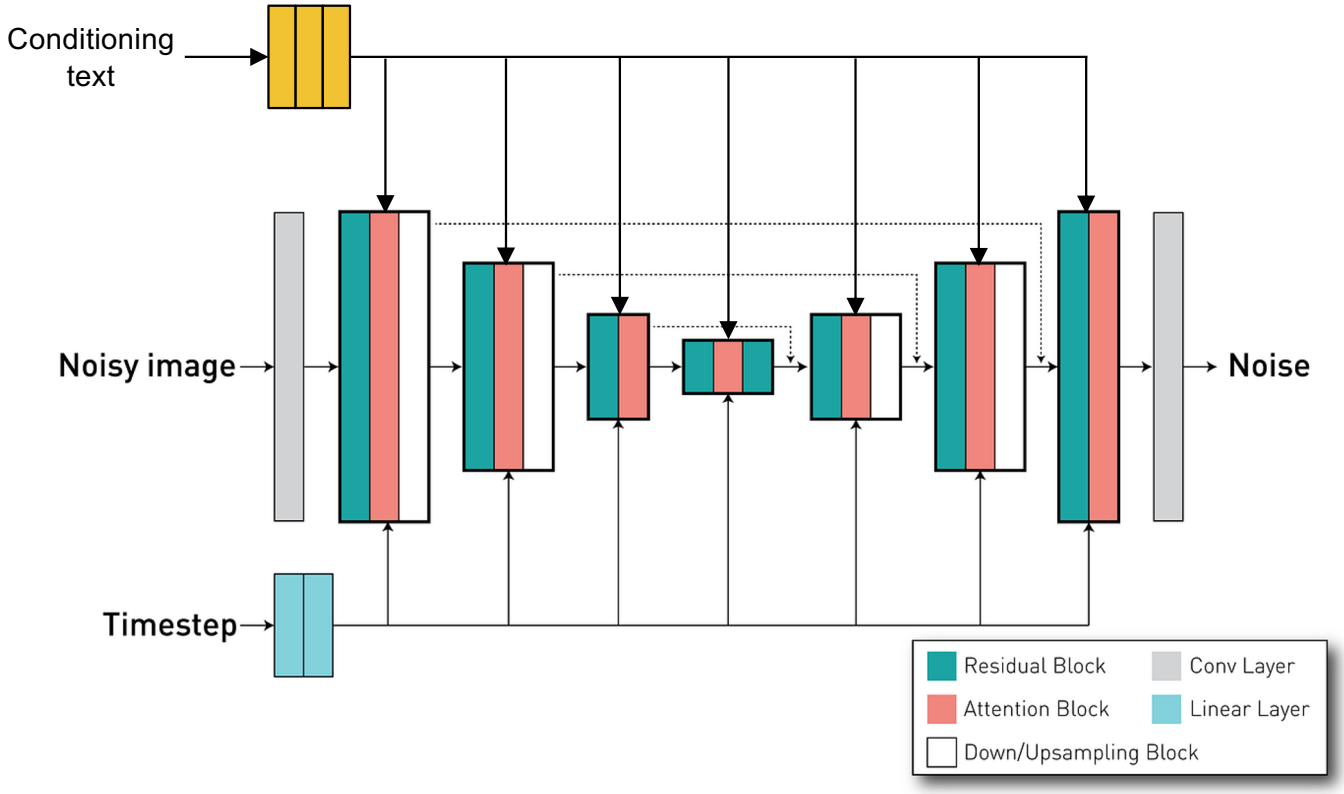


Image-to-Image

StableDiffusionImg2ImgPipeline

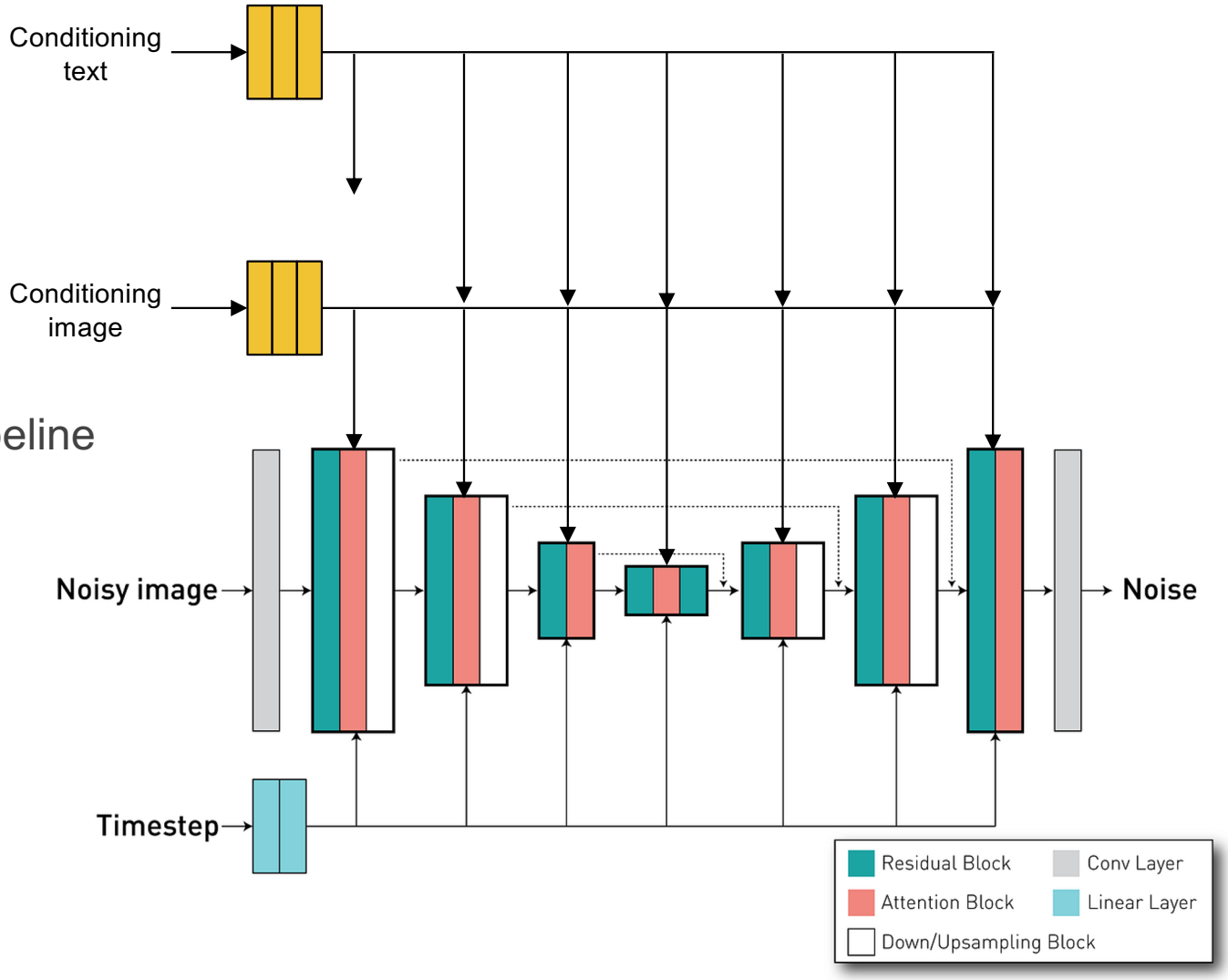


Image-to-Image(ControlNet)

StableDiffusionControlNetPipeline

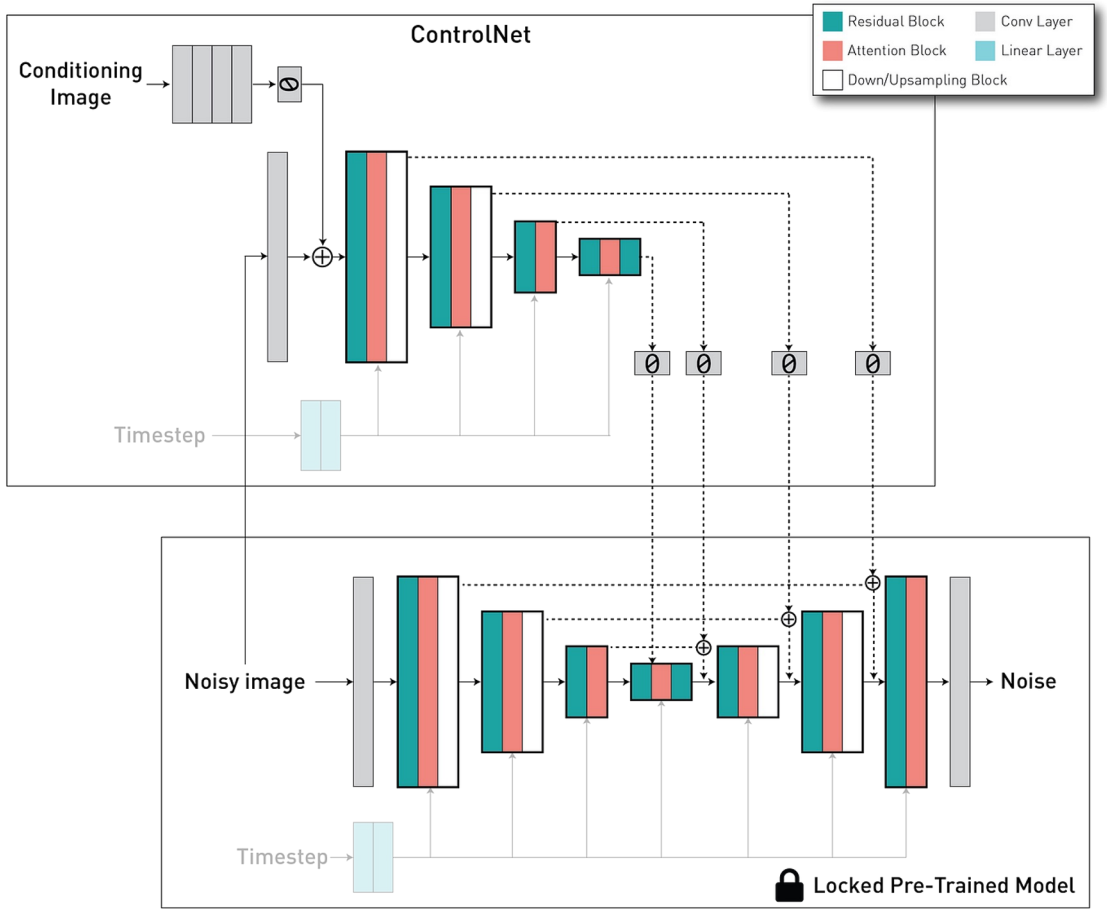
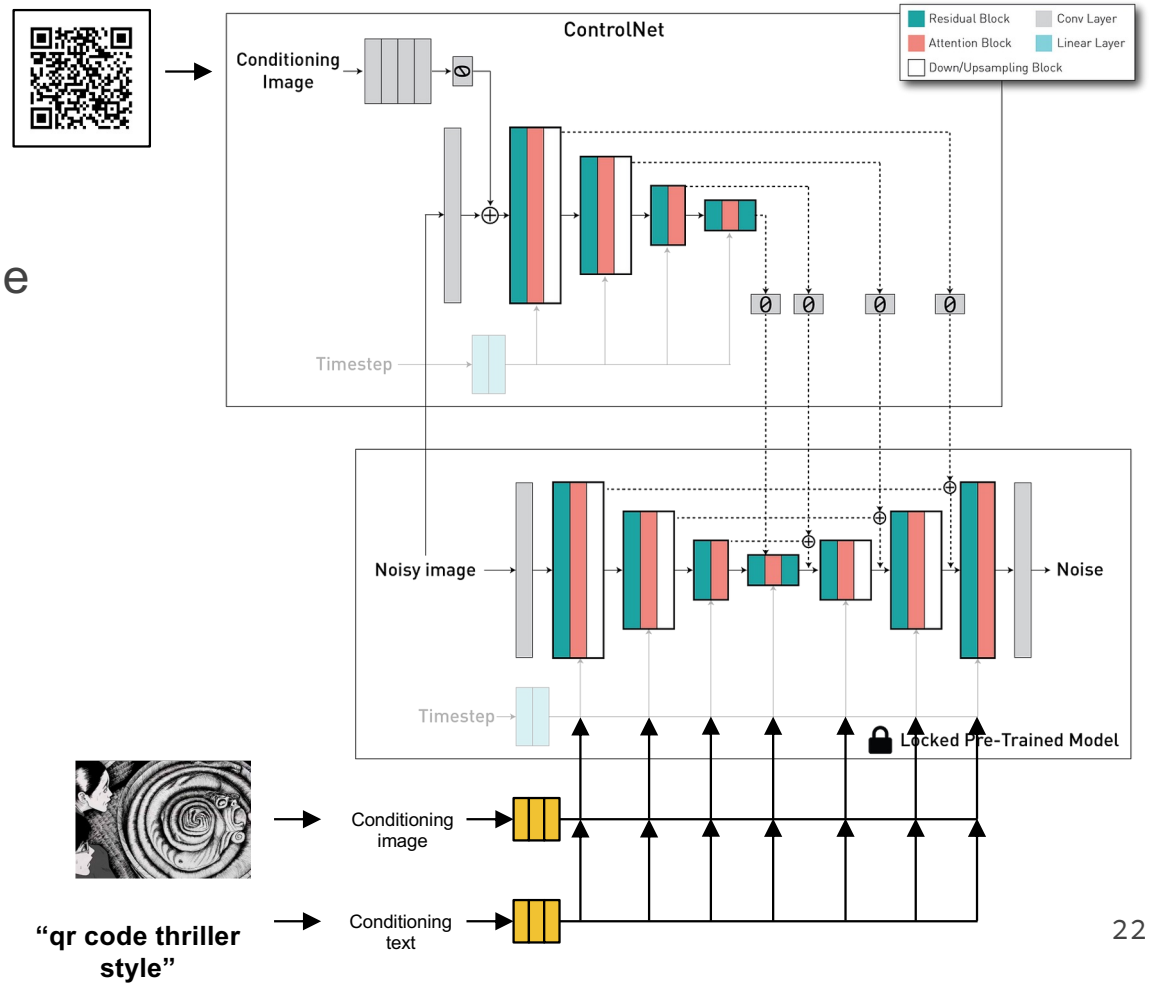


Image-to-Image(ControlNet)

StableDiffusionControlNetImg2ImgPipeline



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