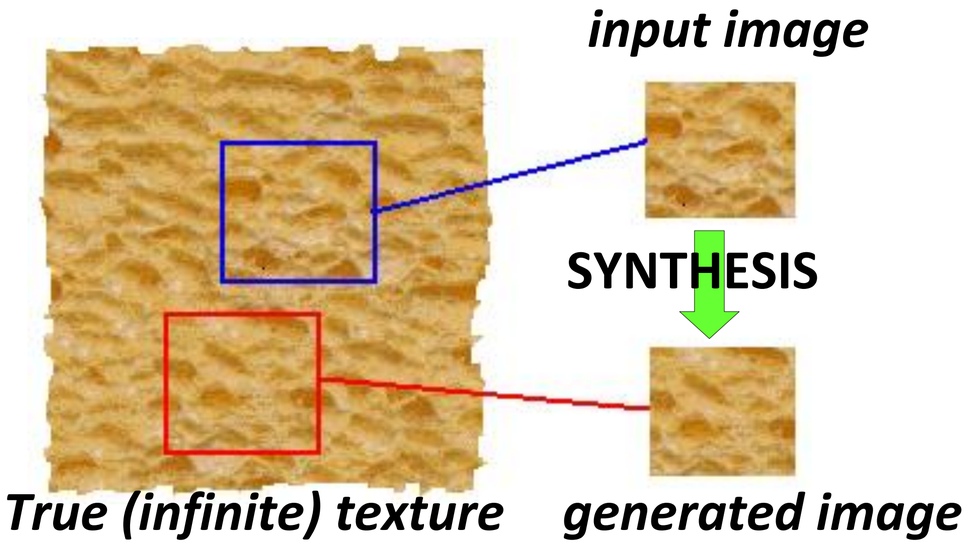
Generating Images from Noise

CS194: Intro to Comp. Vision and Comp. Photo

Alexei Efros, UC Berkeley, Fall 2022

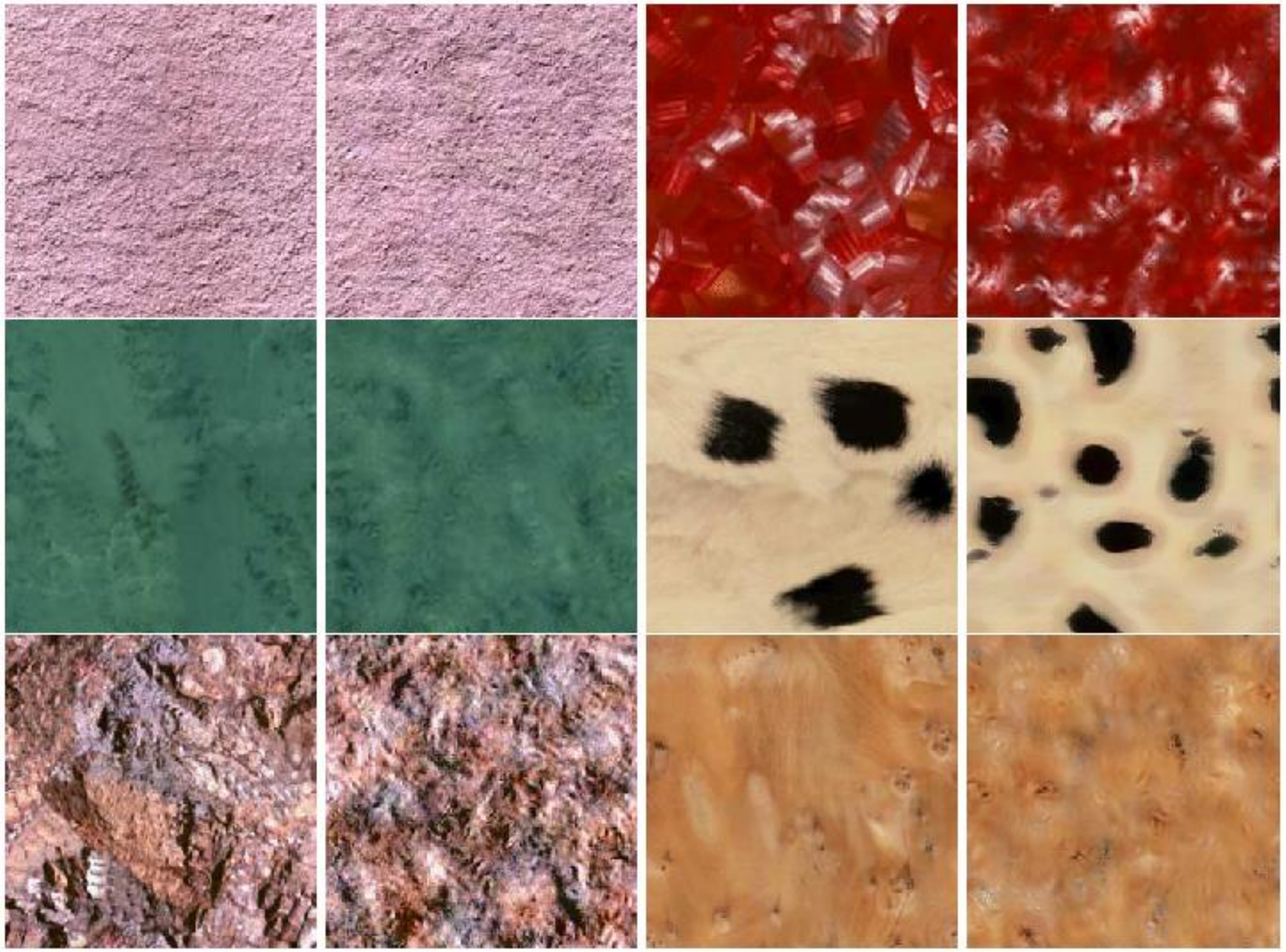
Texture as samples from distribution

Parametric Texture Synthesis



Goal: parametric **generative model** of the "infinite texture"

Heeger & Bergen, SIGGRAPH‘95

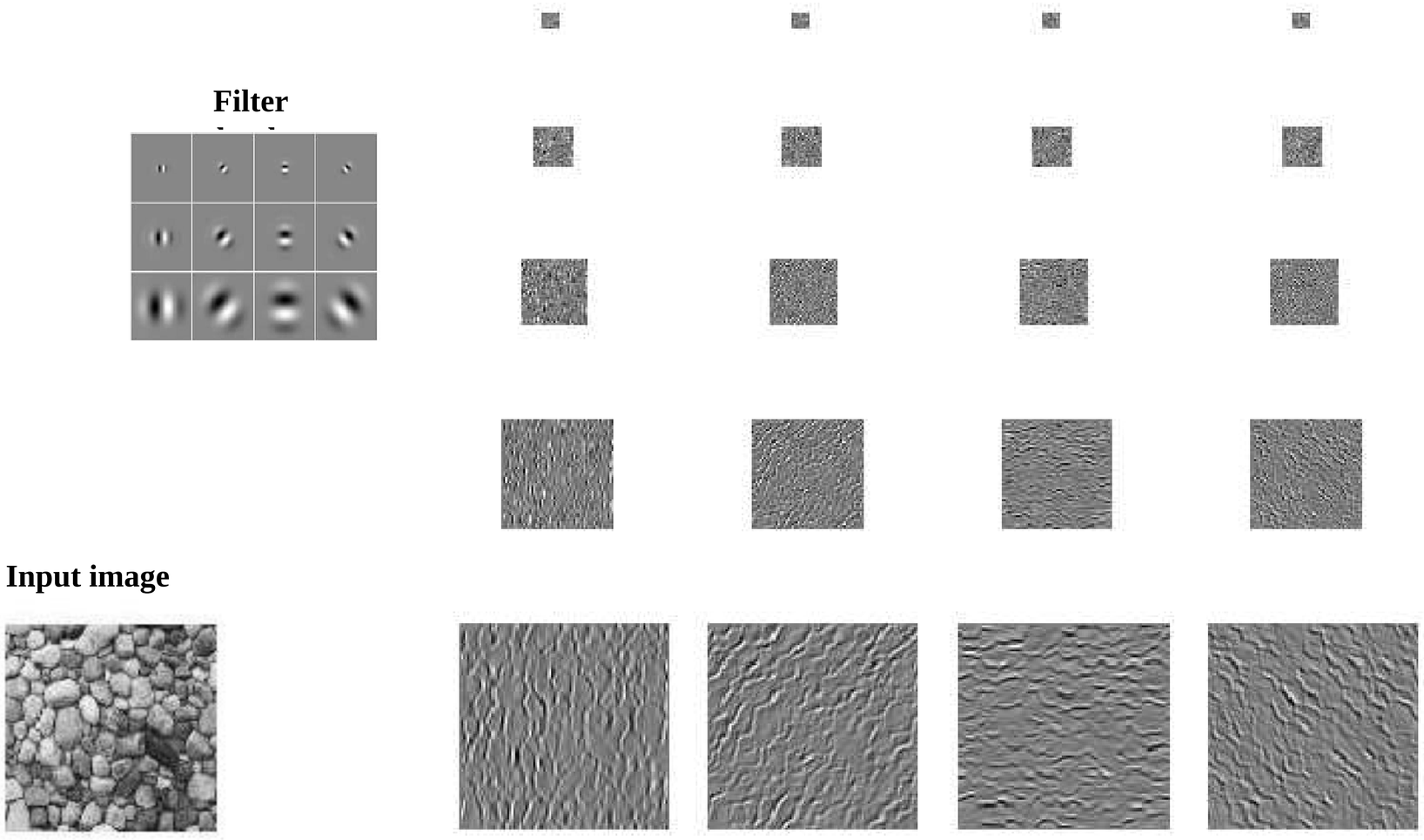


Early Vision Texture Models

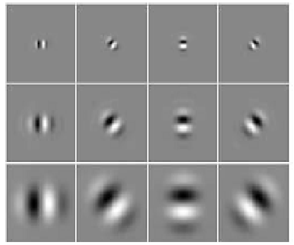
Linear filter bank

Heeger & Bergen (1995)
Portilla & Simoncelli (2000)

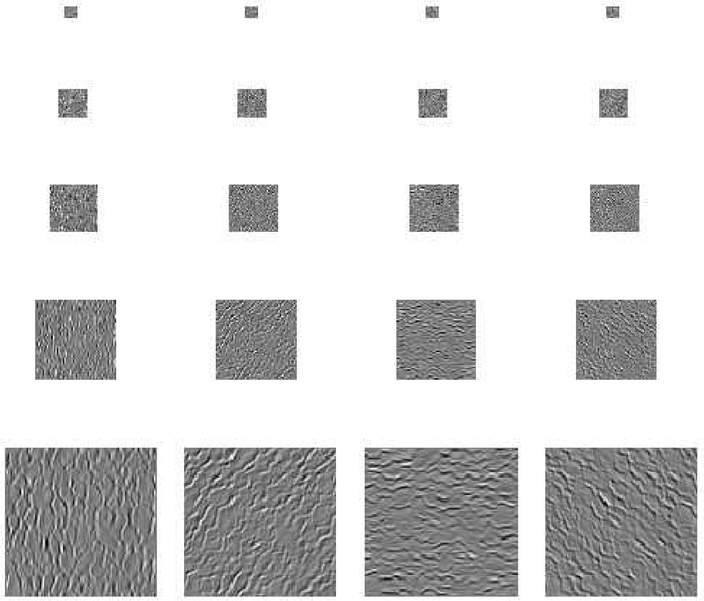
Multi-scale filter decomposition (steerable pyramid)

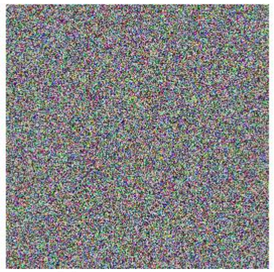


Step 1: Convolve with filterbank

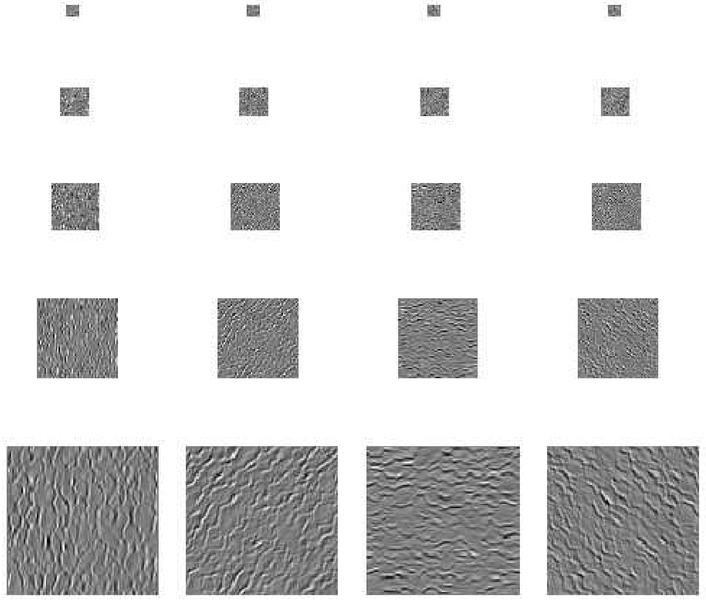


input

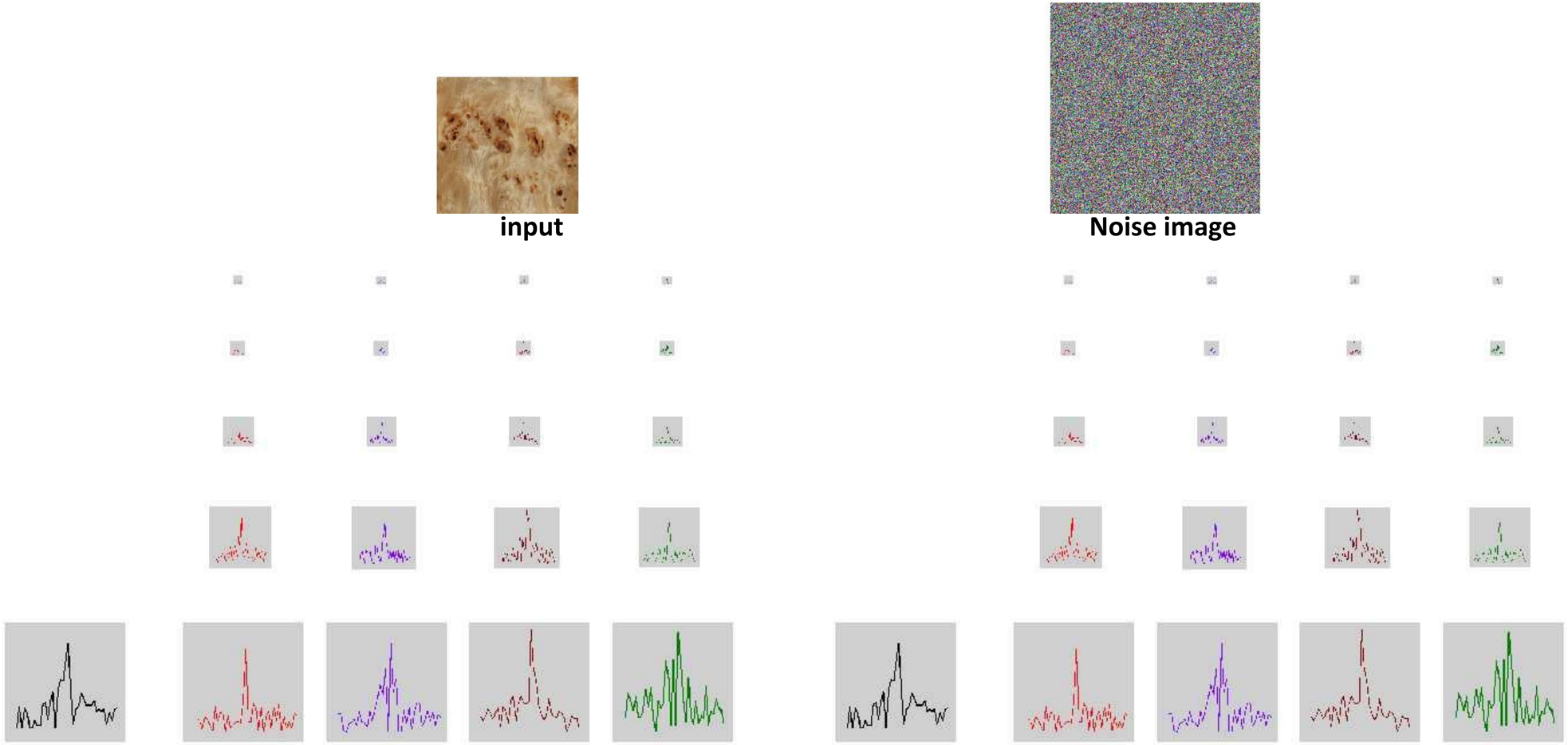




Noise image



Step 2: match per--channel histograms

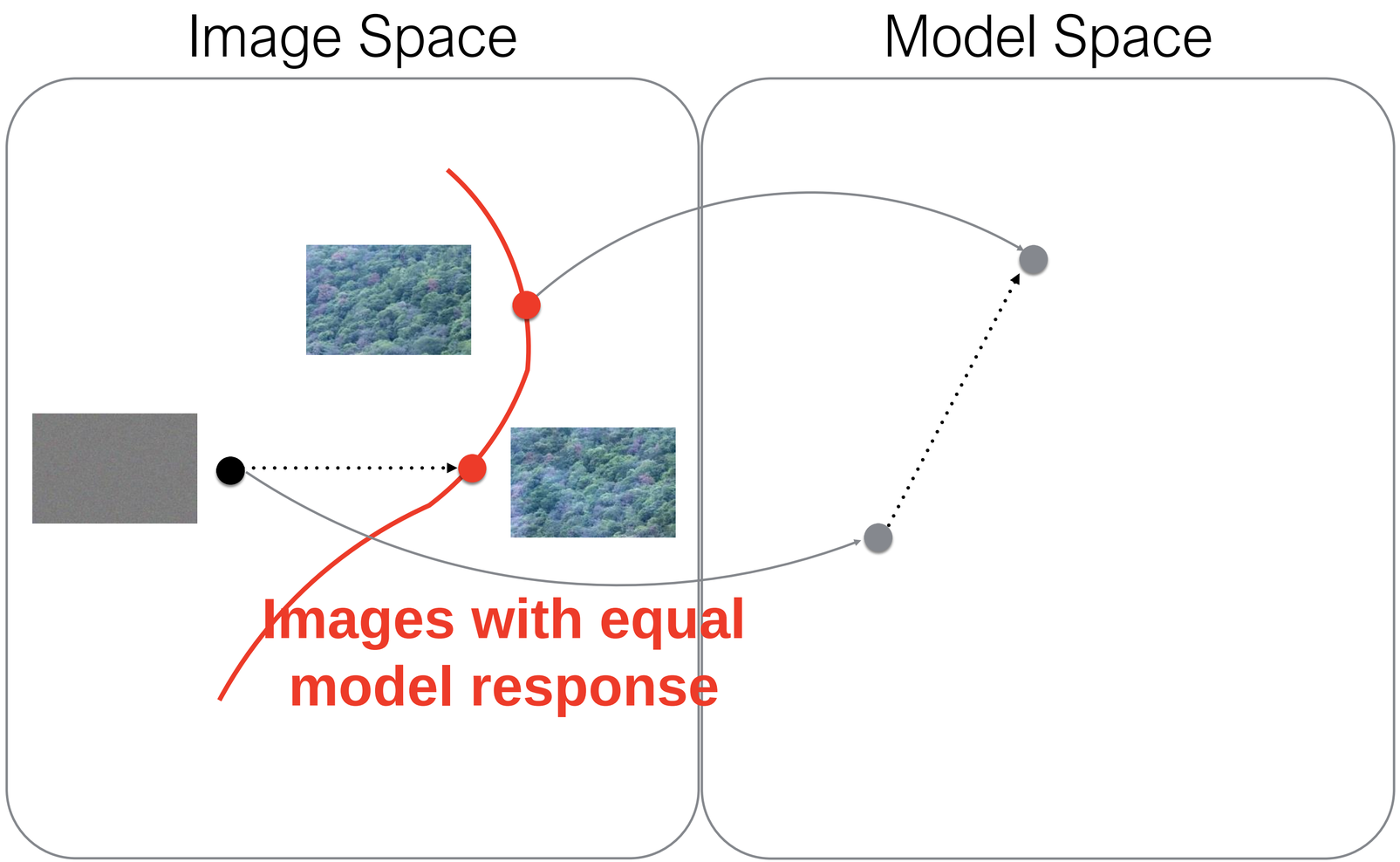


Step 3: collapse pyramid and repeat!

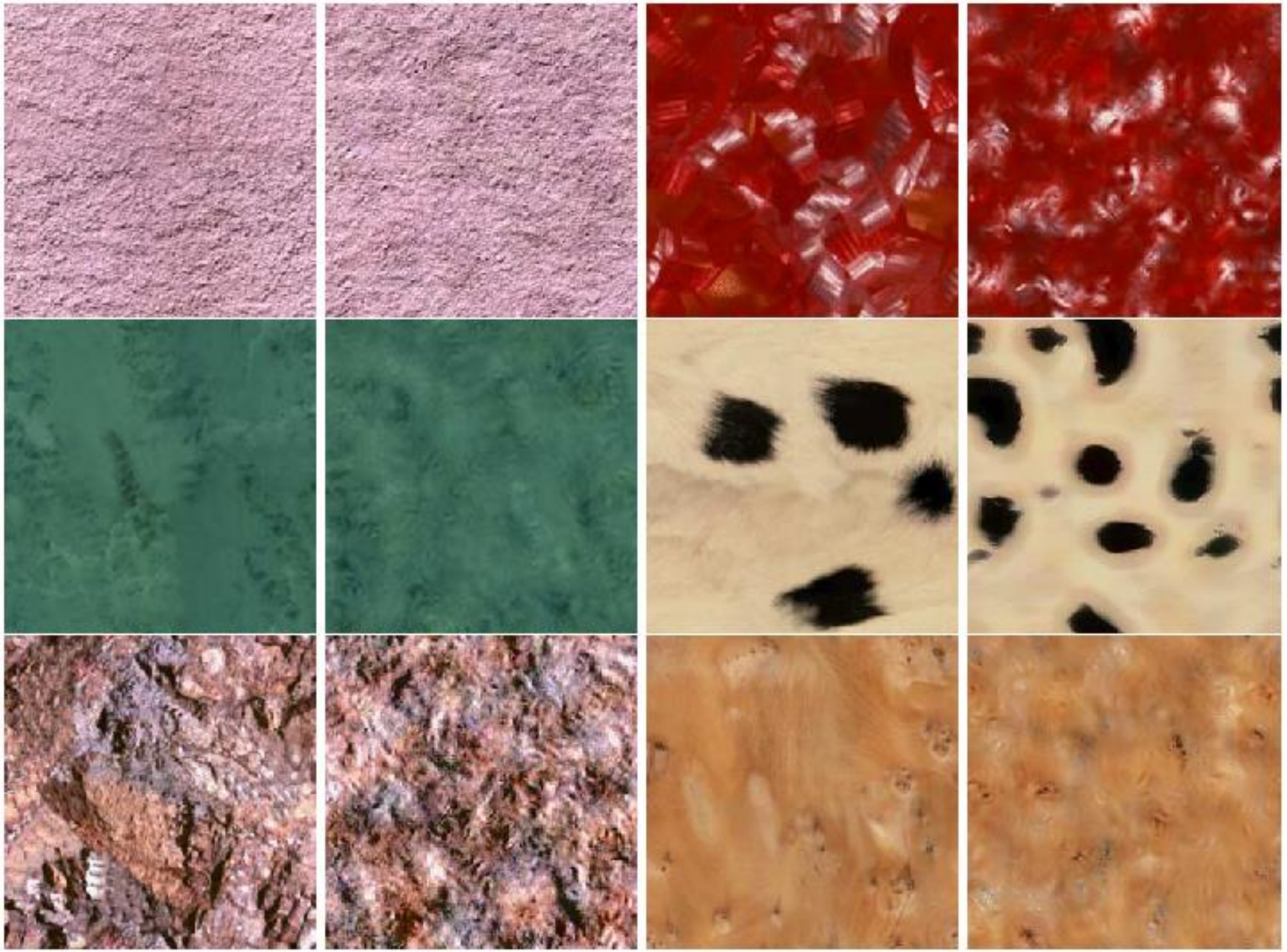
input

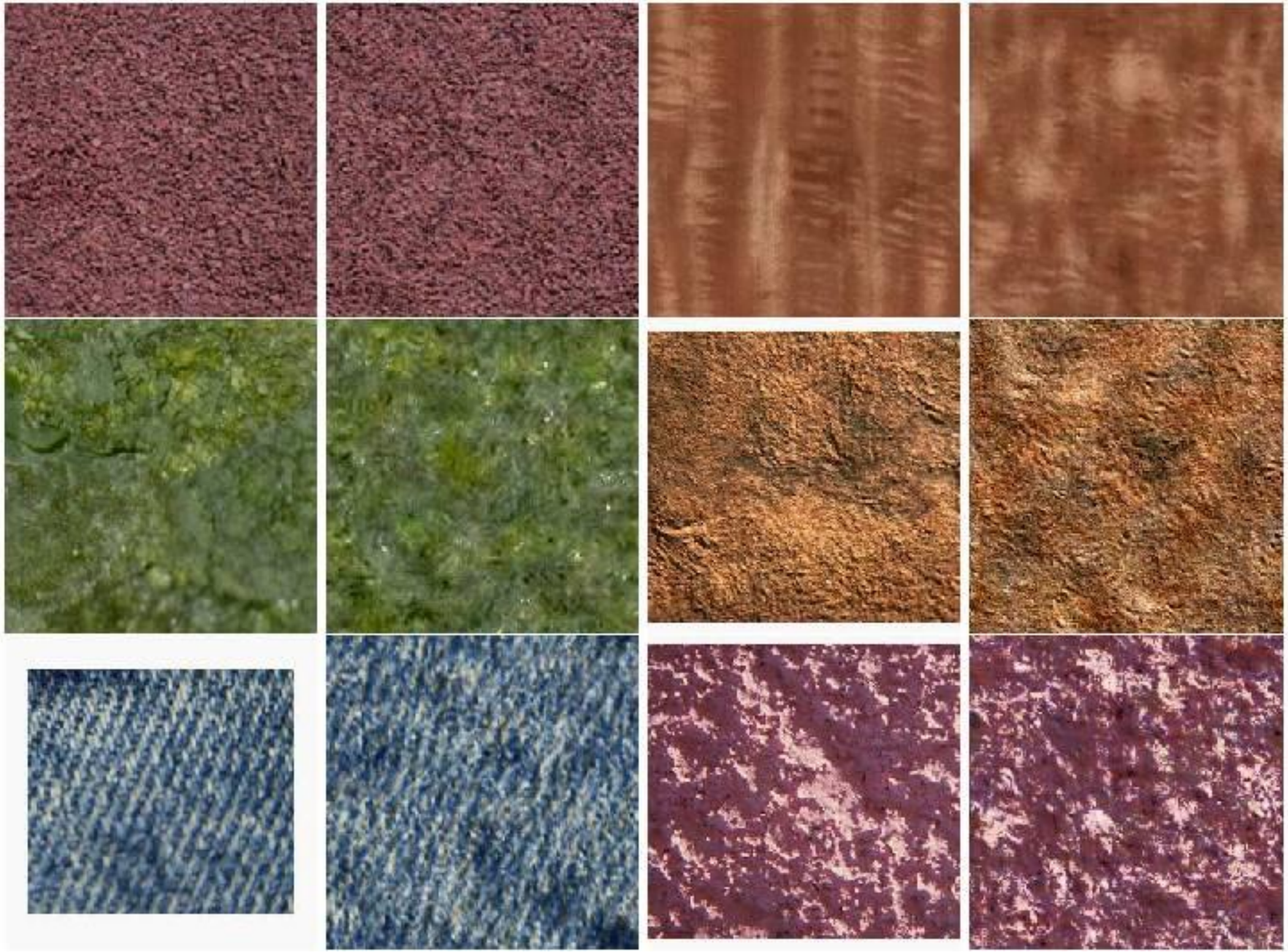
Noise image

Texture Synthesis



Portilla & Simoncelli (2000)





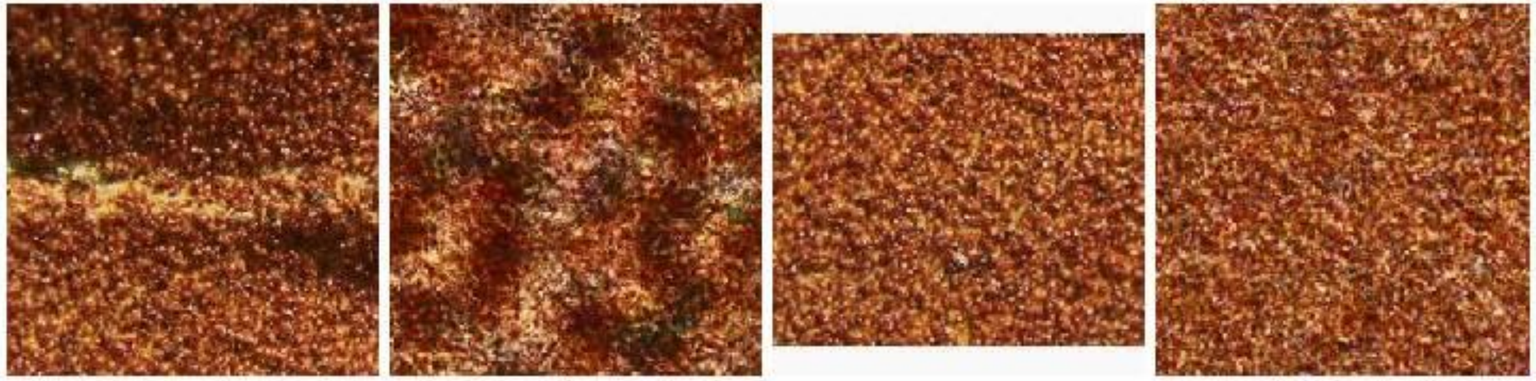


Figure 7: (Left pair) Inhomogeneous input texture produces blotchy synthetic texture. (Right pair) Homogenous input.

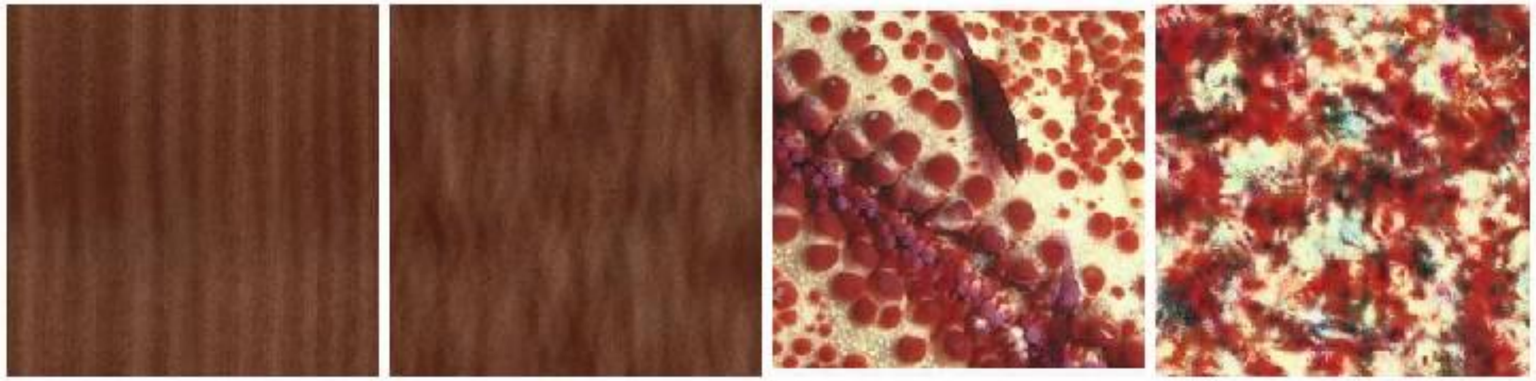


Figure 8: Examples of failures: wood grain and red coral.

Figure 9: More failures: hay and marble.

Simoncelli & Portilla ’98+

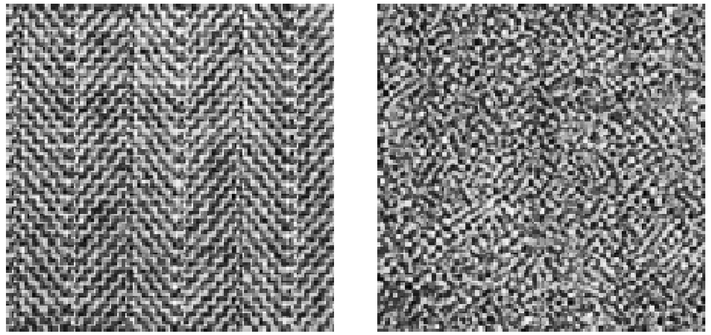
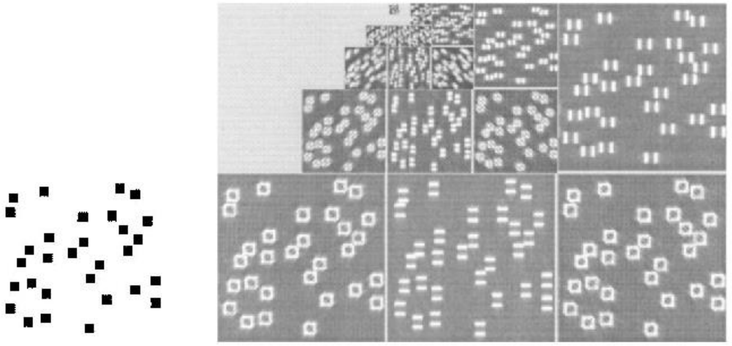


Figure 1. Textures with matching marginal statistics.

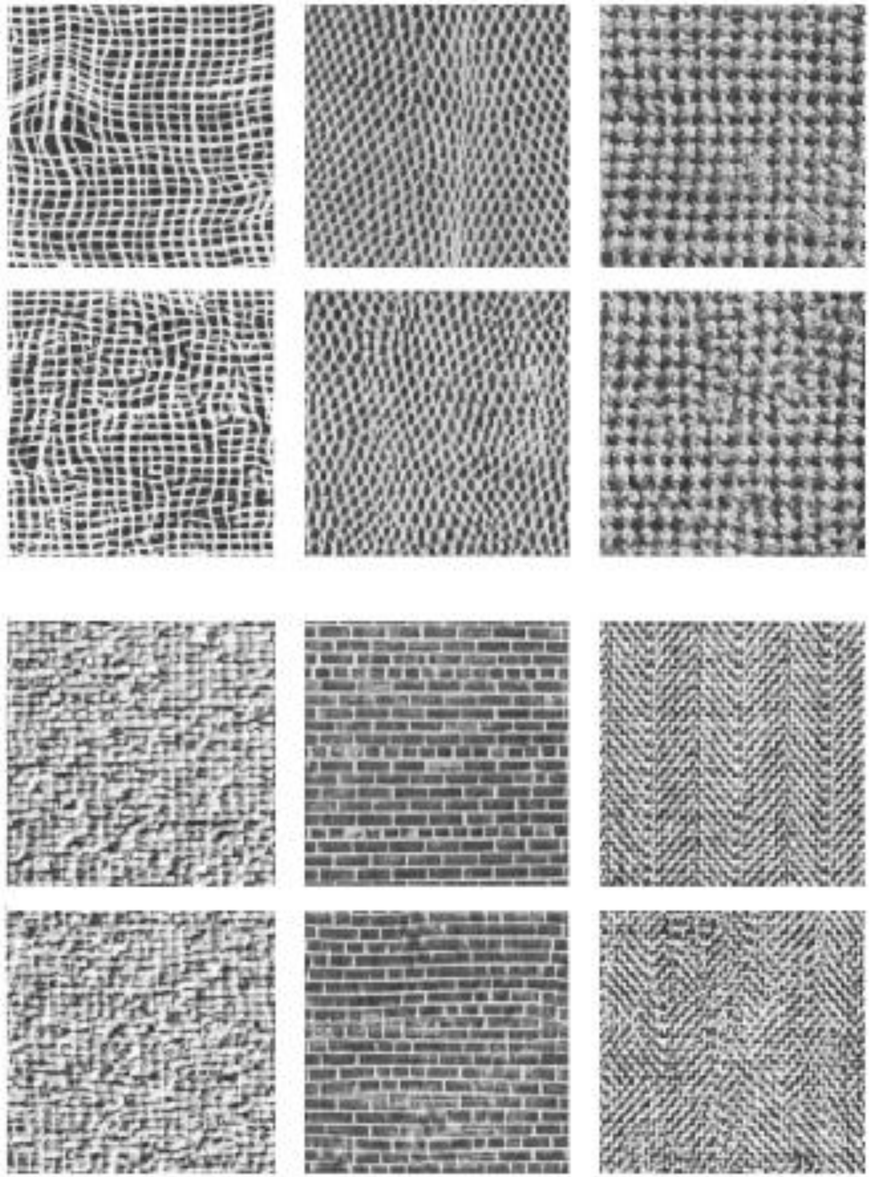
- Marginal statistics are not enough
- Neighboring filter responses are highly correlated
  - an edge at low-res will cause an edge at high-res
- Let’s match 2nd order statistics too!

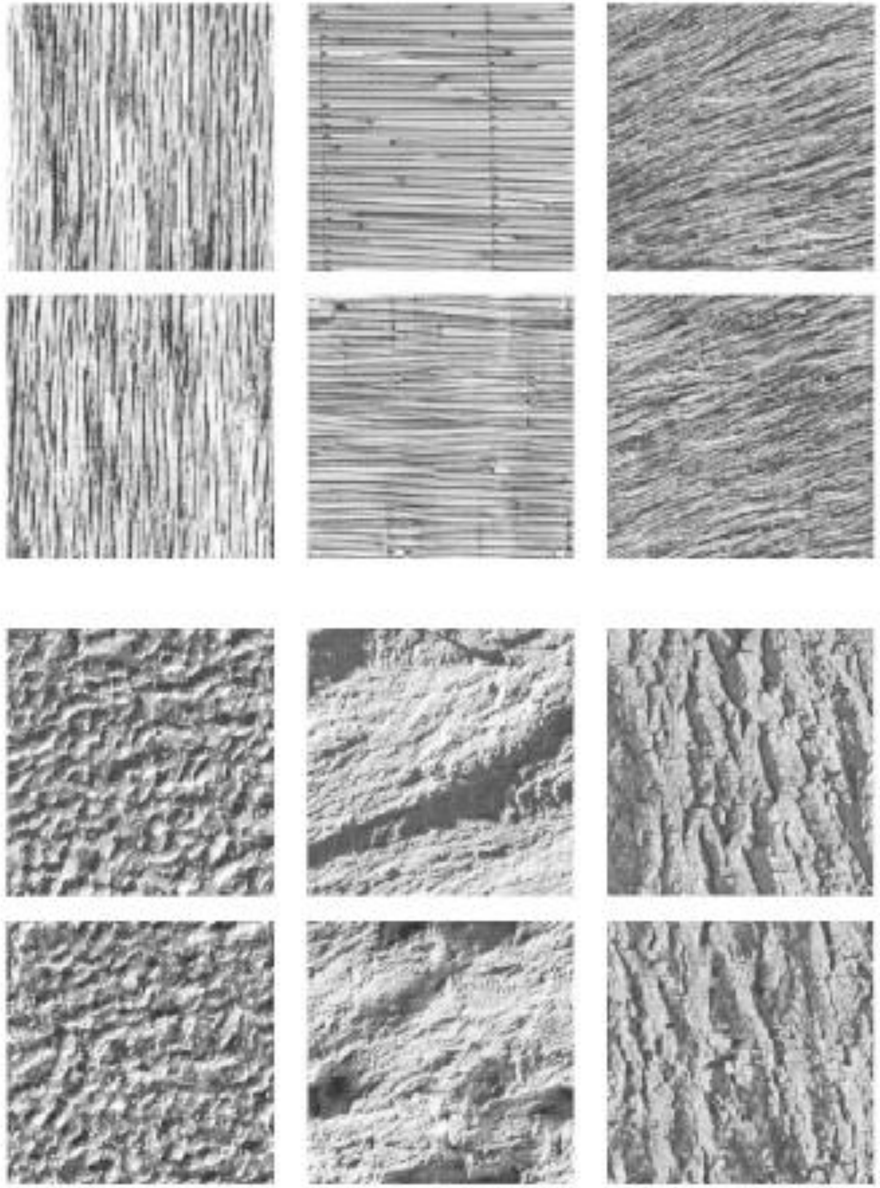
- J Portilla and E P Simoncelli. *A Parametric Texture Model based on Joint Statistics of Complex Wavelet Coefficients.* Int'l Journal of Computer Vision. 40(1):49-71, October, 2000.

Simoncelli & Portilla ’98+

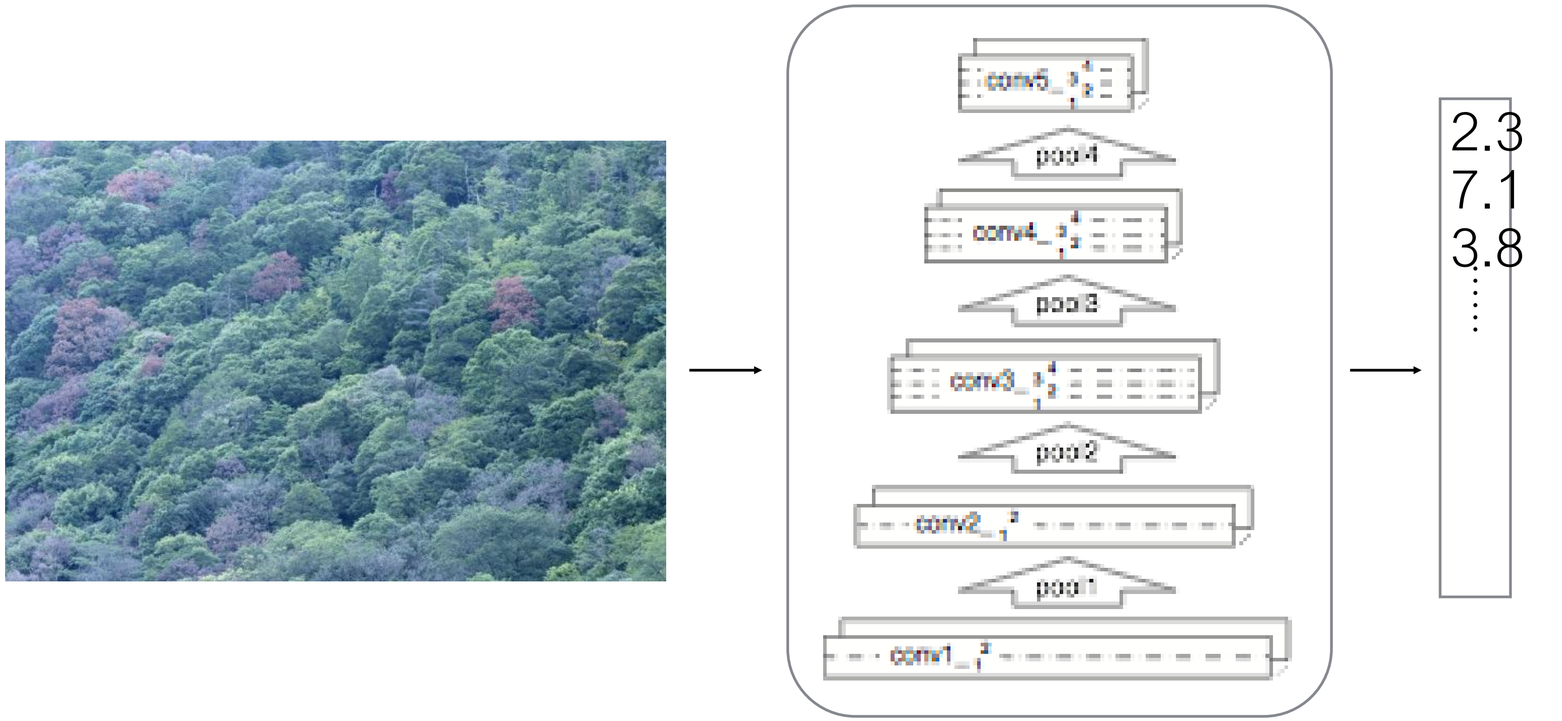


- Match joint histograms of pairs of filter responses at adjacent spatial locations, orientations, and scales.
- Optimize using repeated projections onto statistical constraint sufraces





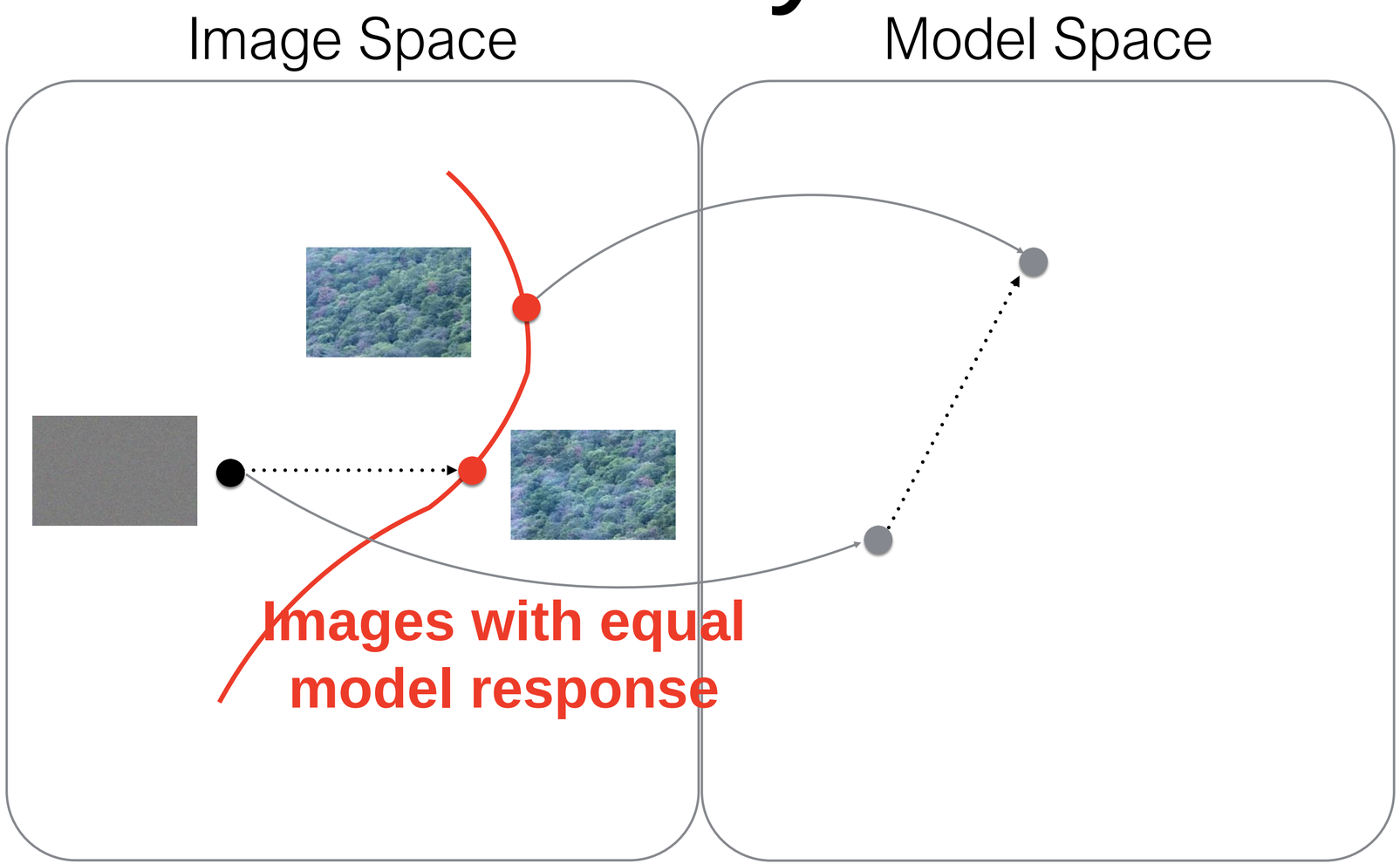
Convolutional Neural Network Texture Model



Convolutional Neural Network

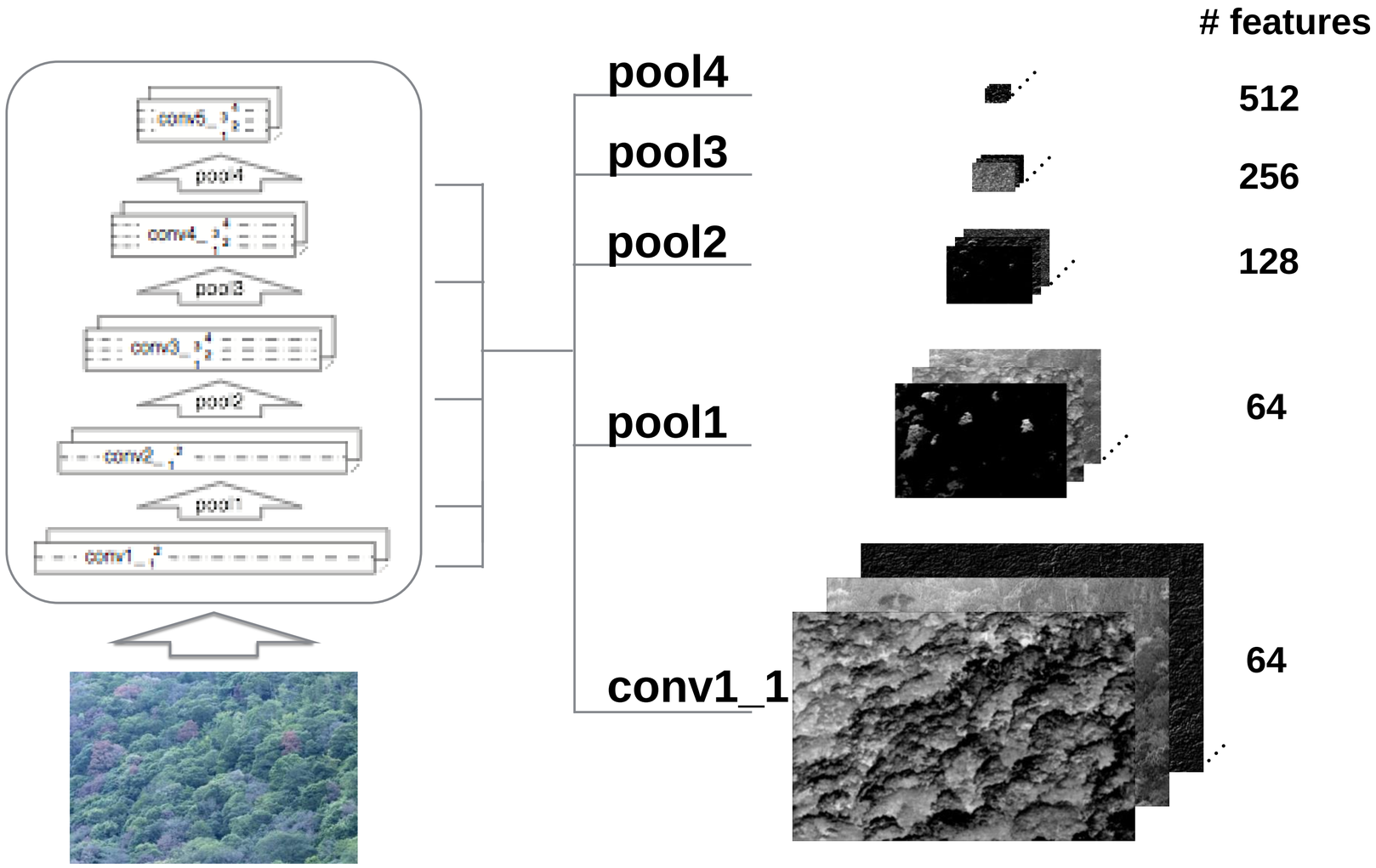
Gatys et al. (NIPS 2015)

Texture Synthesis

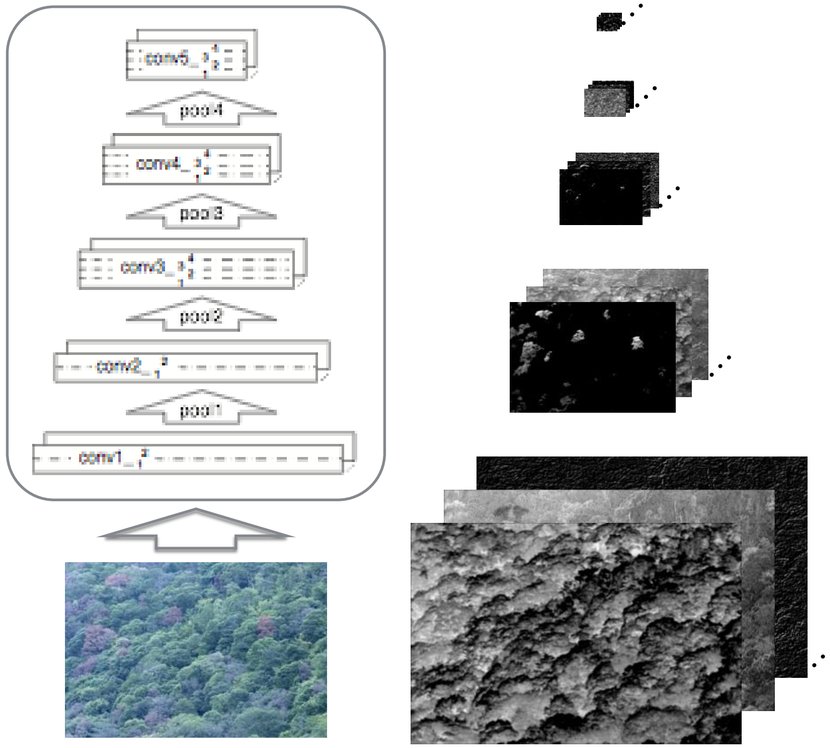


Portilla & Simoncelli (2000)

CNN - Multiscale Filter Bank



CNN - Texture Features



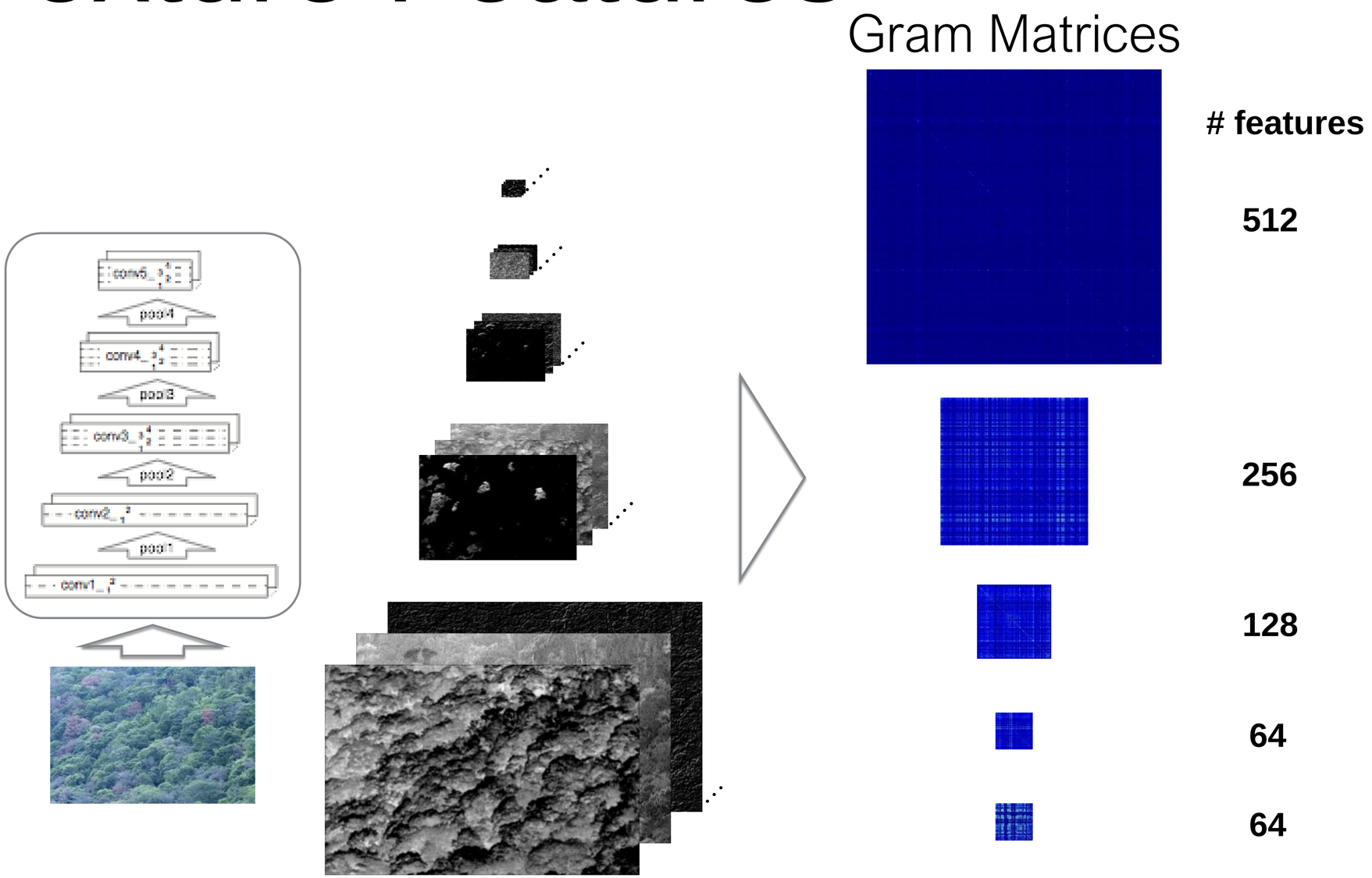
$$F = \left[\bar{f}_1, \bar{f}_2, \bar{f}_3, ..., \bar{f}_N\right]^T$$

$$G = FF^T$$

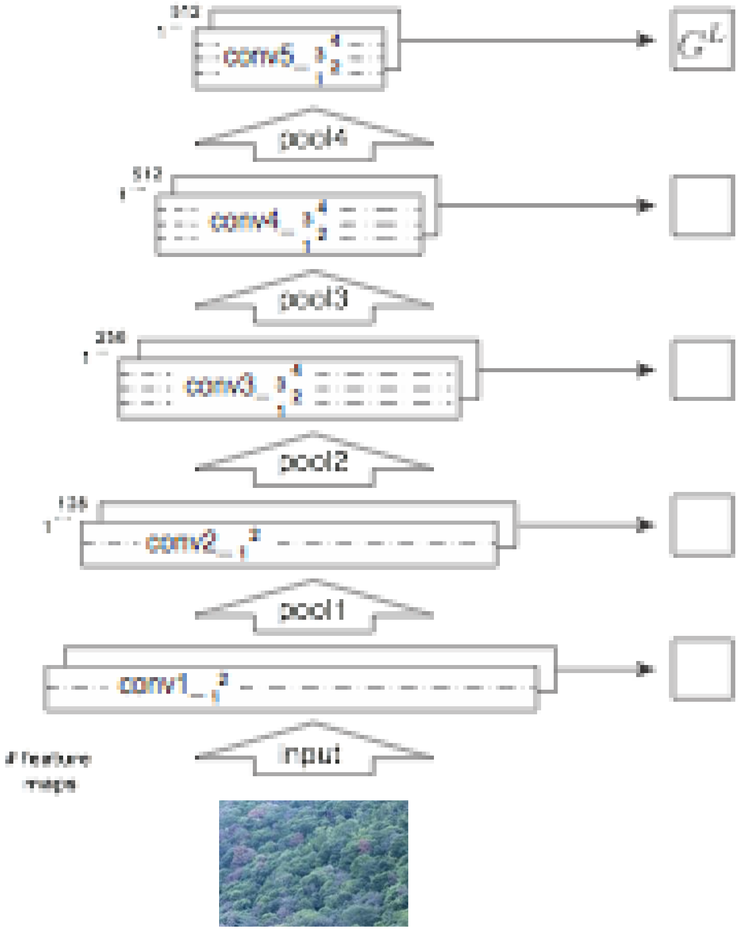
$$= \begin{pmatrix} \langle \bar{f}_1, \bar{f}_1 \rangle & \cdots & \langle \bar{f}_1, \bar{f}_N \rangle \\ \langle \bar{f}_2, \bar{f}_1 \rangle & & \vdots \\ \vdots & \ddots & \vdots \\ \langle \bar{f}_N, \bar{f}_1 \rangle & \cdots & \langle \bar{f}_N, \bar{f}_N \rangle \end{pmatrix}$$

$$\langle \bar{f}_i, \bar{f}_j \rangle = \sum_k F_{ik} F_{jk}$$

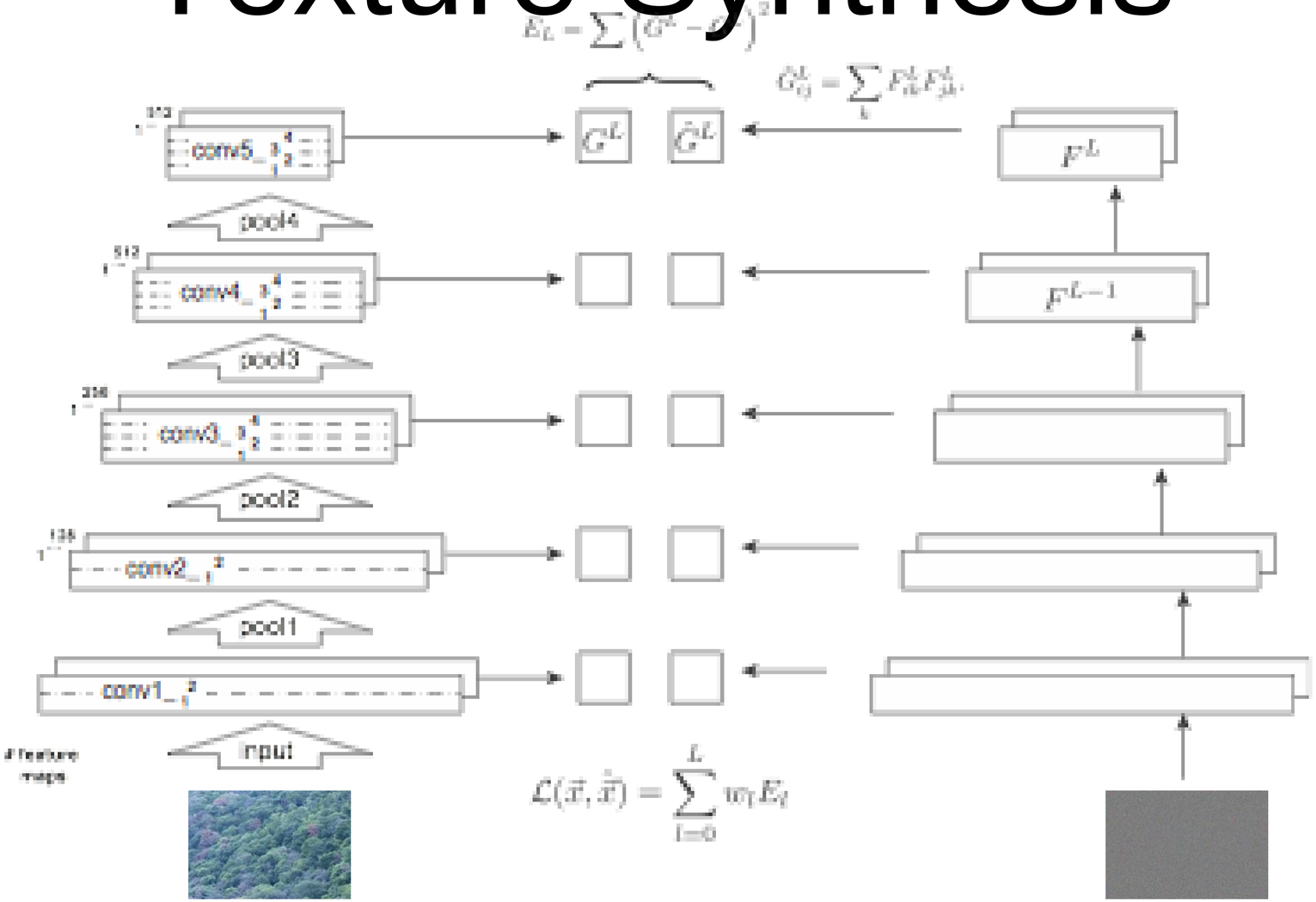
CNN-Texture Features



Texture Synthesis



Texture Synthesis



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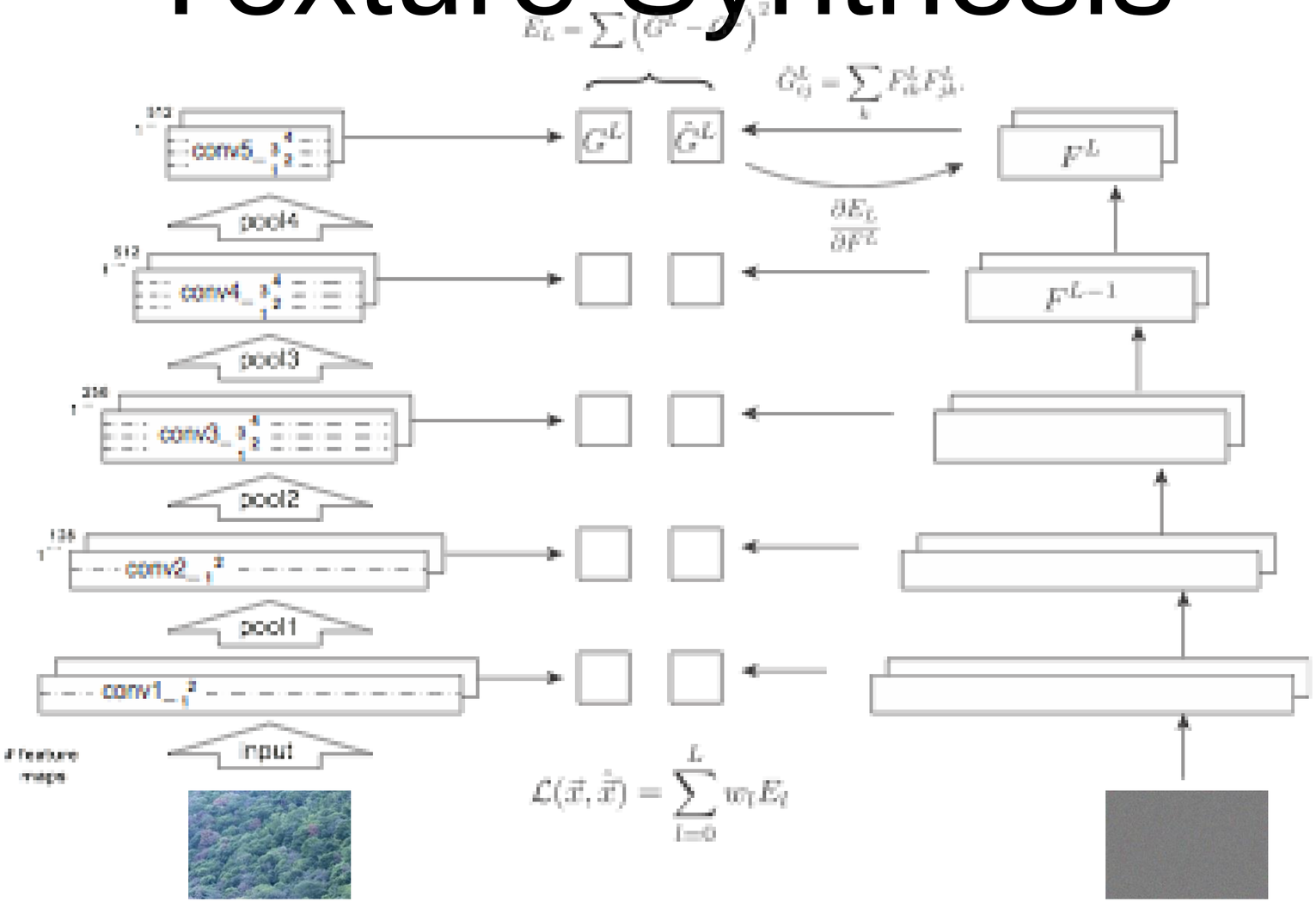
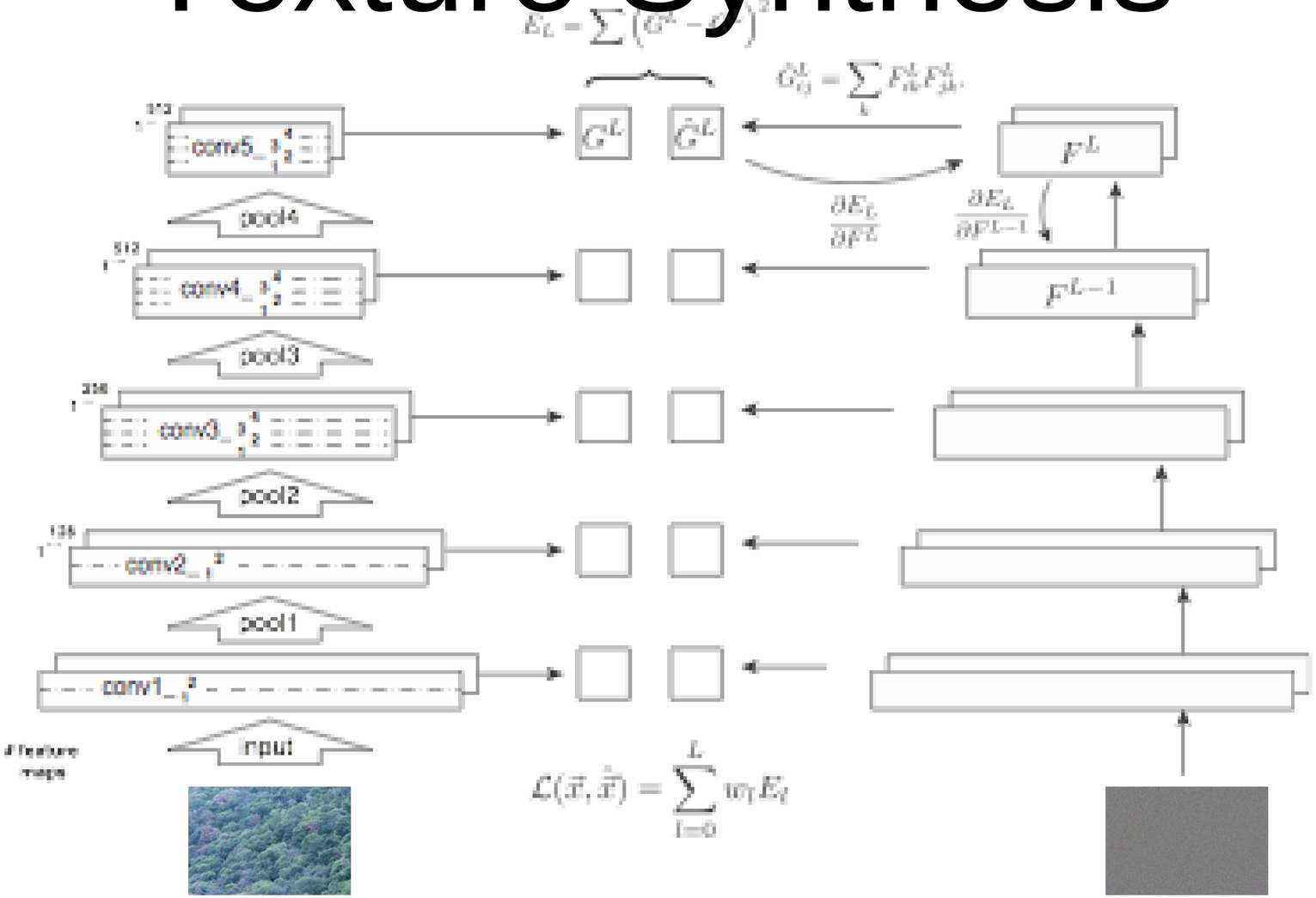
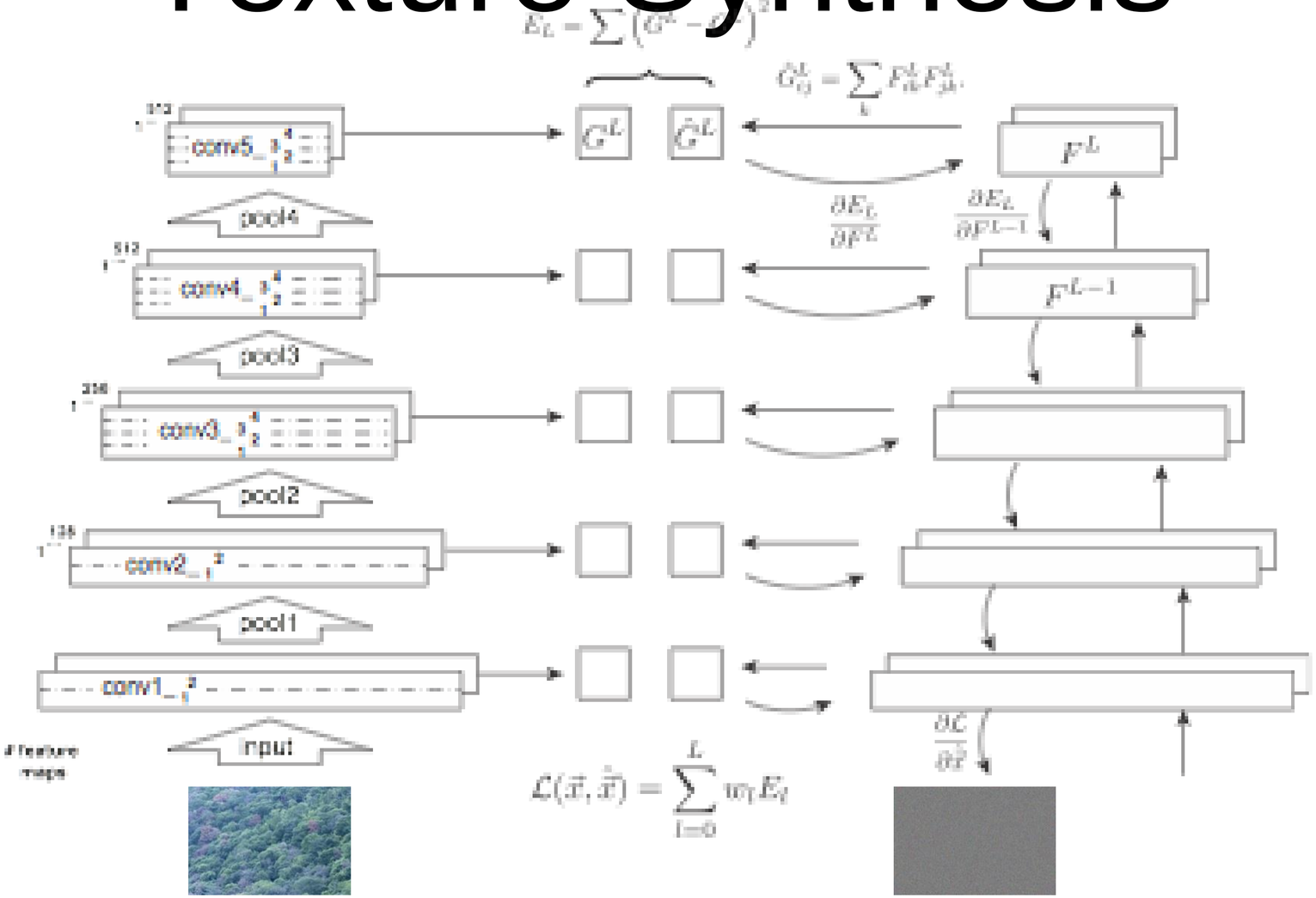


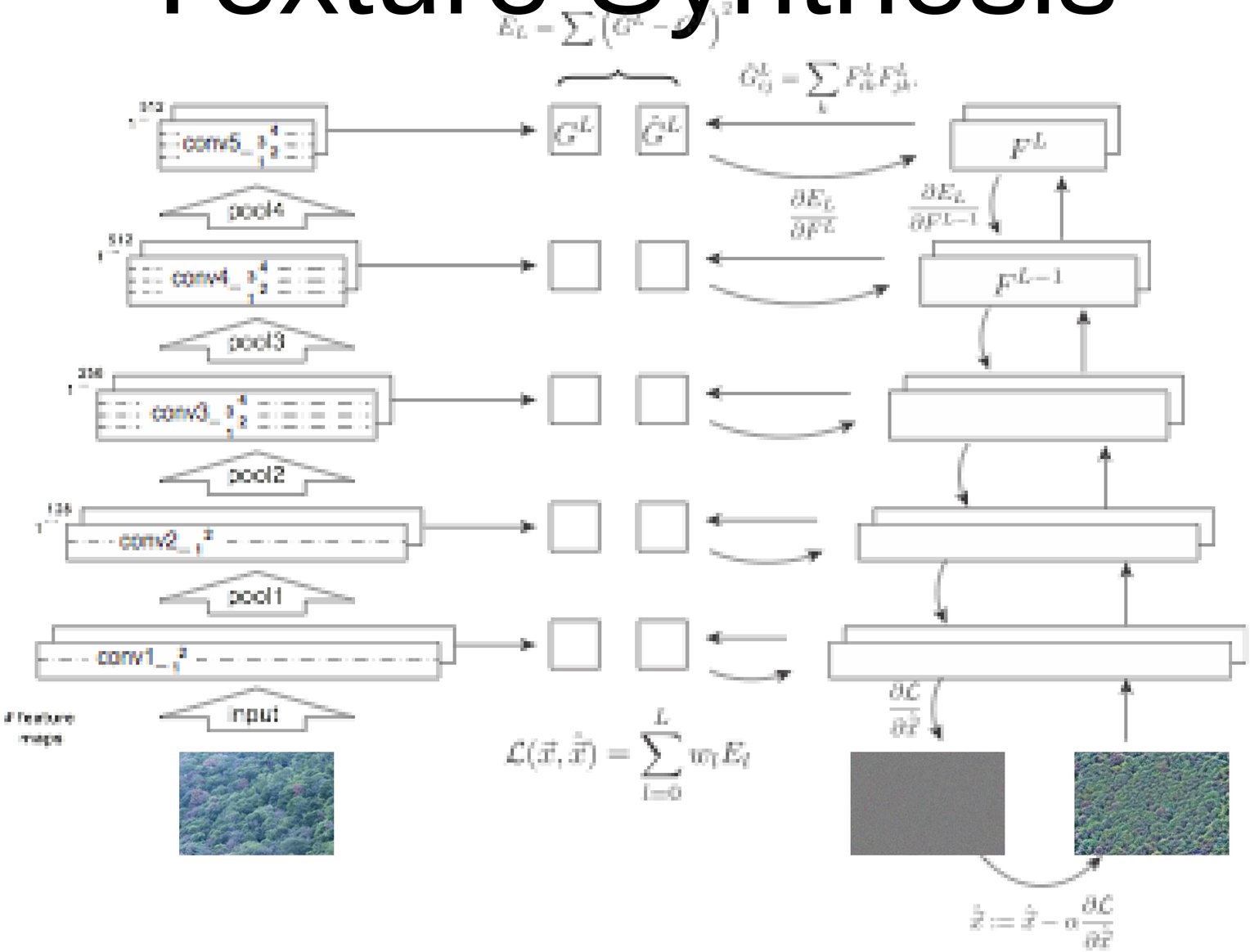
Texture Synthesis



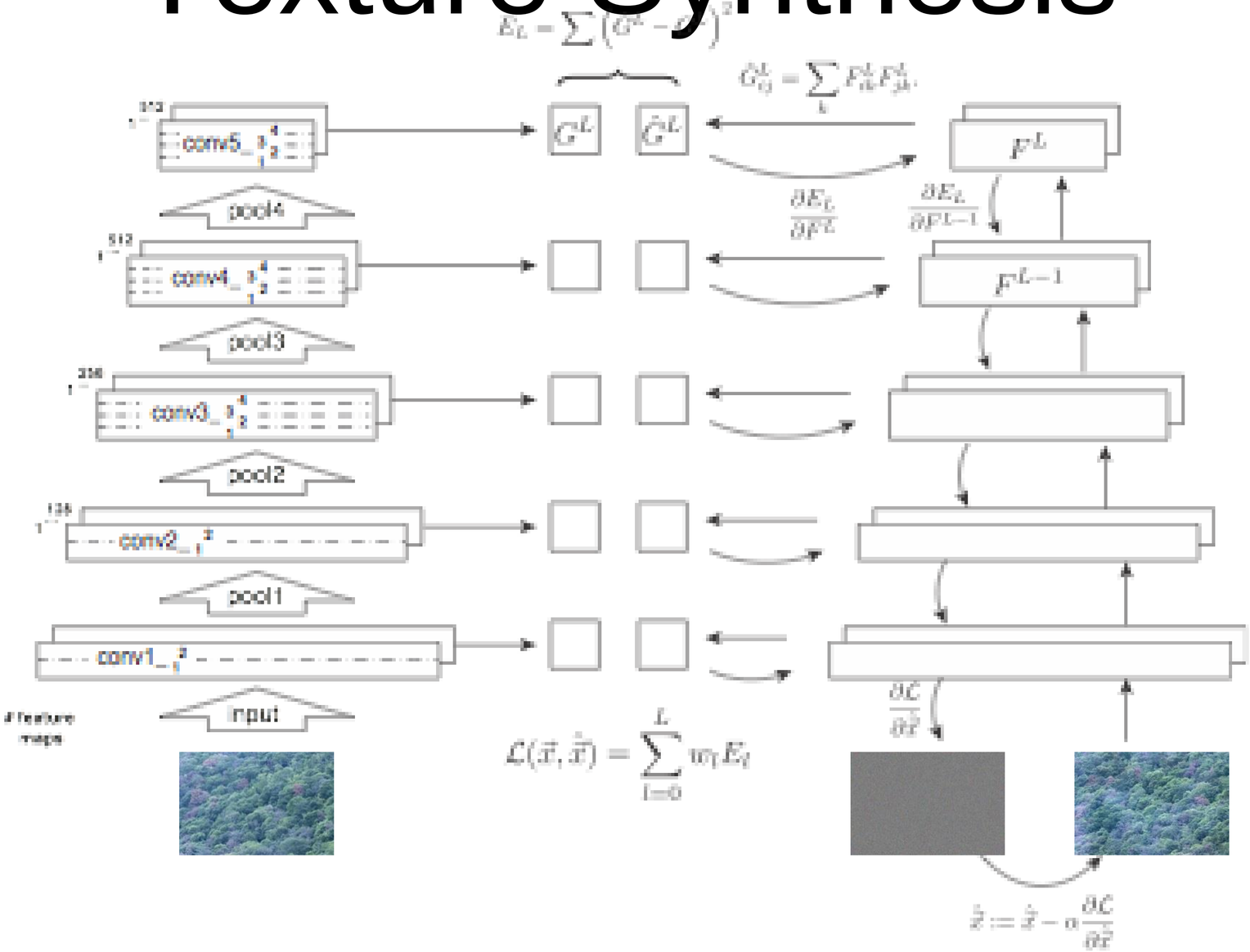
Texture Synthesis



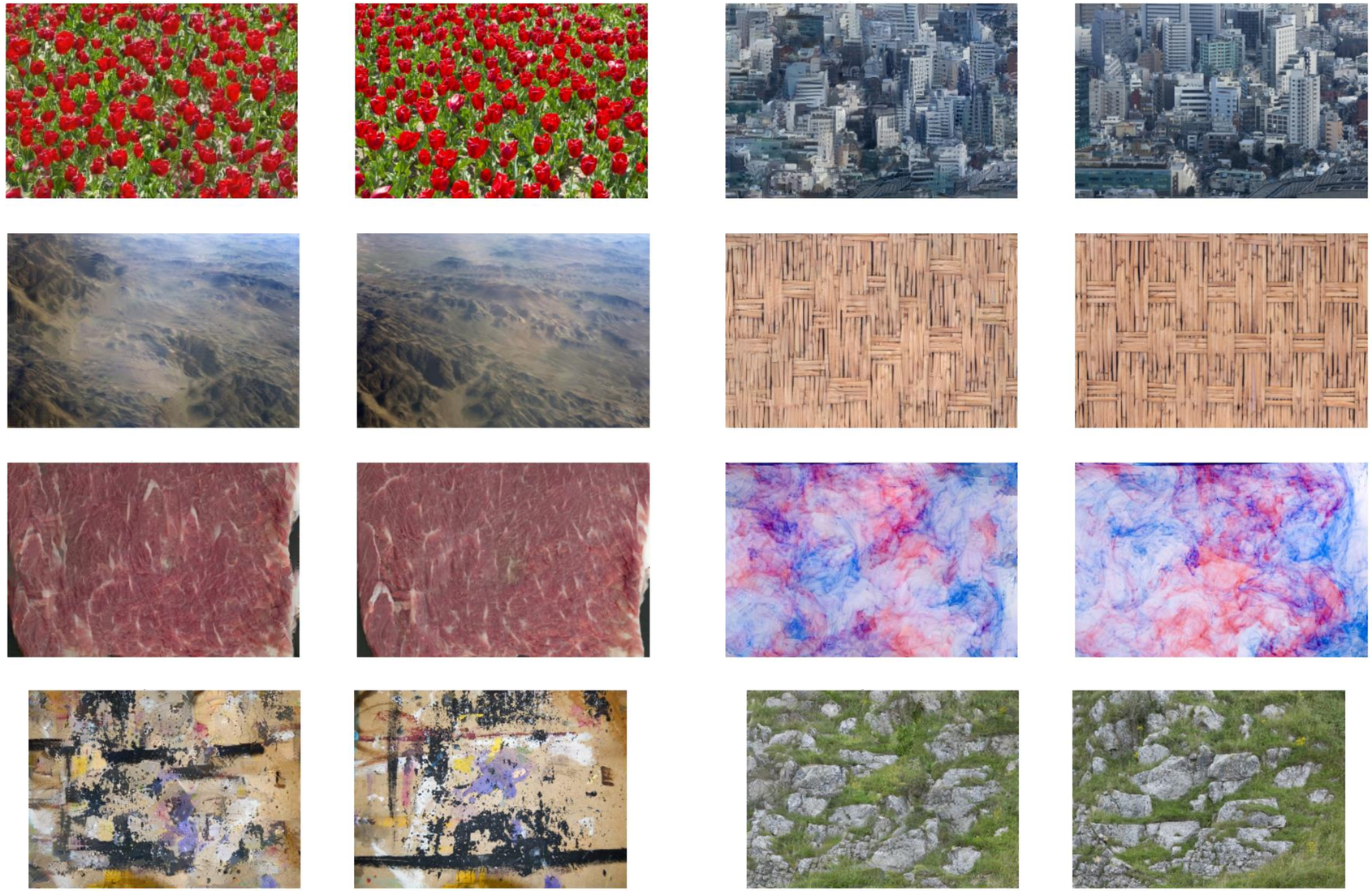
Texture Synthesis



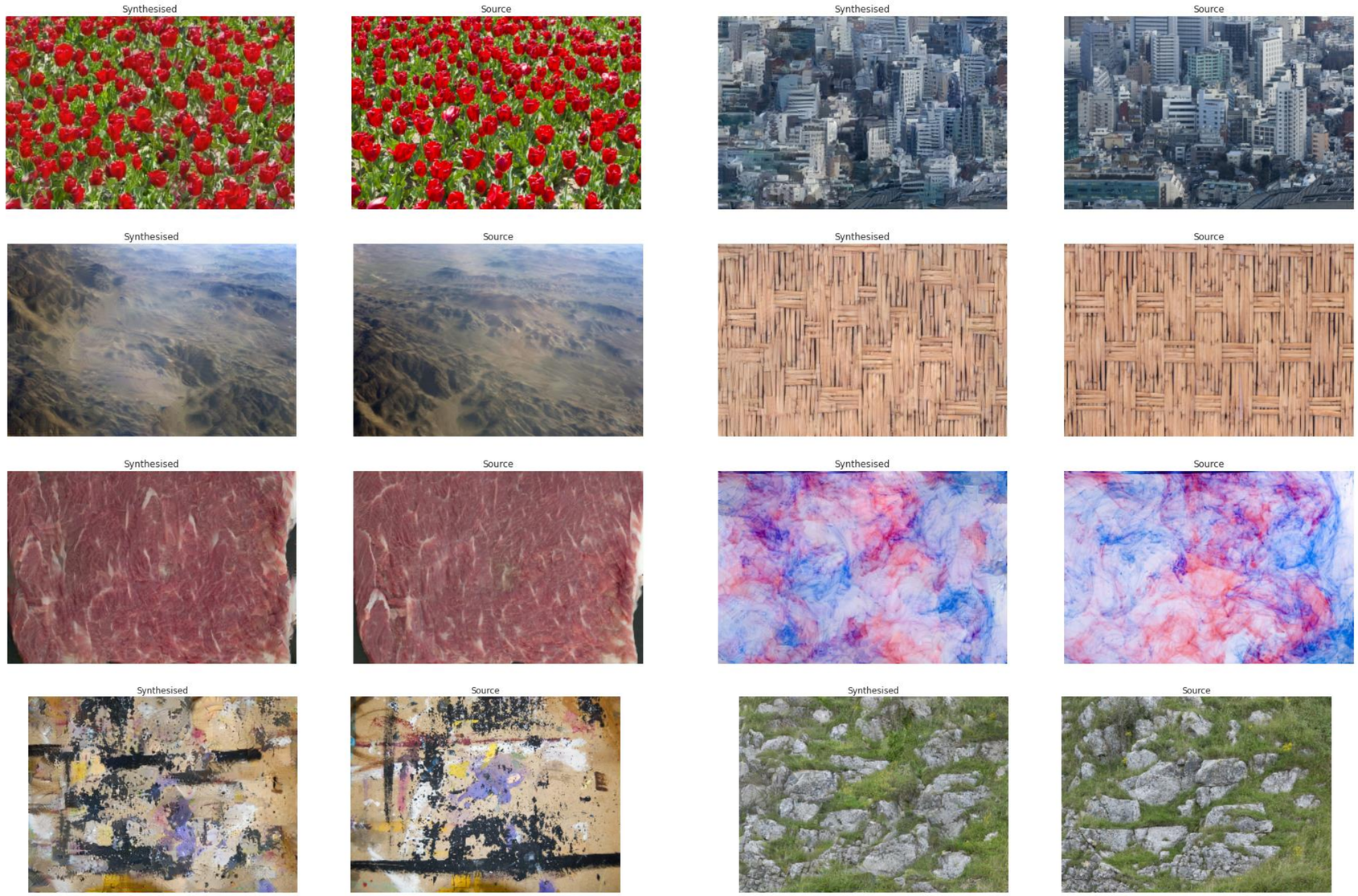
Texture Synthesis



Test Julesz' Conjecture



Test Julesz' Conjecture



ImageNet Recognition is just Texture Recognition

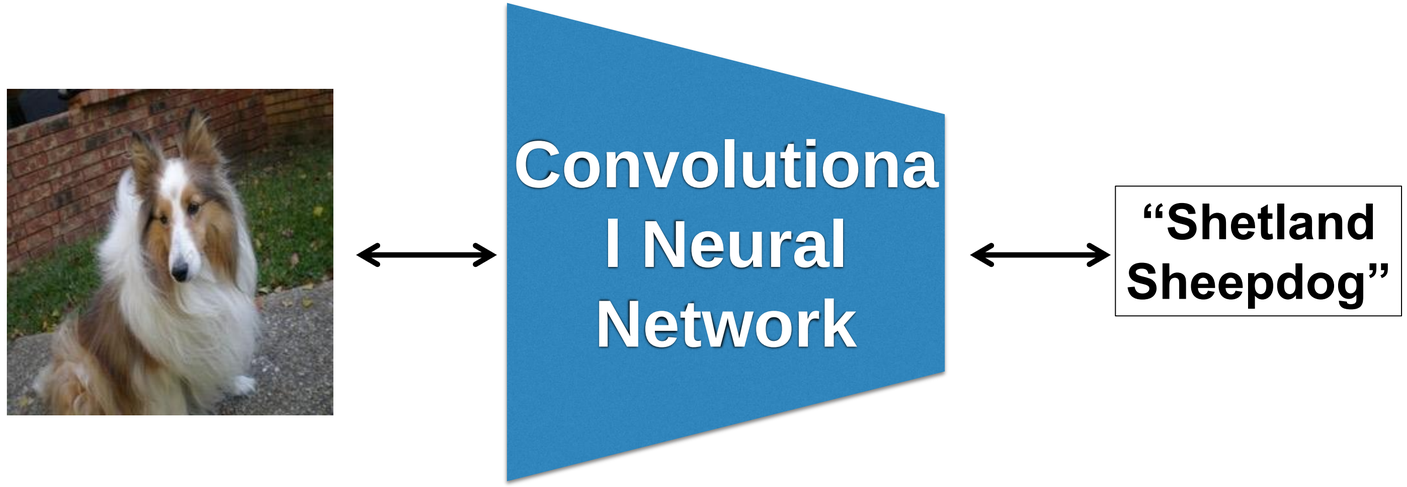


image *X*

label *Y*

ImageNet Recognition is just Texture Recognition

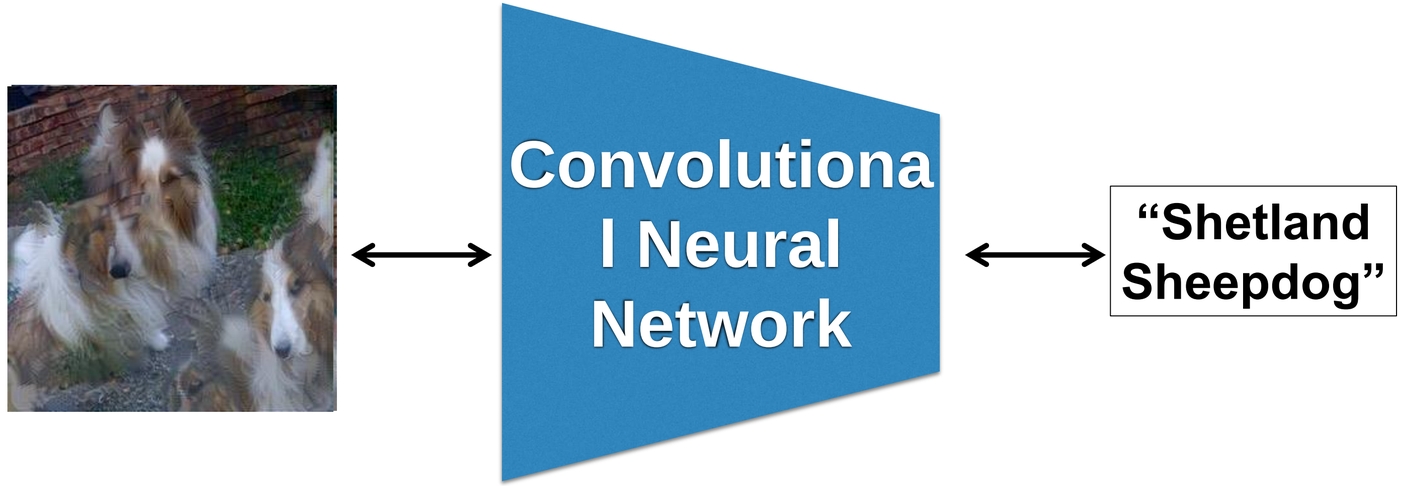
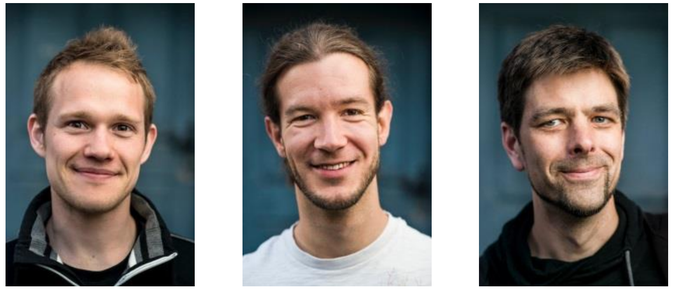


image *X*

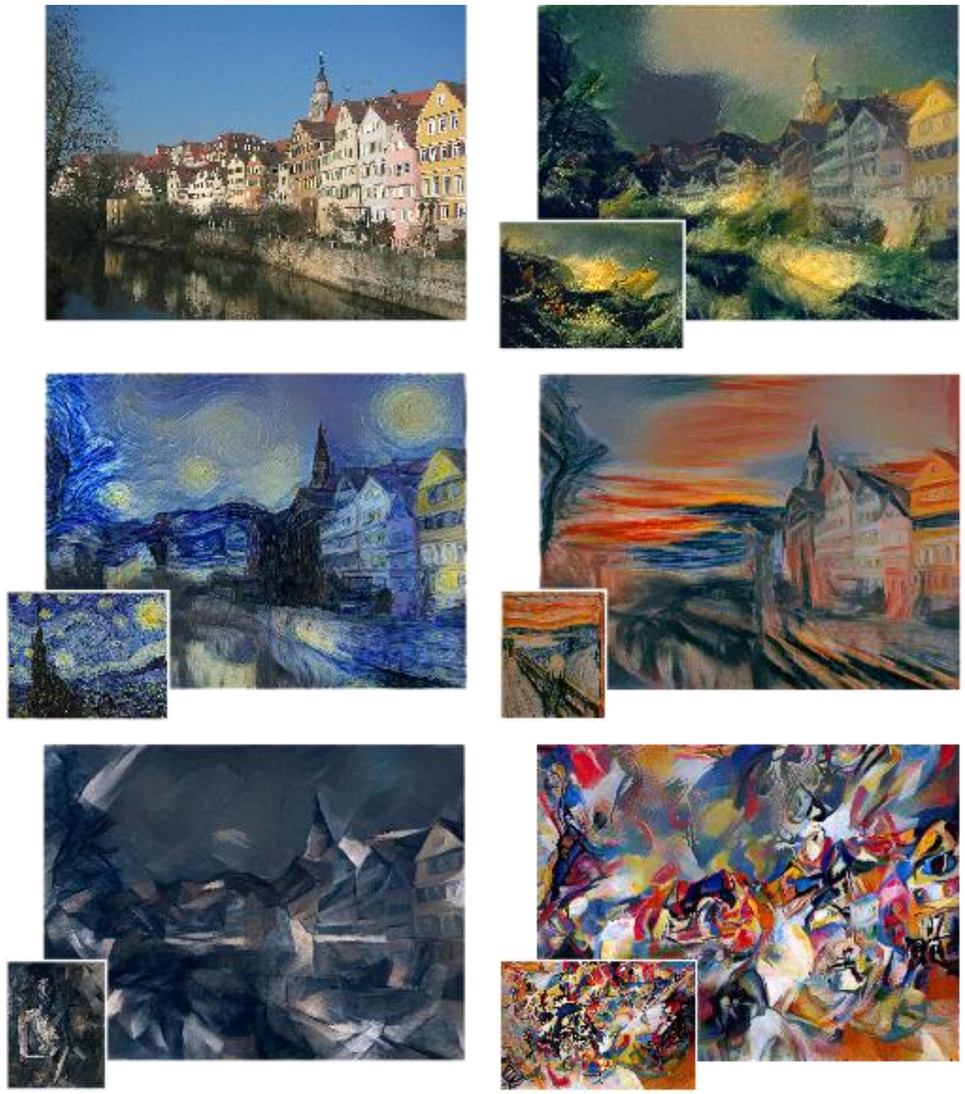
label *Y*

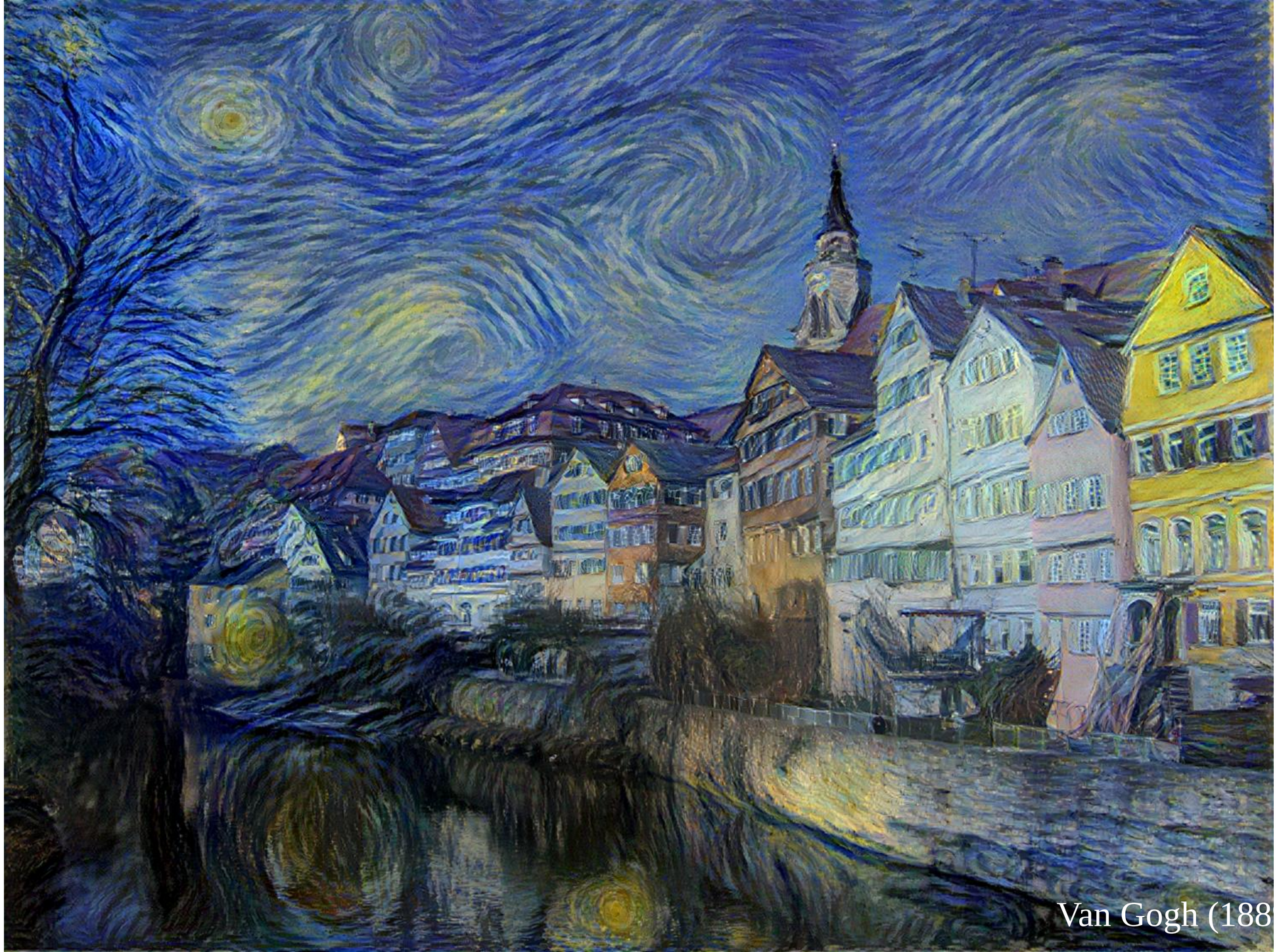
Gatys et al, 2017

A Neural Algorithm of Artistic Style



Gatys, Ecker, Bethge (arXiv 2015)




Van Gogh (188

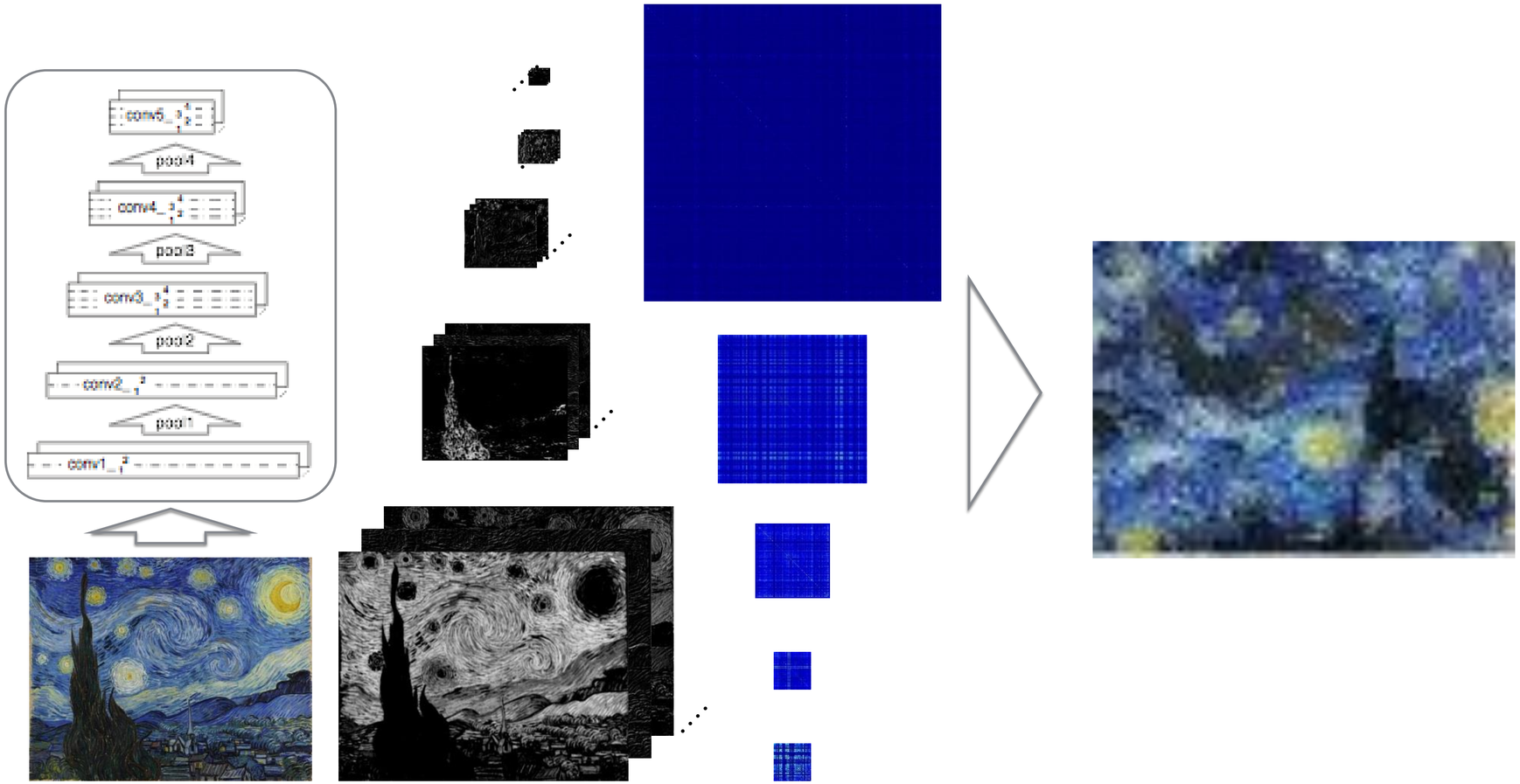
Picasso (1910)


Munch (1893)


Turner (1805)


Kandinsky (191

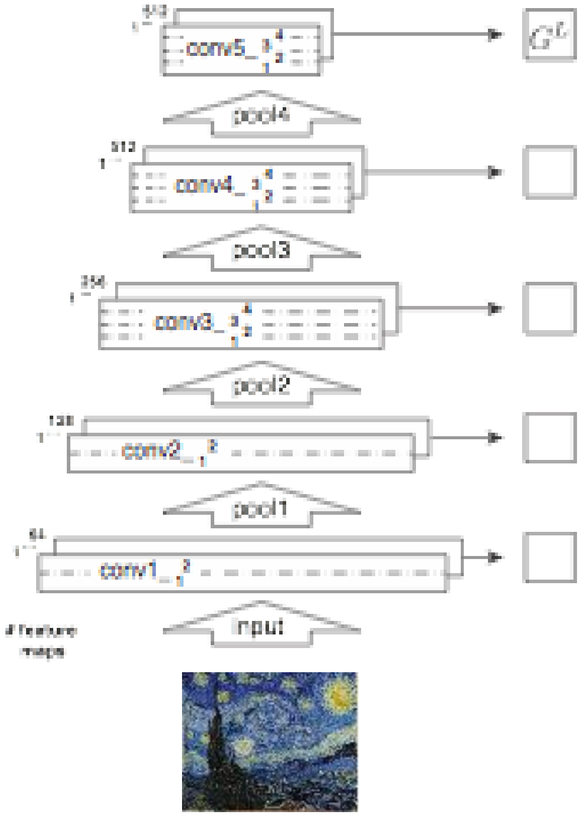
CNN - Texture Synthesis



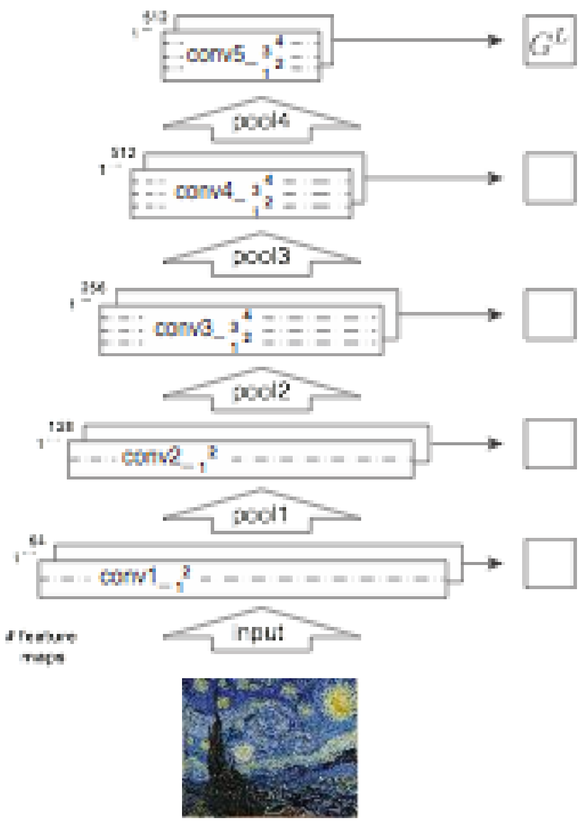
Gatys et al. (NIPS 2015)

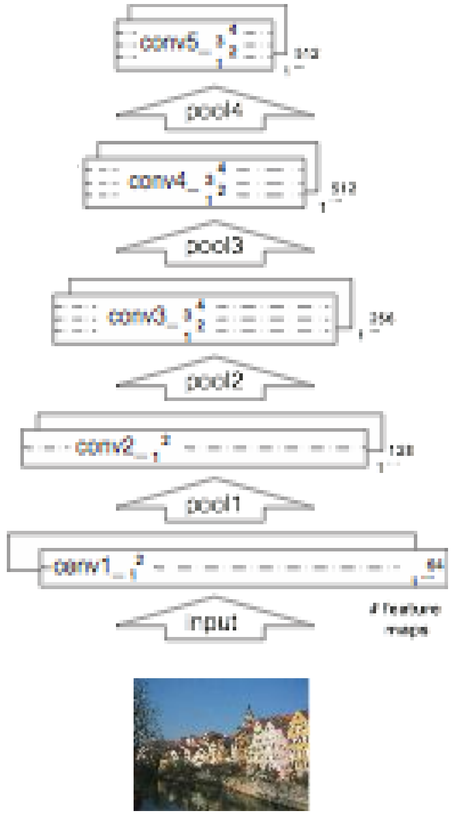
Artistic Style Transfer

Artistic Style Transfer



Artistic Style Transfer





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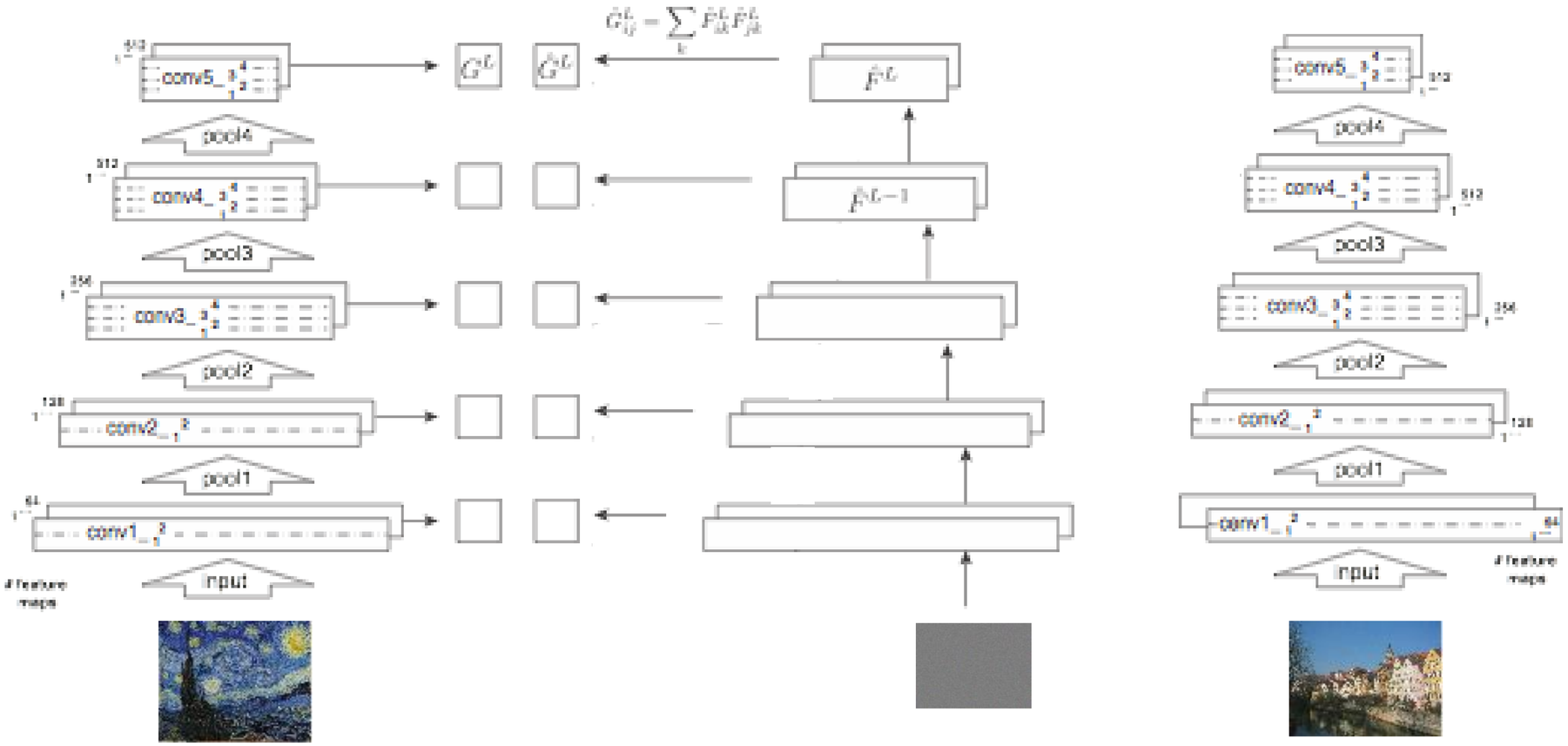

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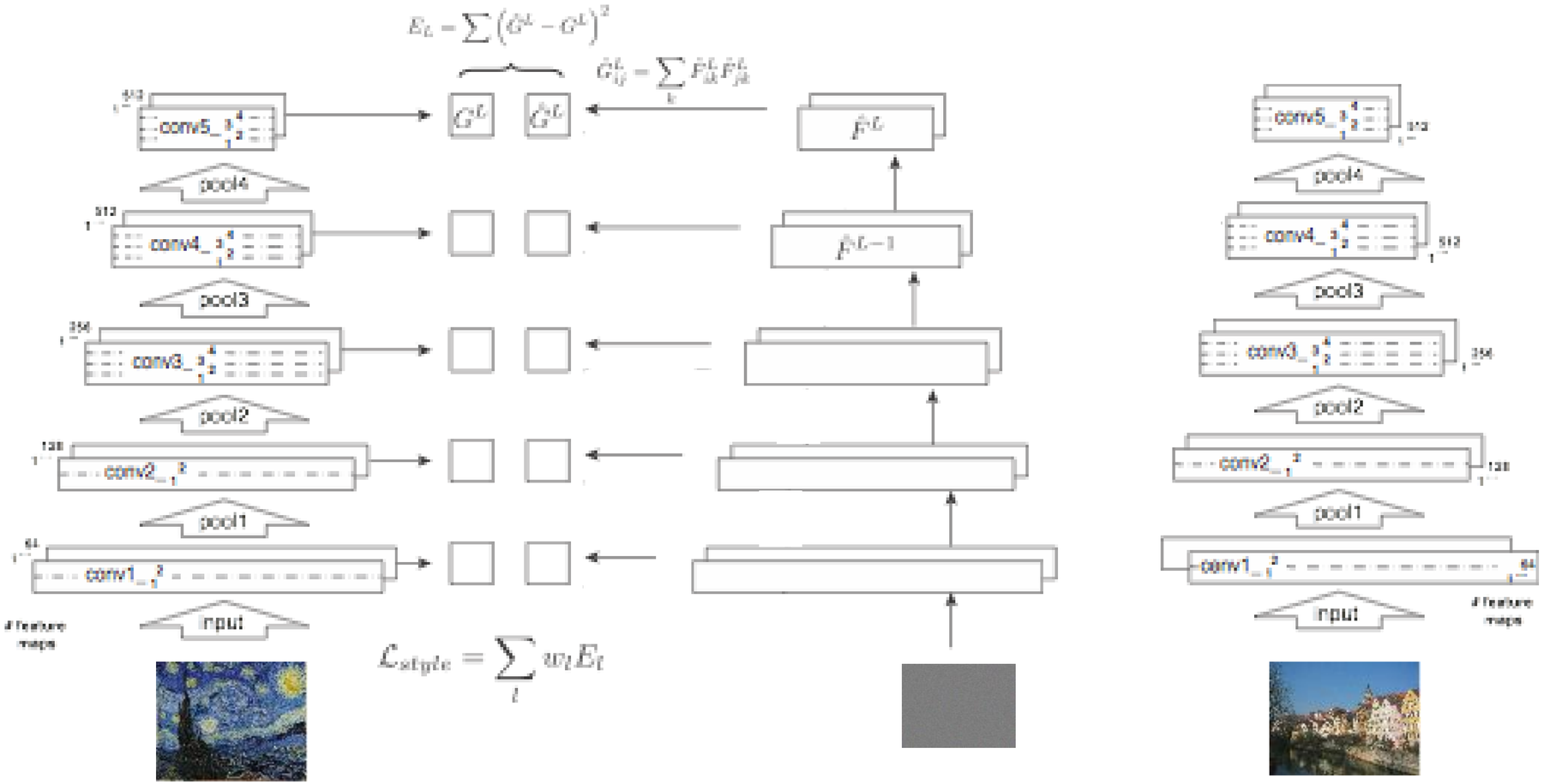

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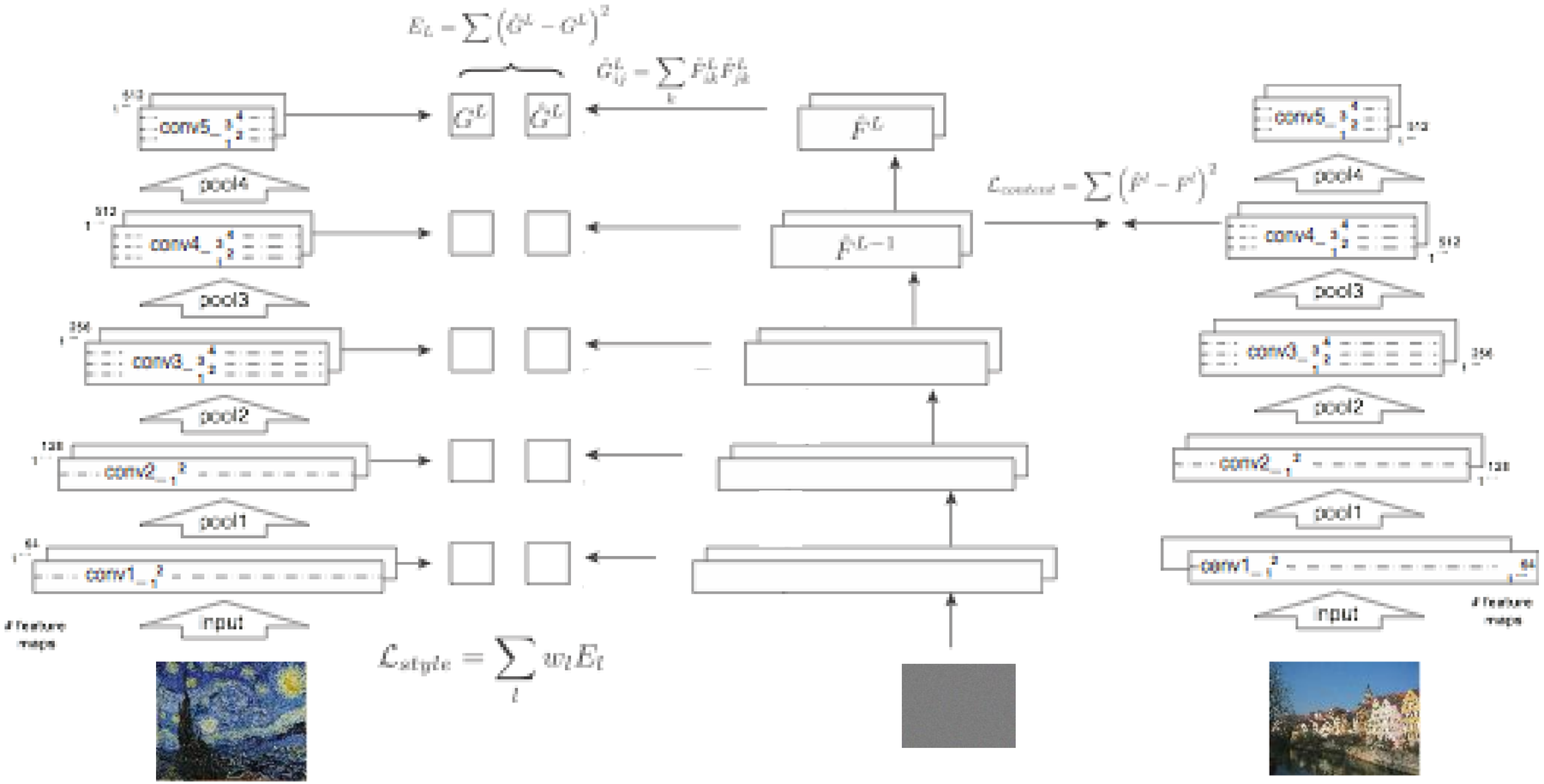

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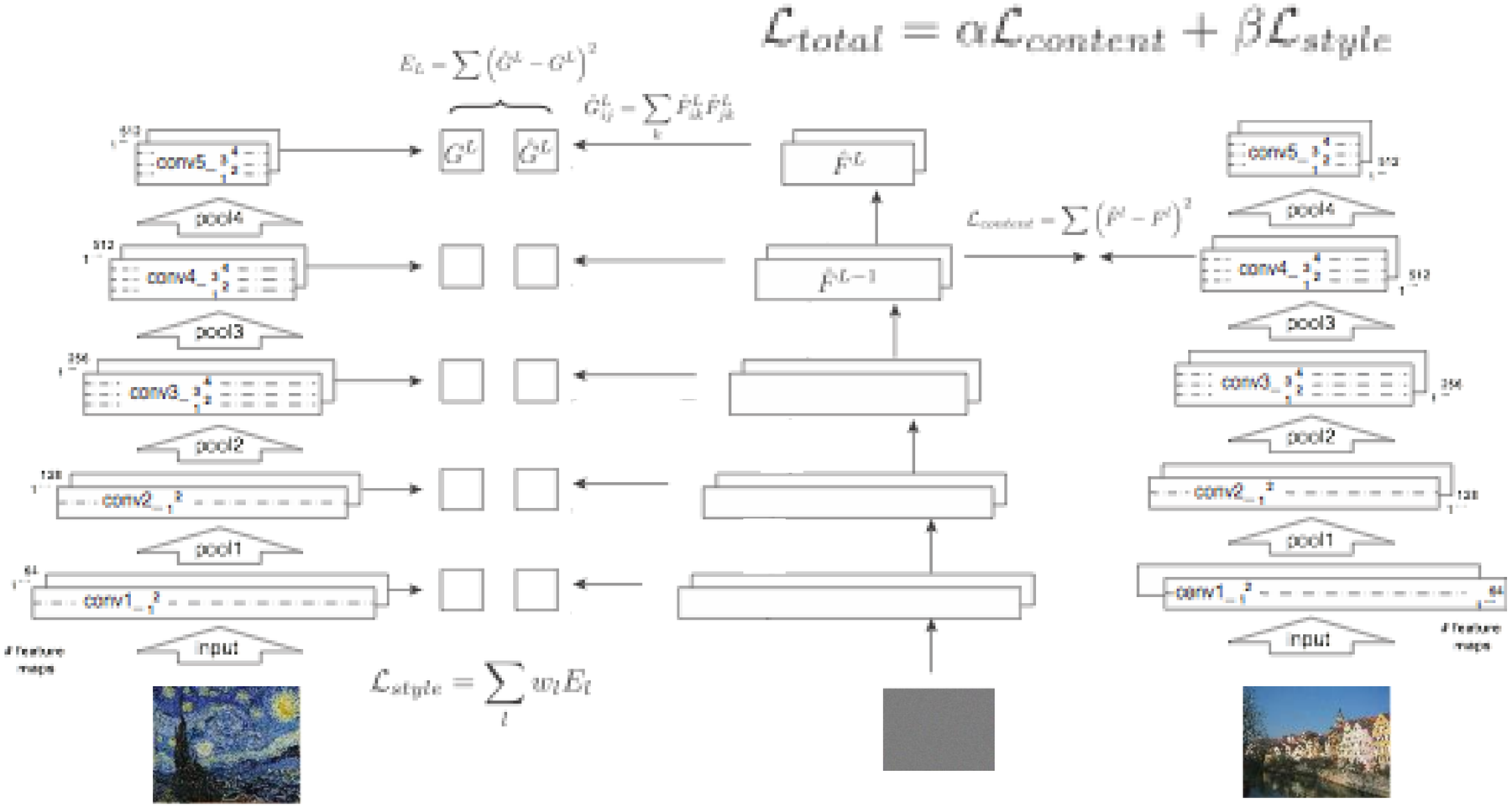

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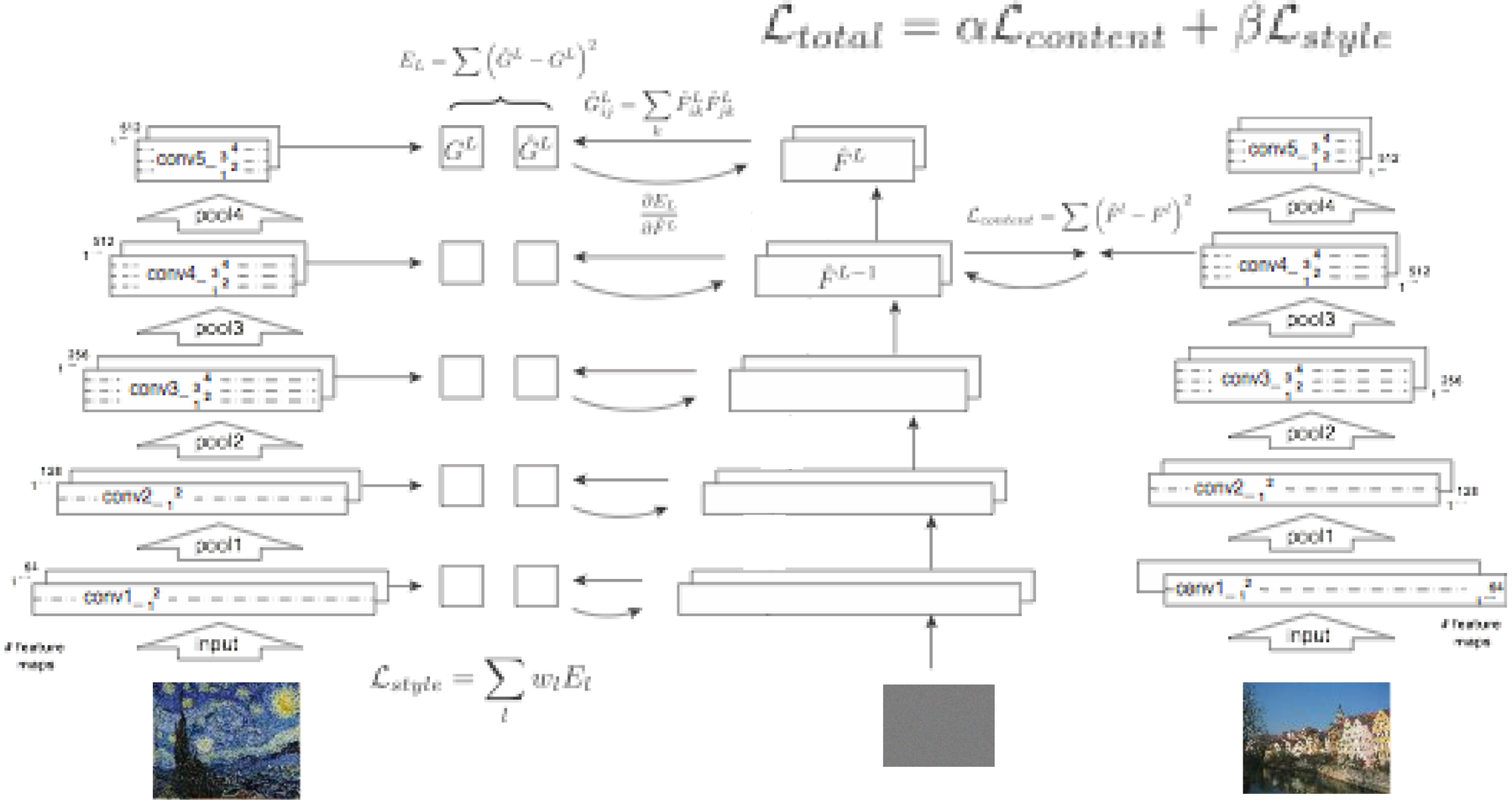

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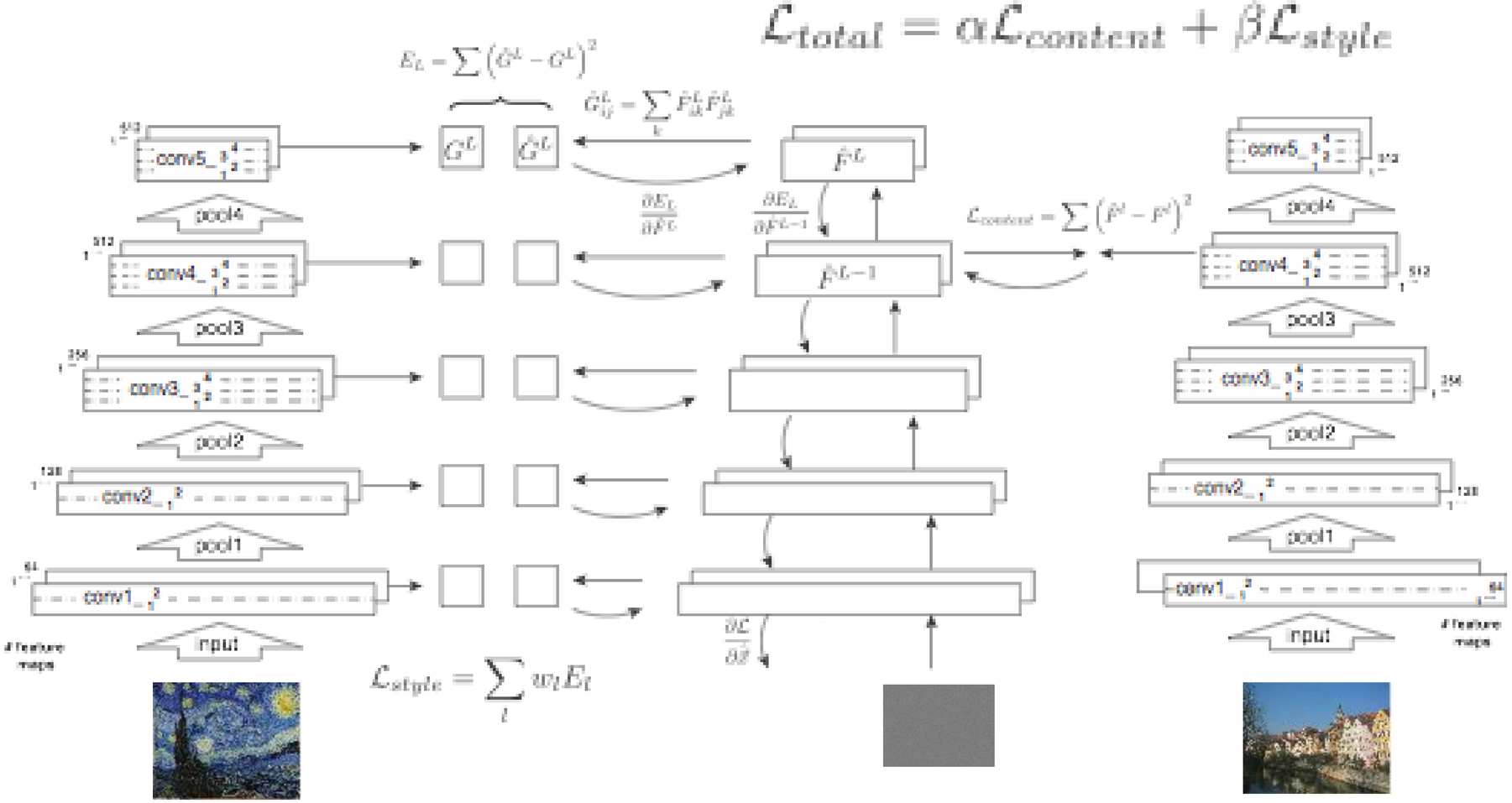

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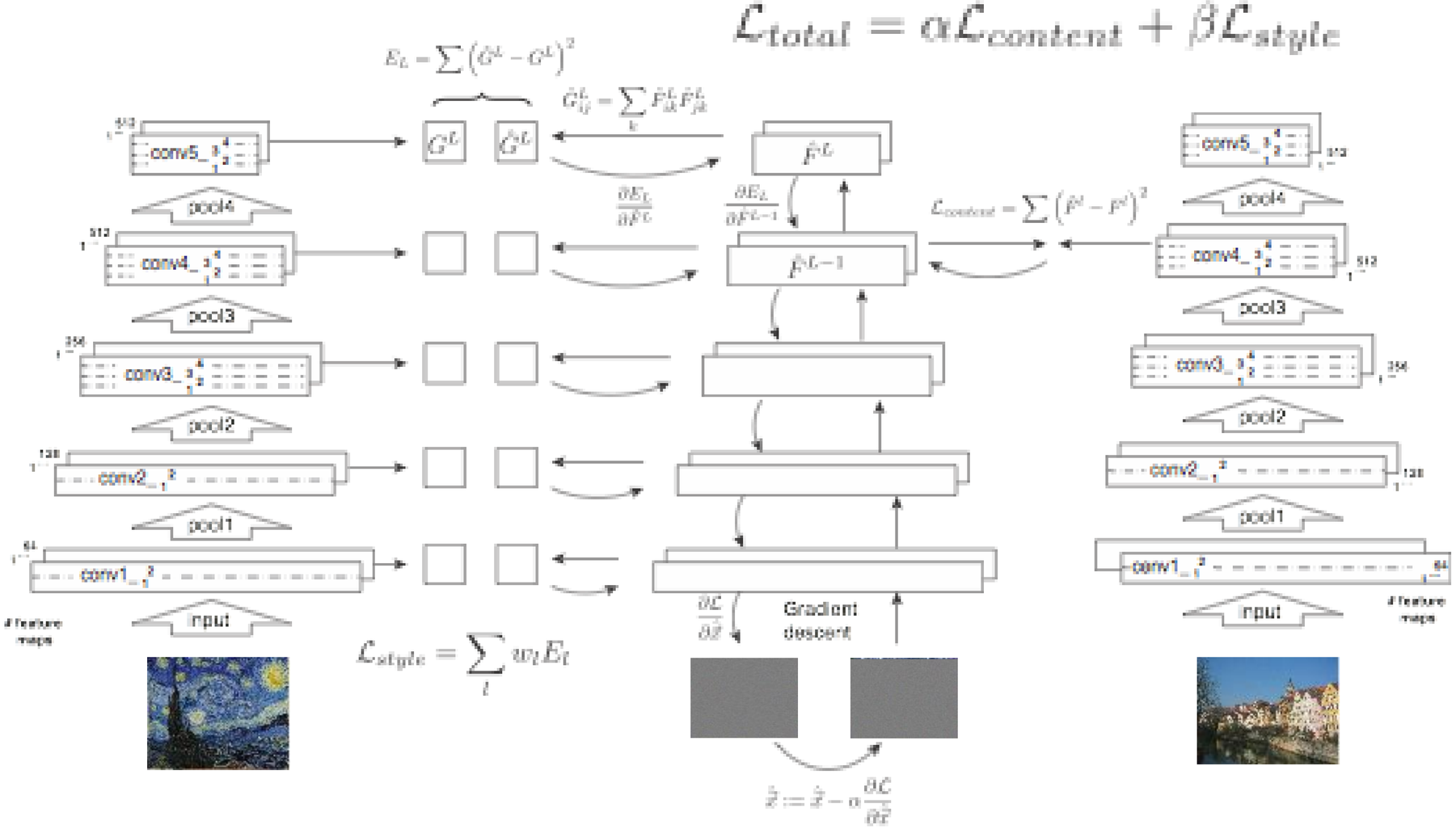

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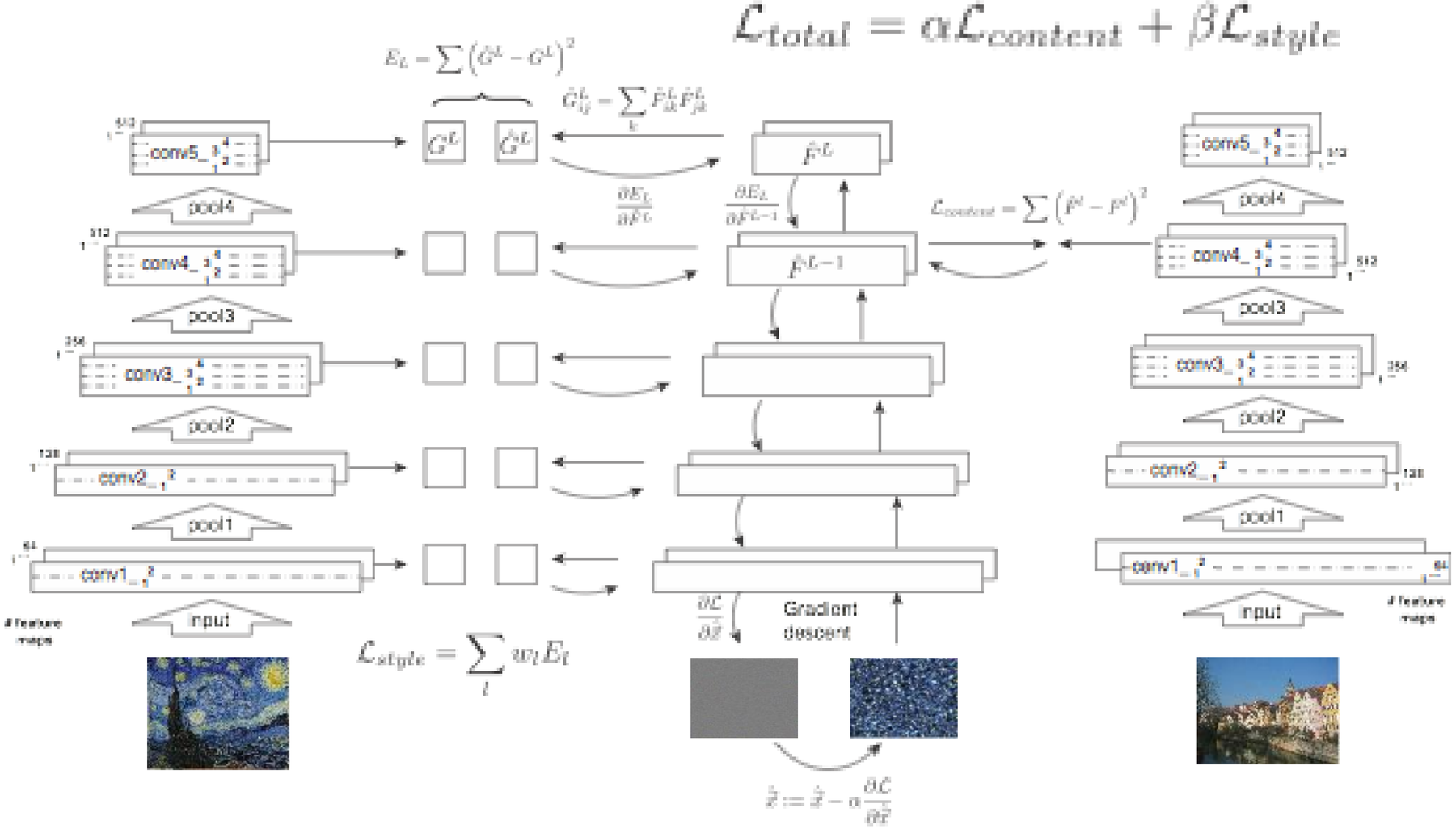
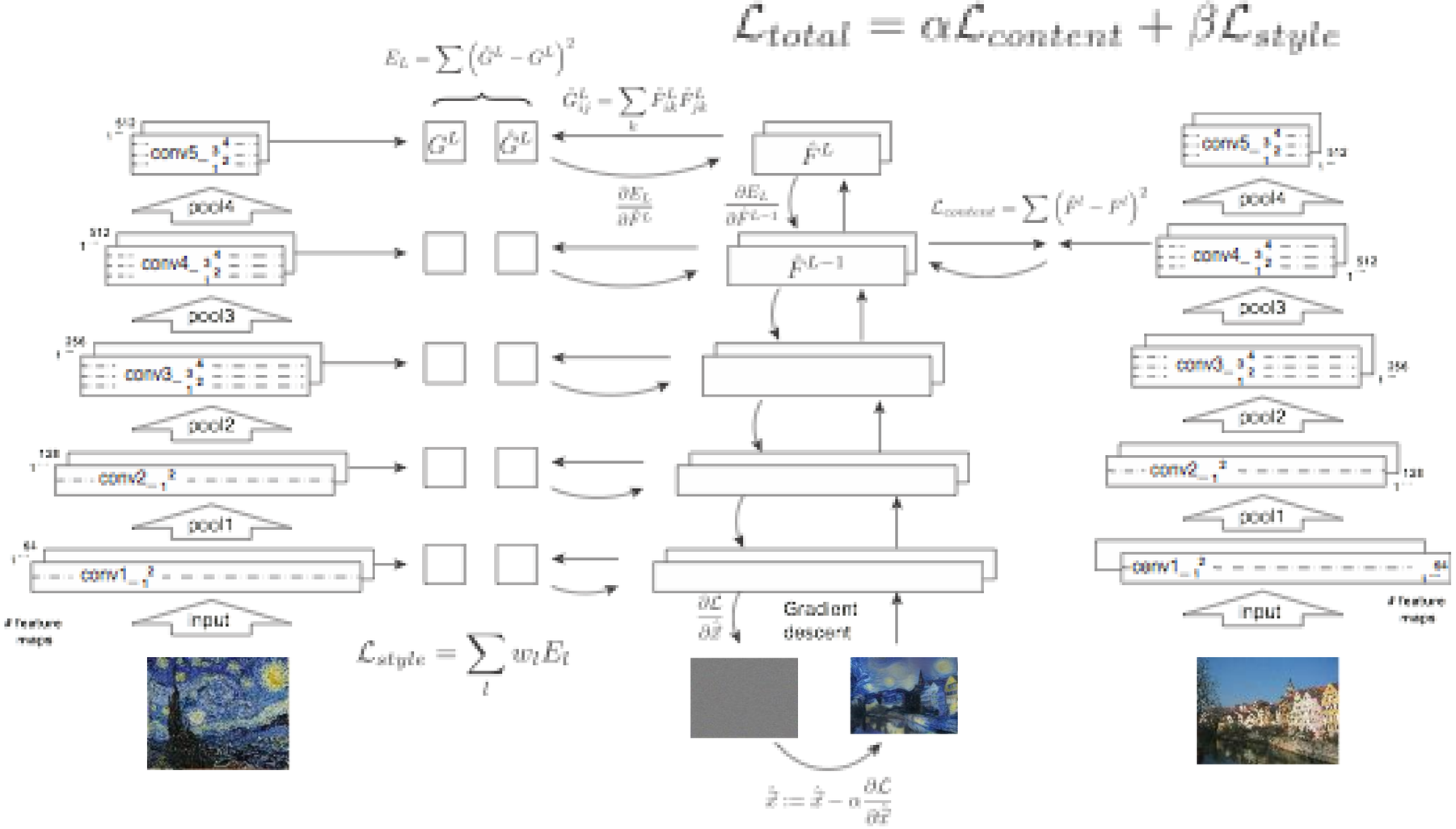


Artistic Style Transfer



Relative Weighting of Content and Style

1e-4

1e-3

1e-2

1e-1

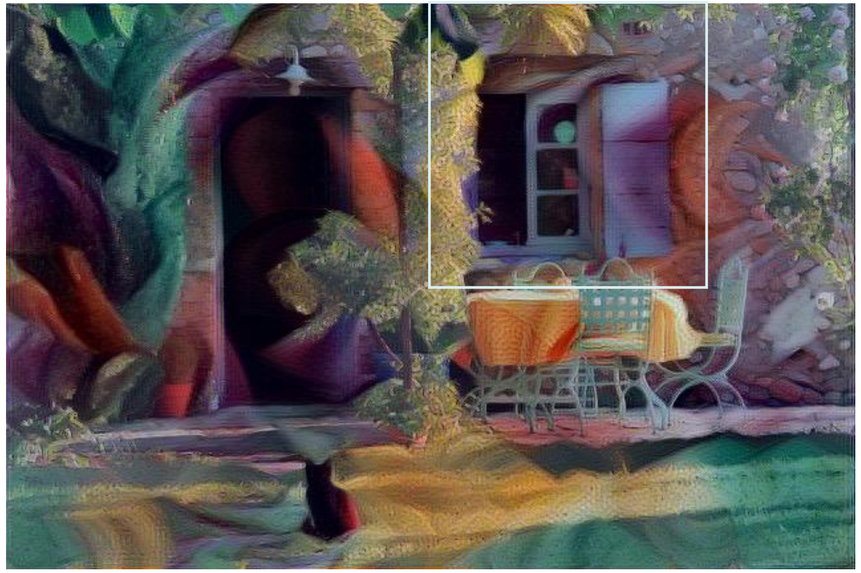
Different Reconstruction Layers

Conv2_2

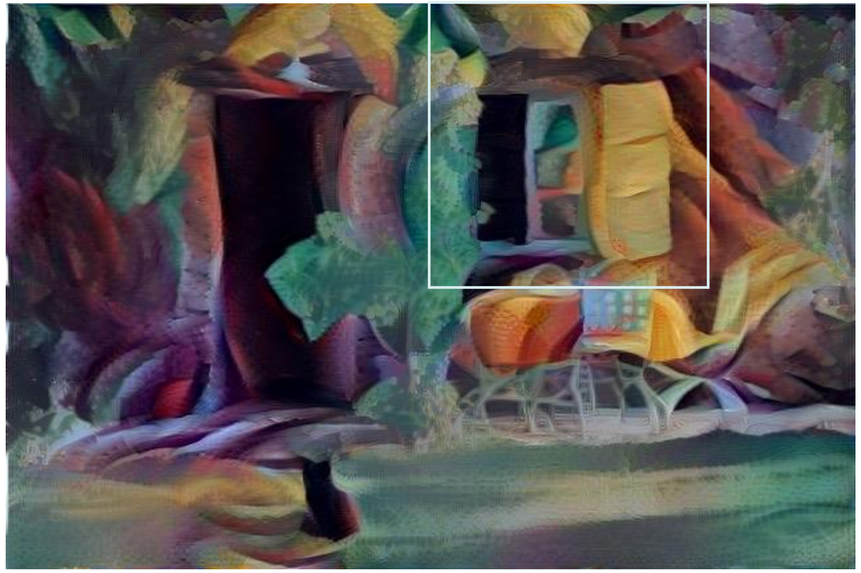
Conv4_2

Different Reconstruction Layers

Conv2_2



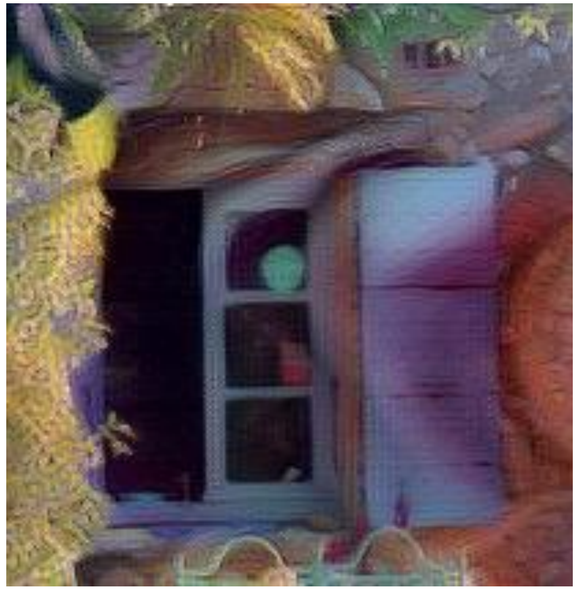
Conv4_2



Different Reconstruction Layers

Original

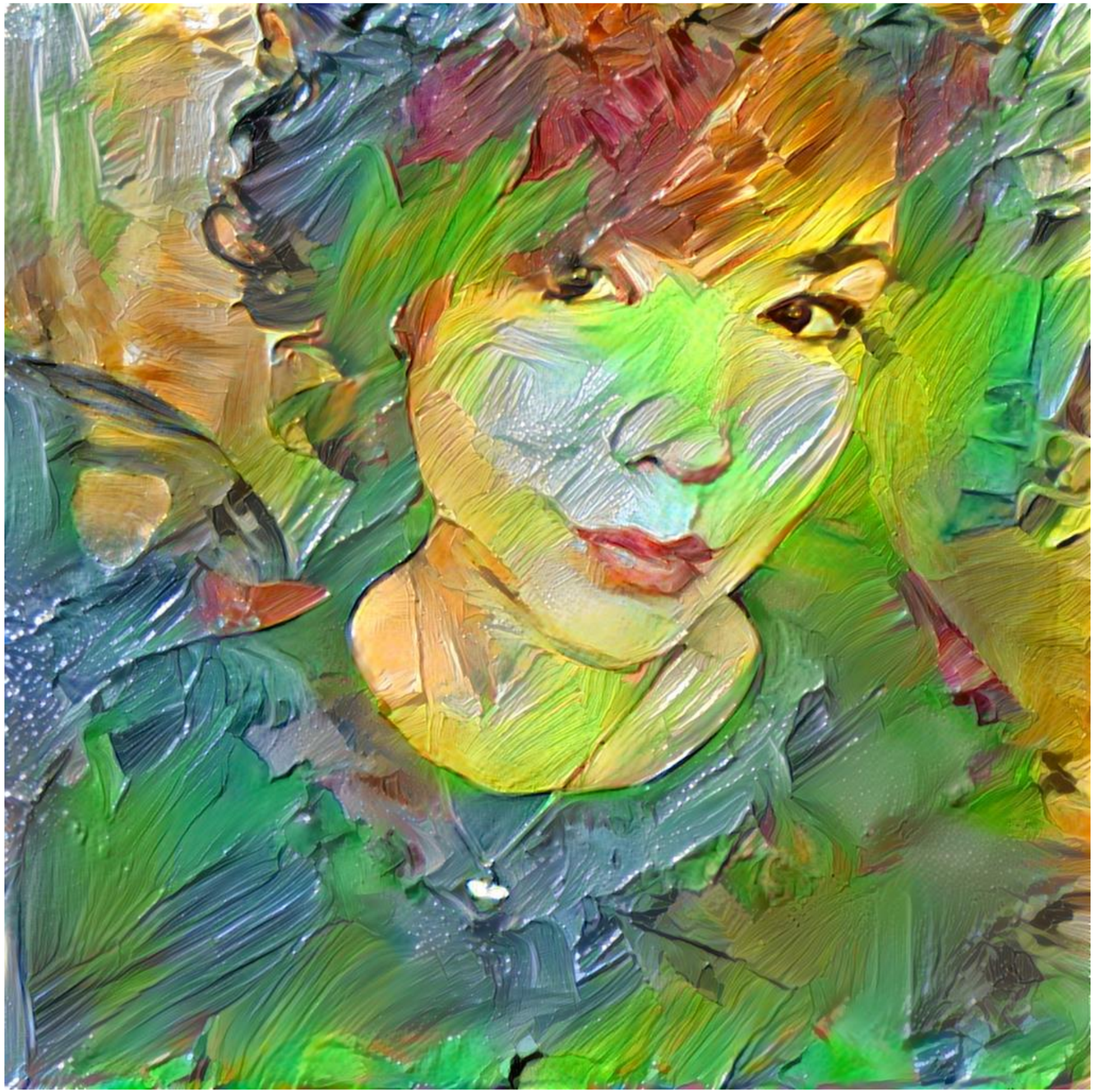
Conv2_2



Conv4_2

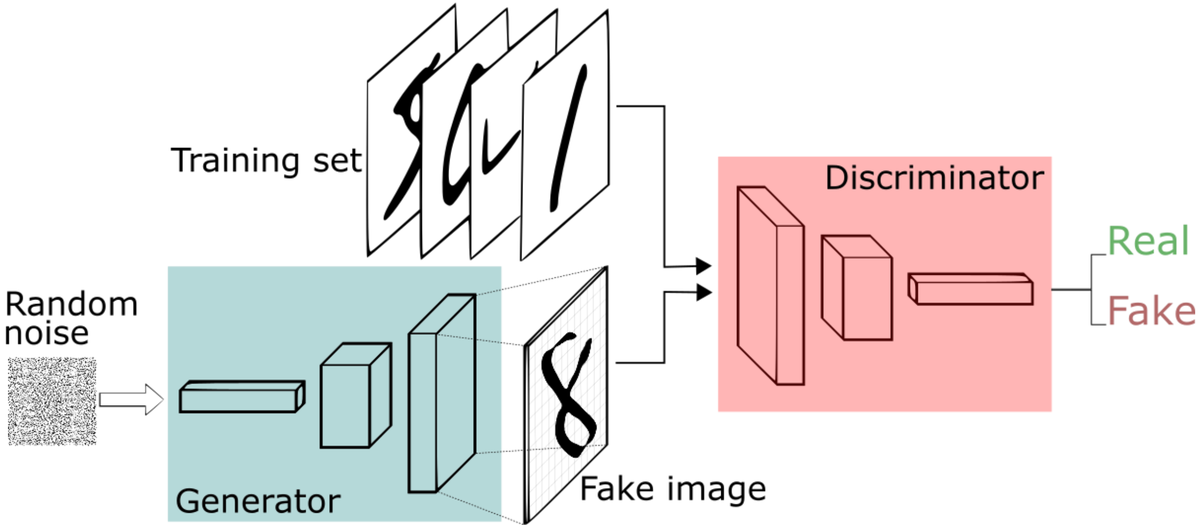
General Style Transfer

General Style Transfer



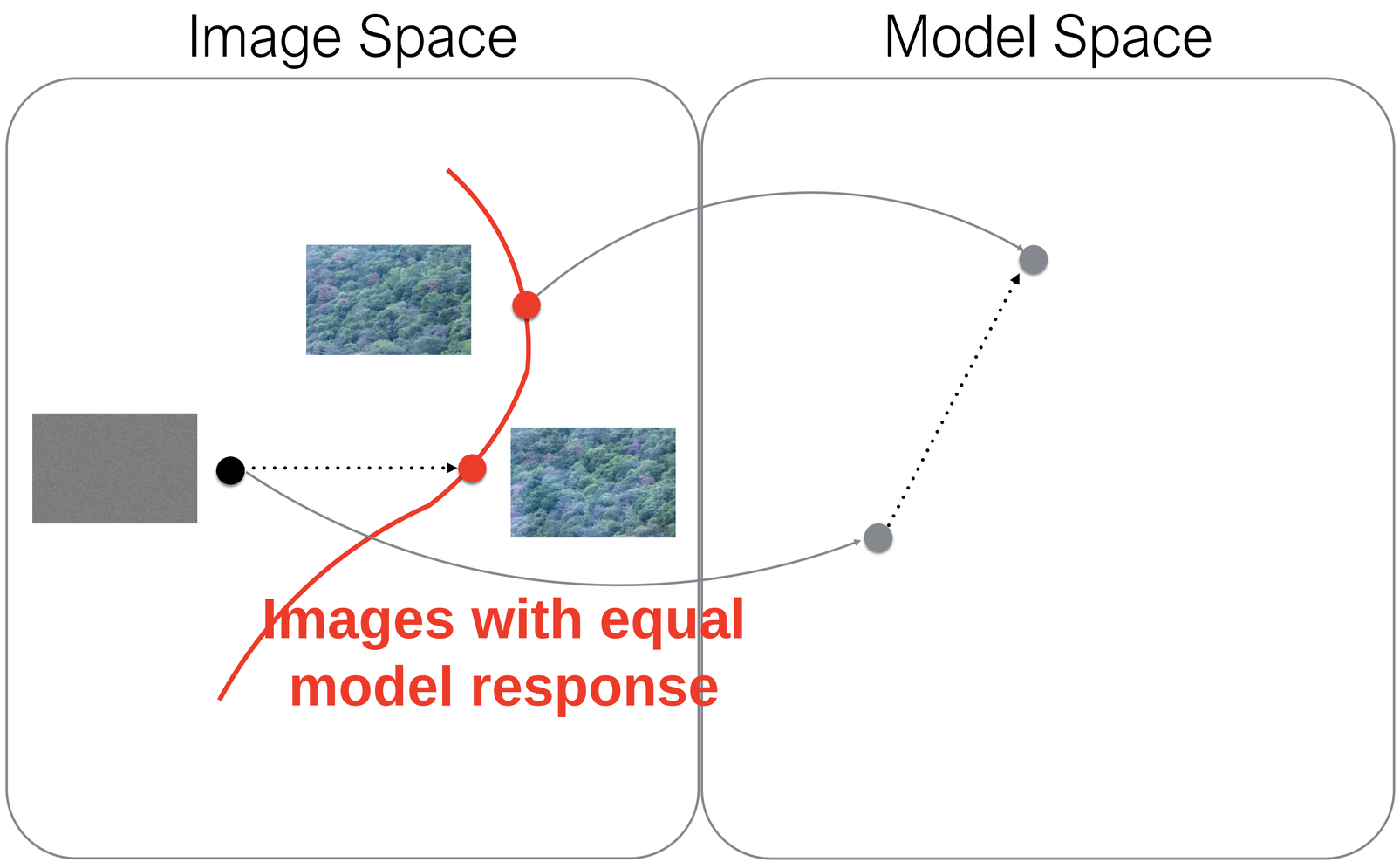

© Wayne Tilcock

GANs as Texture Synthesis?



- **Conjecture:** GANs might be learning the “right” features to match for natural images

Projecting onto the “Image Manifold”



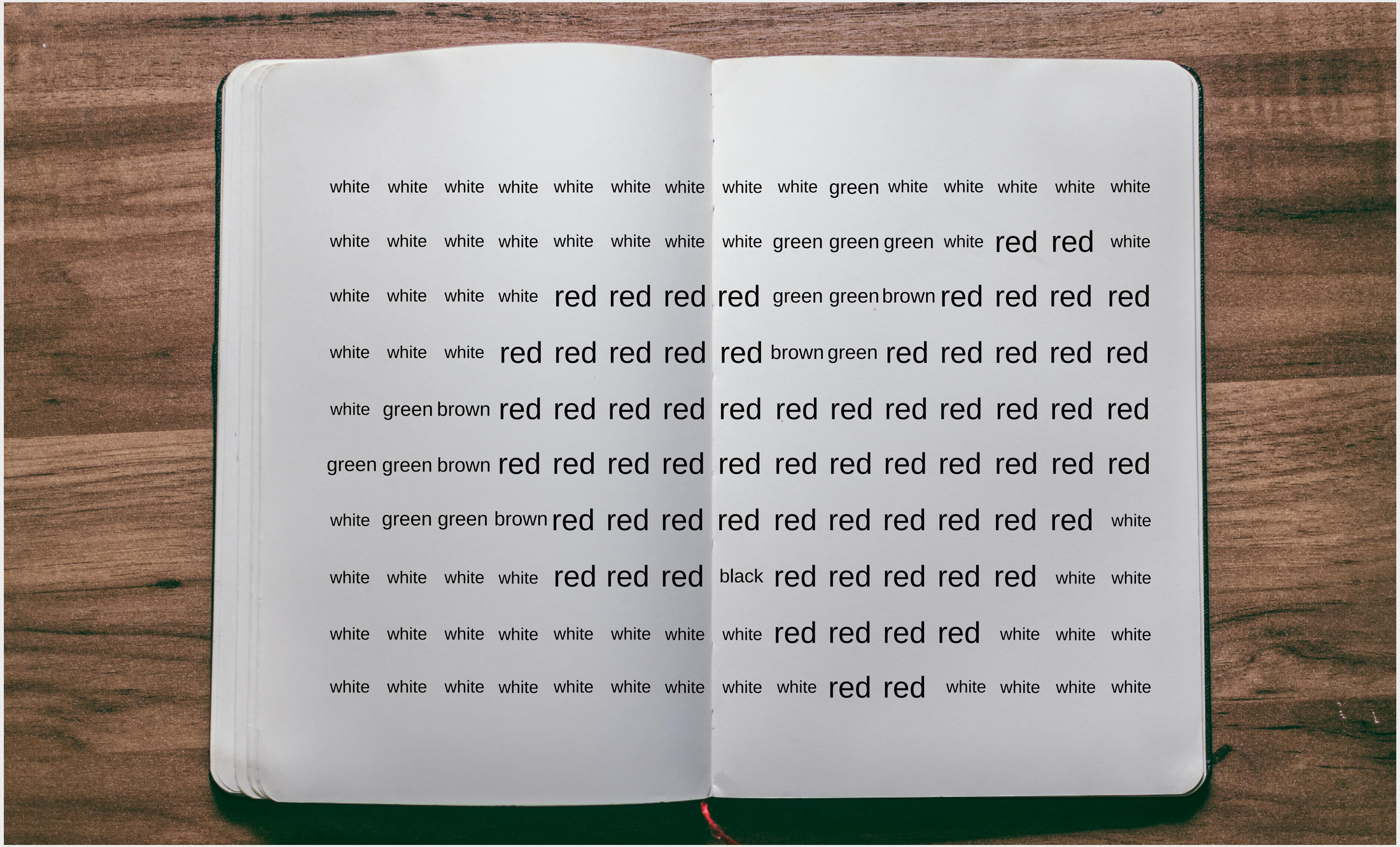
Portilla & Simoncelli (2000)

Imagen

DALL-E 2

diffusion

By Steve Seitz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Language Generator

(+ pixels)

Image Generator

(+ language)

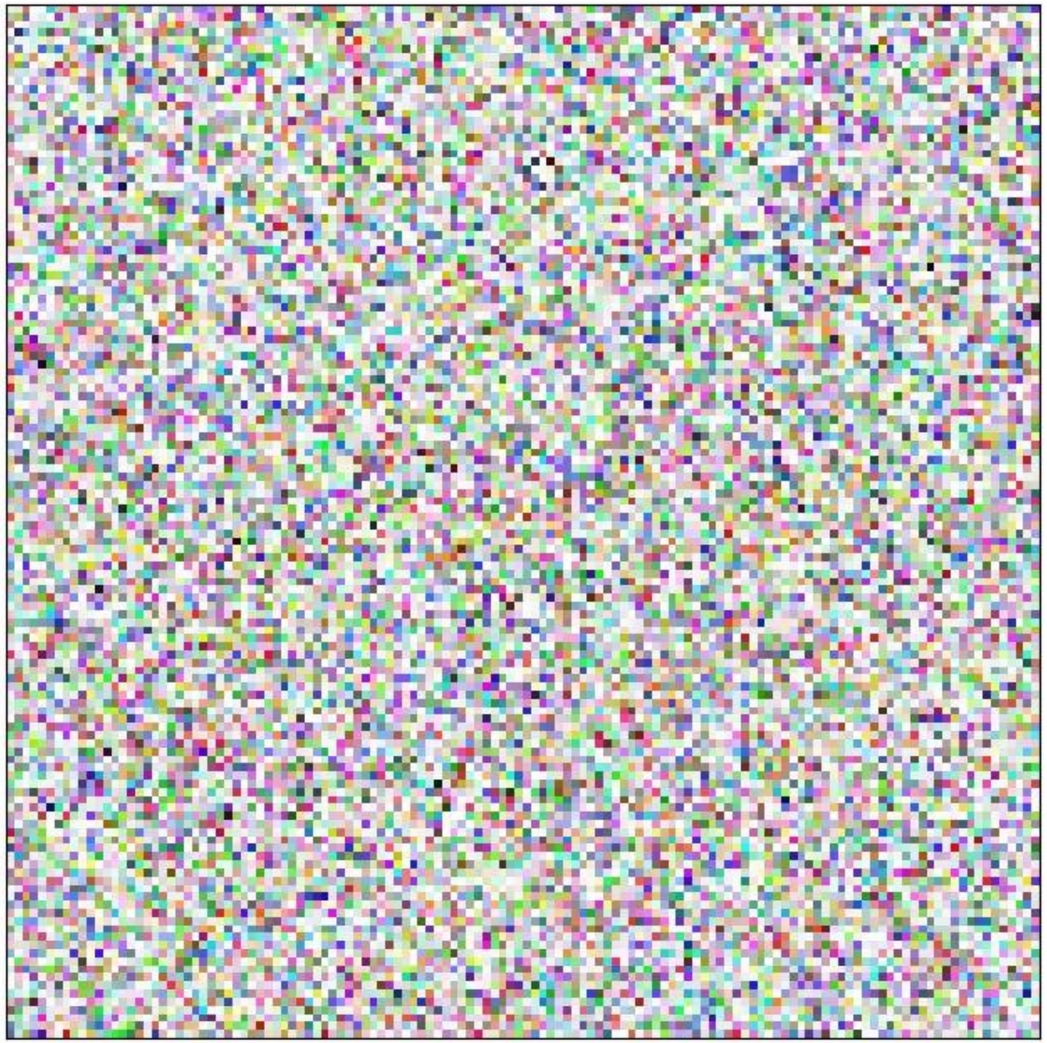
Parti

Imagen

slide from Steve Seitz's video

Generate 100 images

slide from Steve Seitz's video



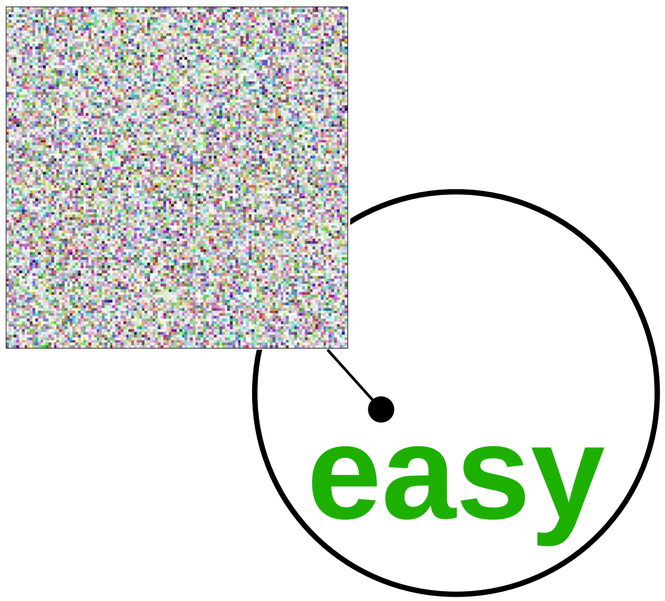
Generate 100 images

slide from Steve Seitz's video

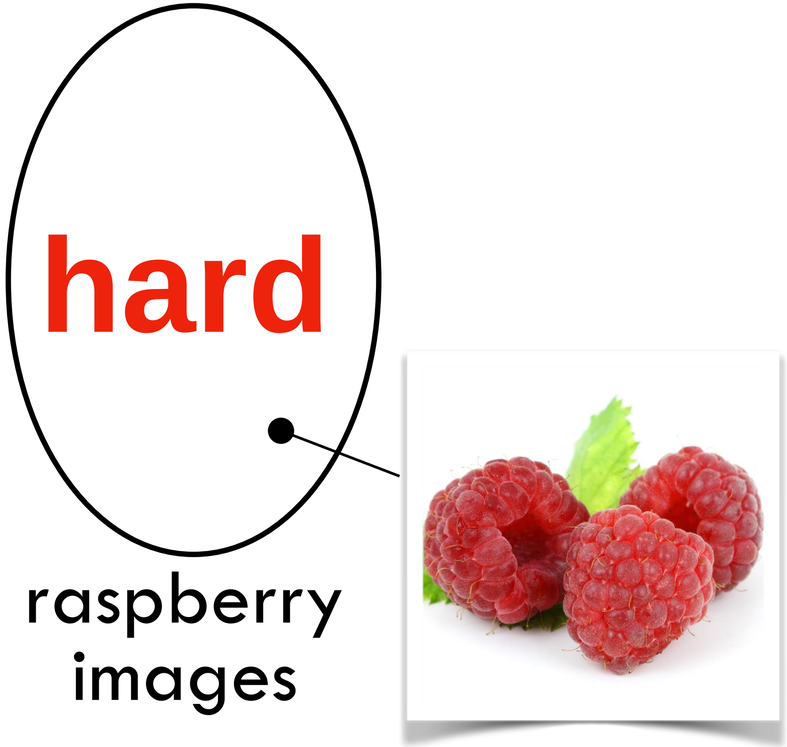
slide from Steve Seitz’s video

Generate 100 images of raspberries

slide from Steve Seitz's video



random
images



raspberry
images

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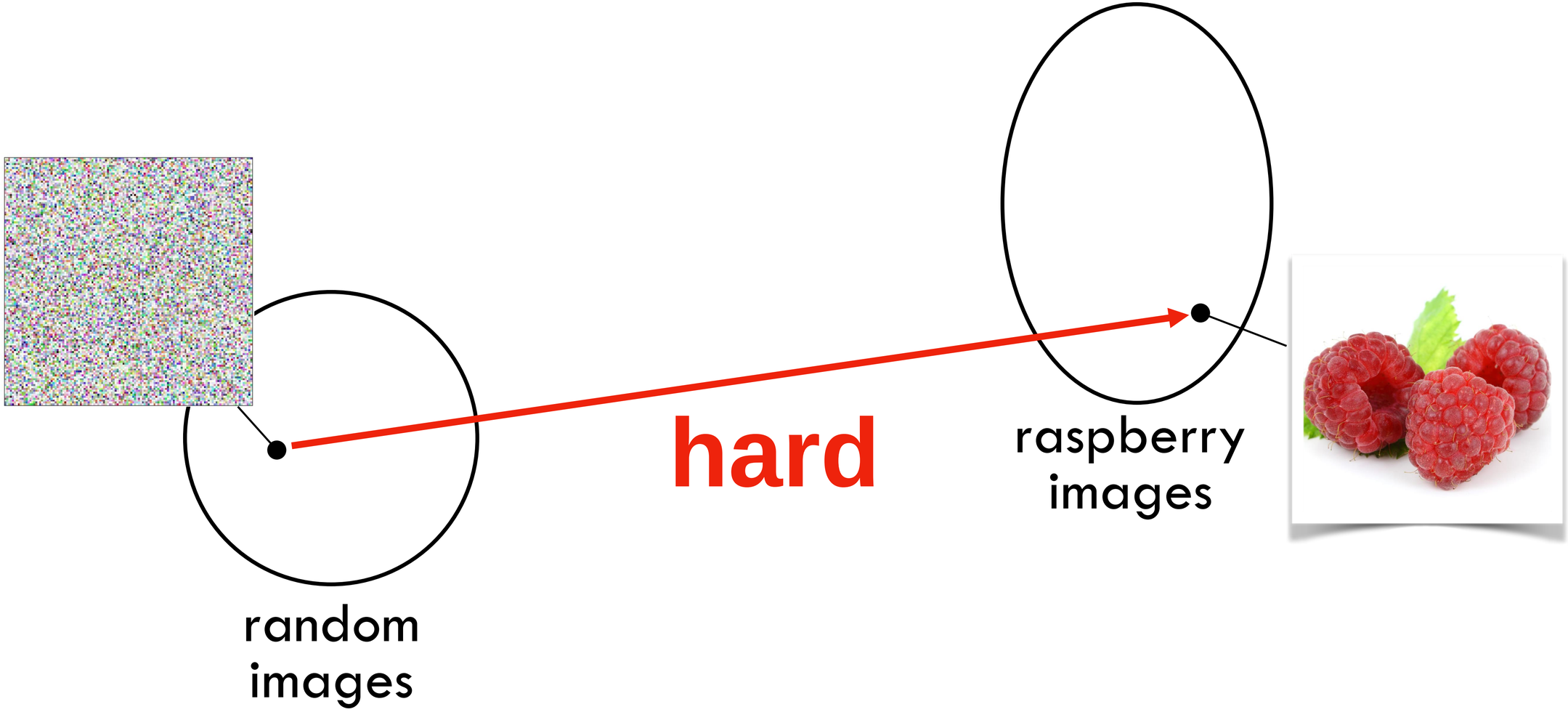

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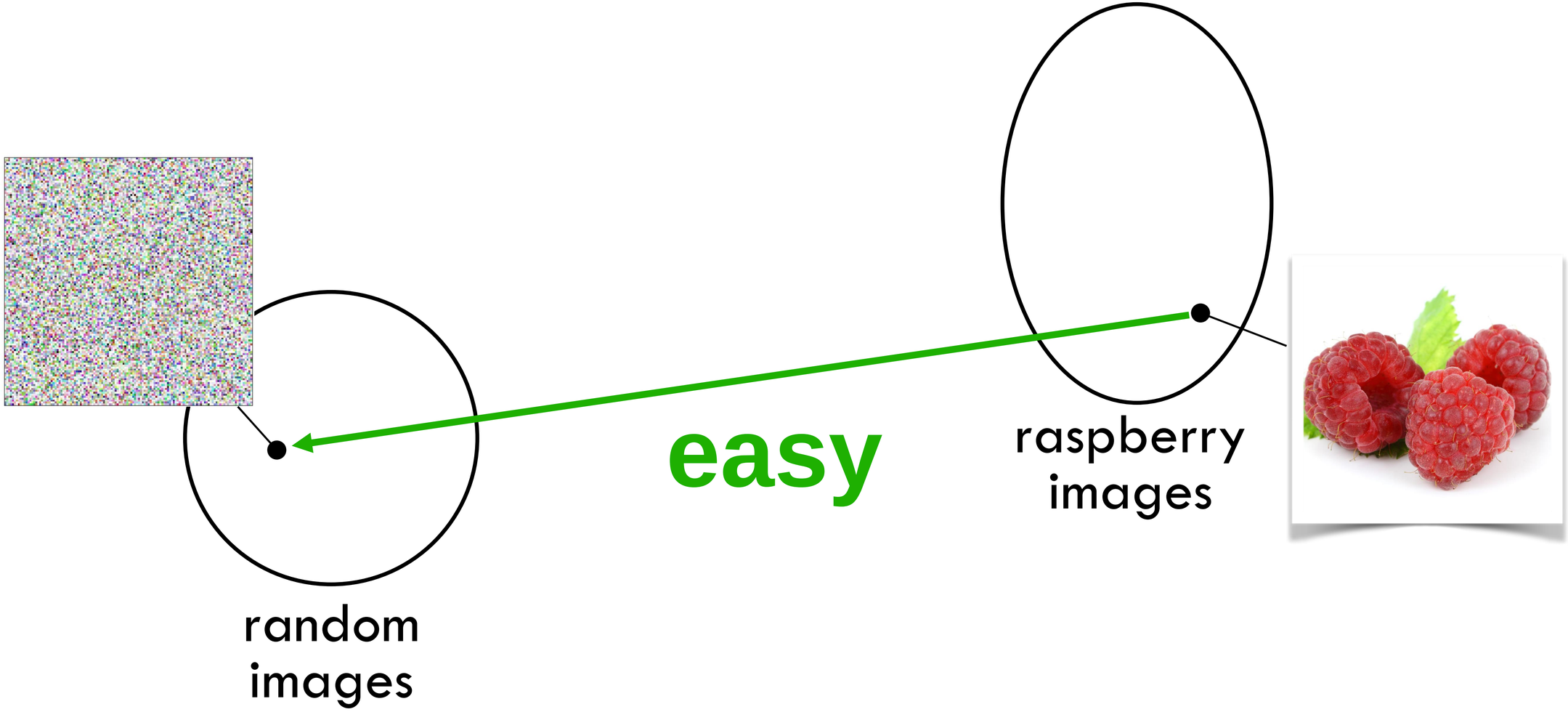

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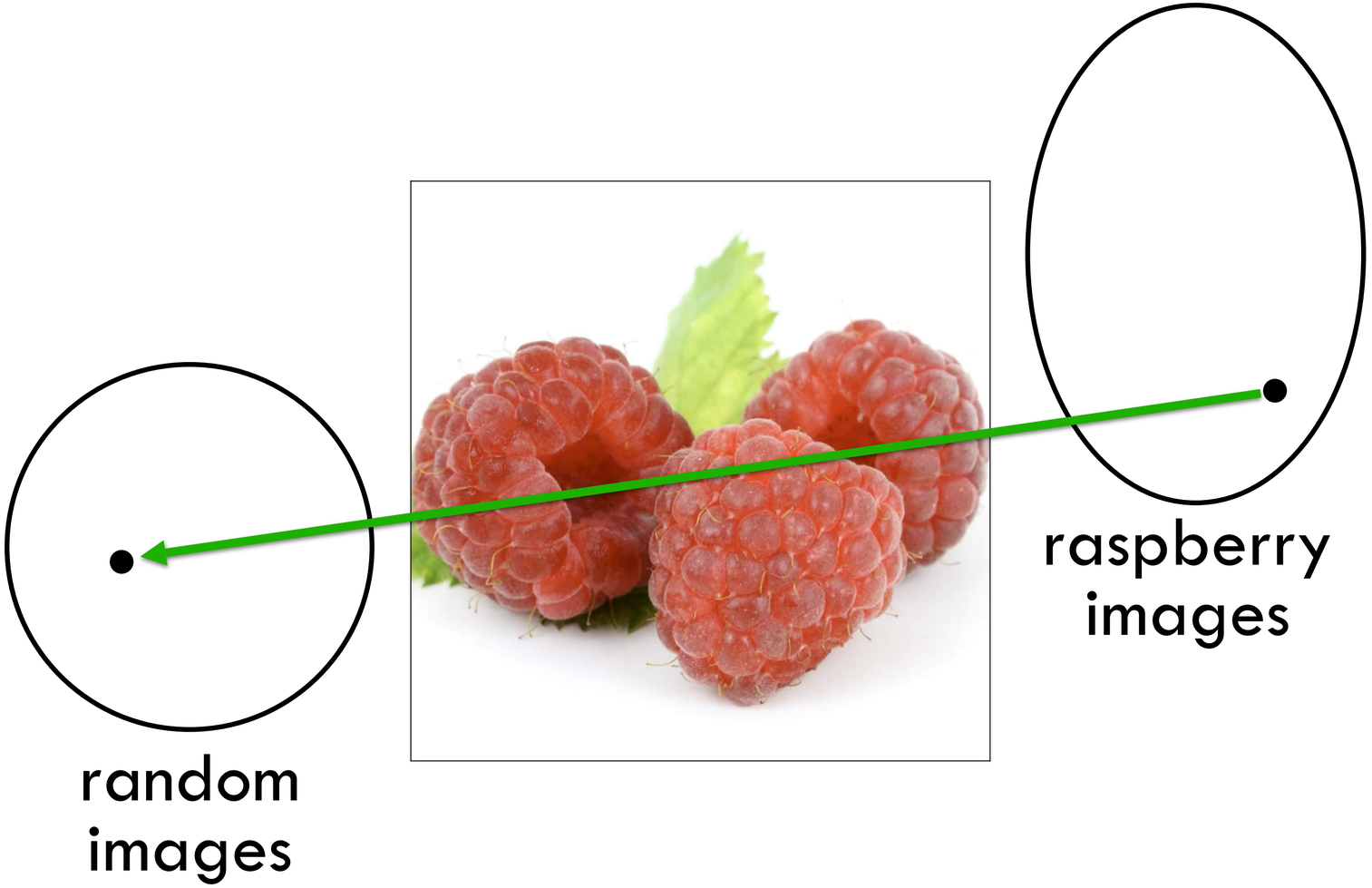

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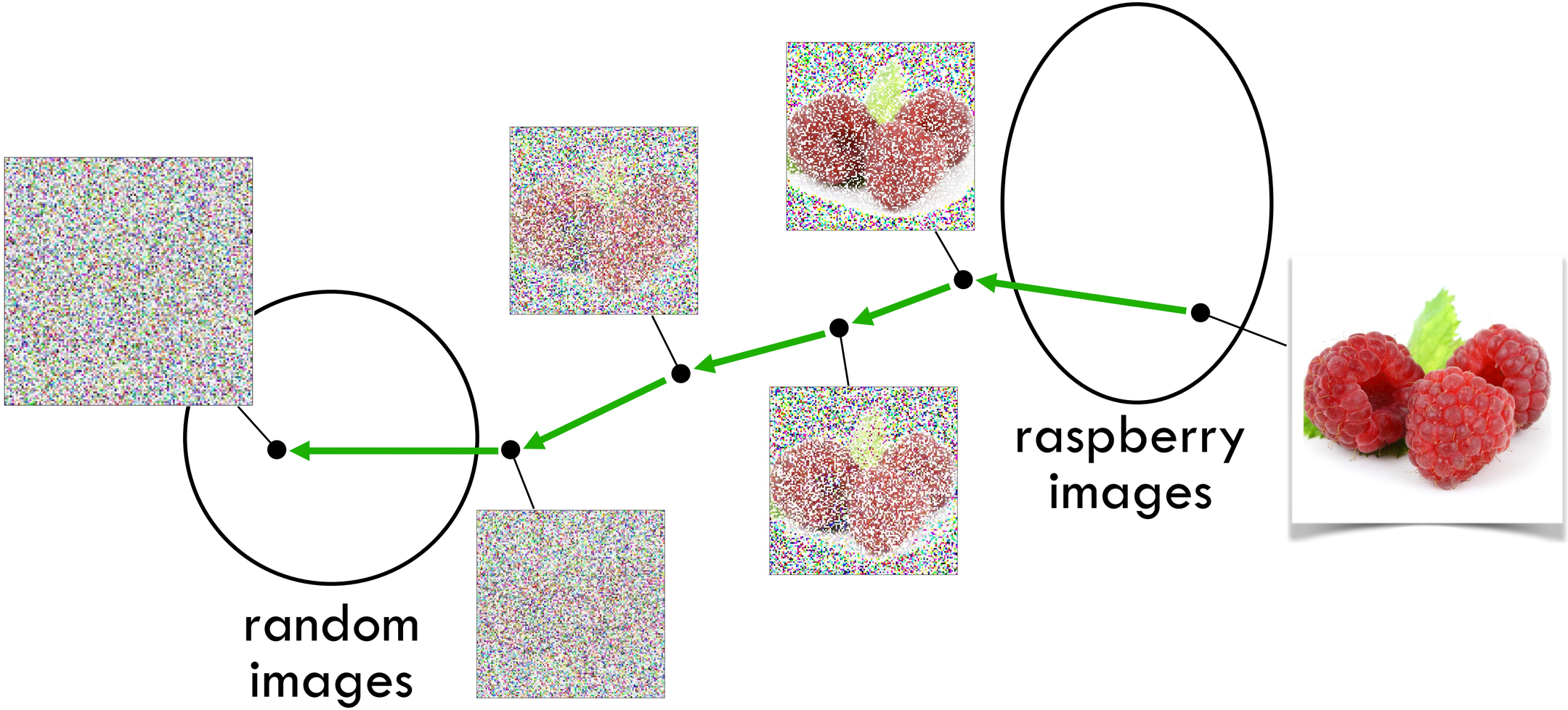

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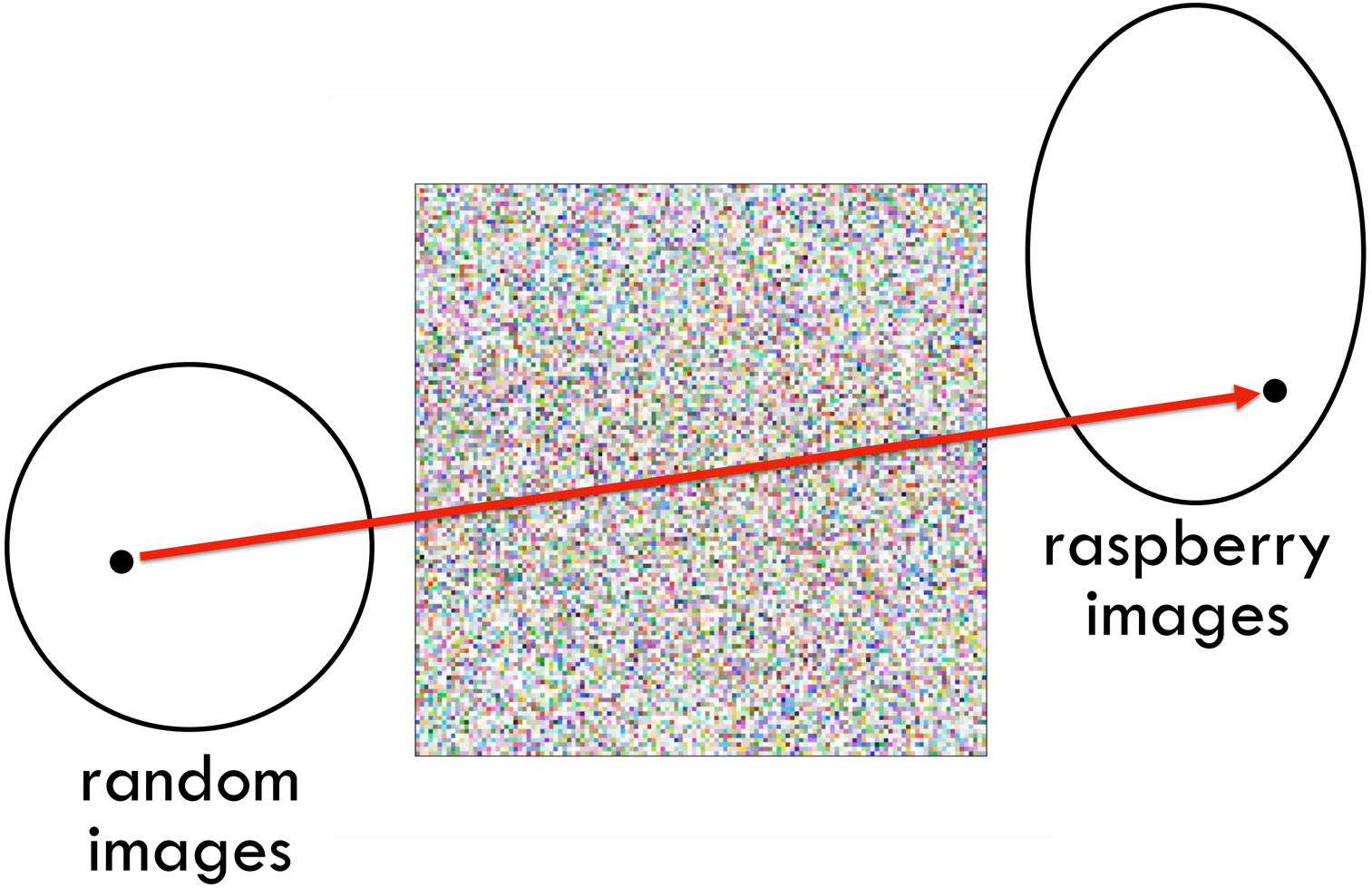

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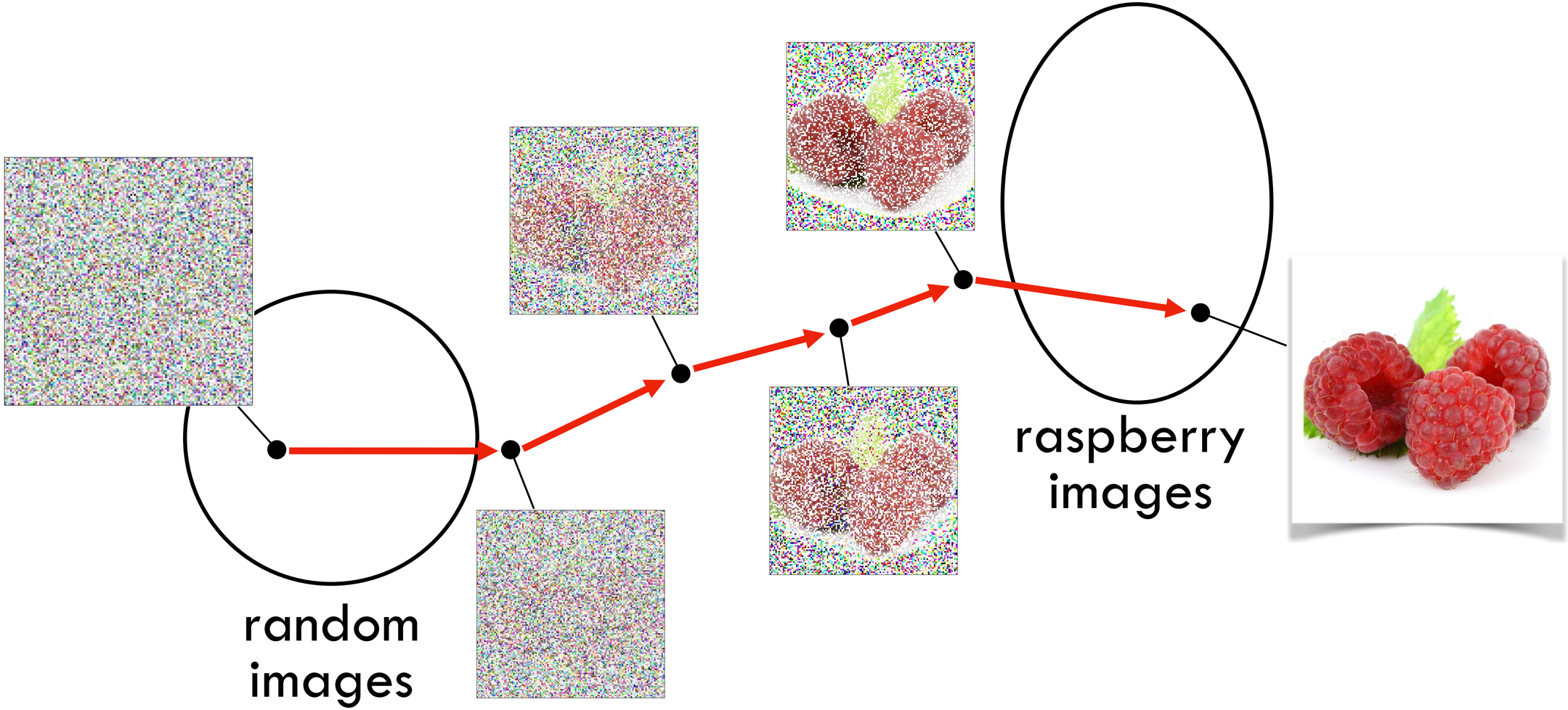

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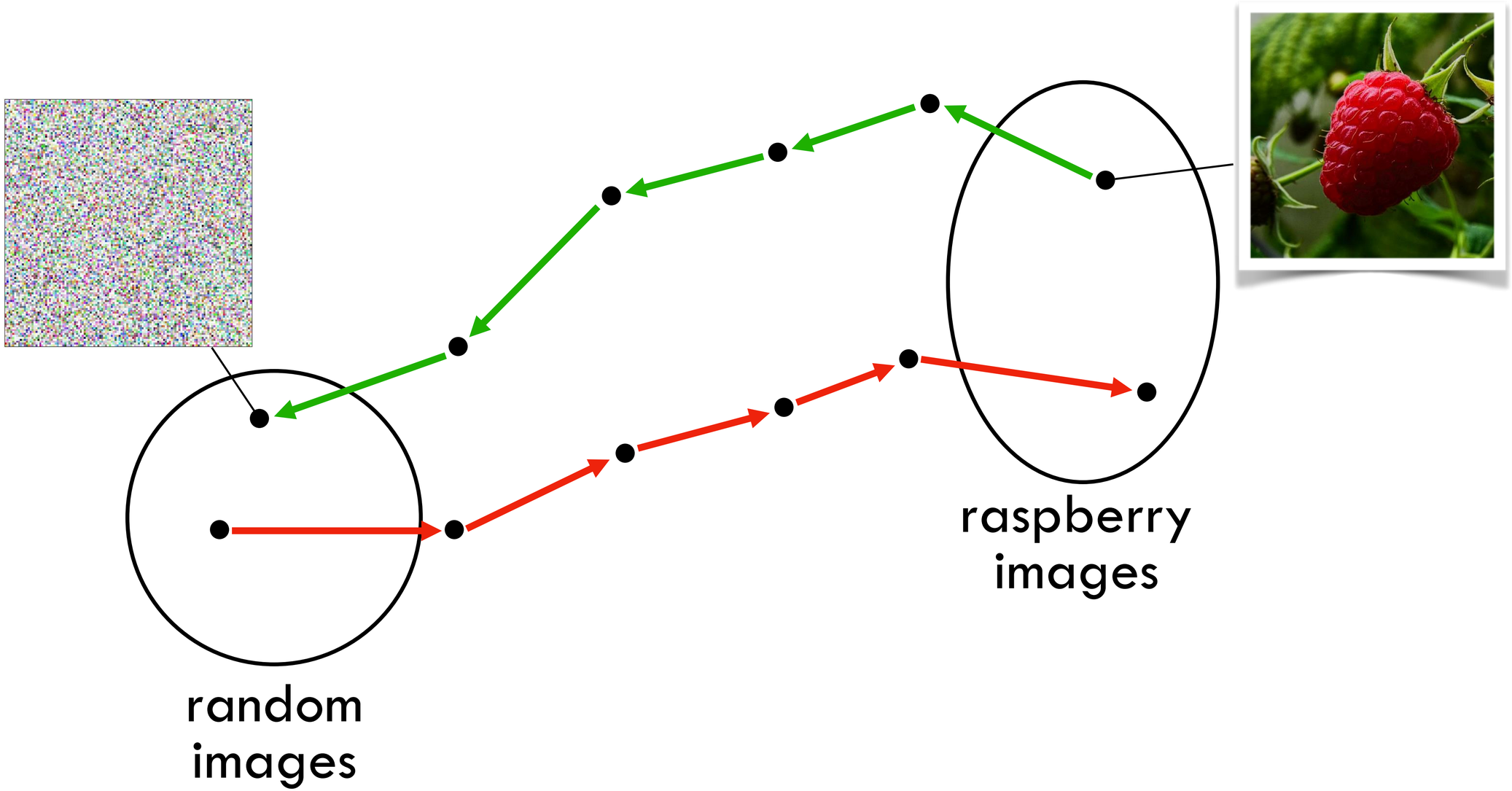

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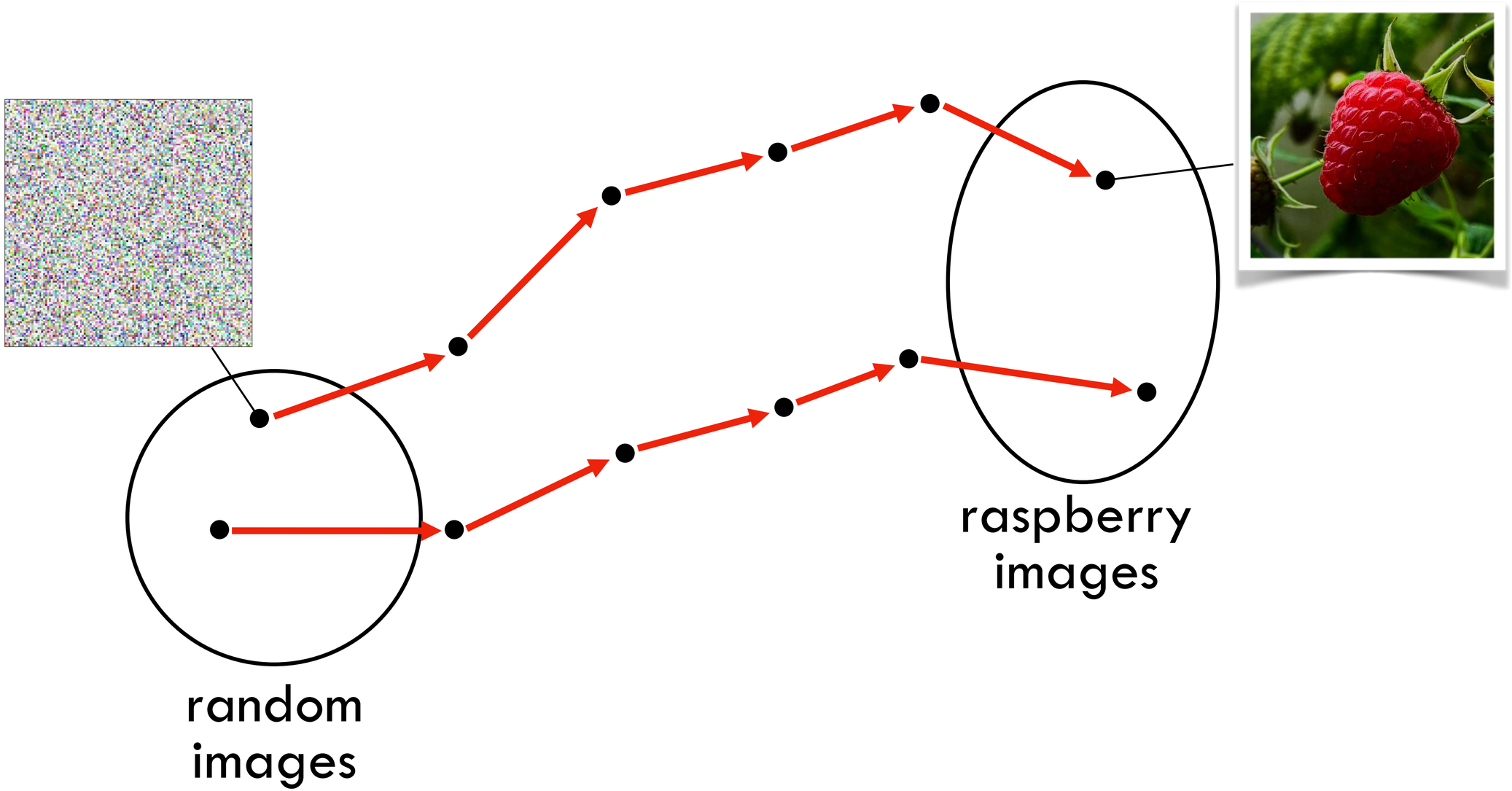

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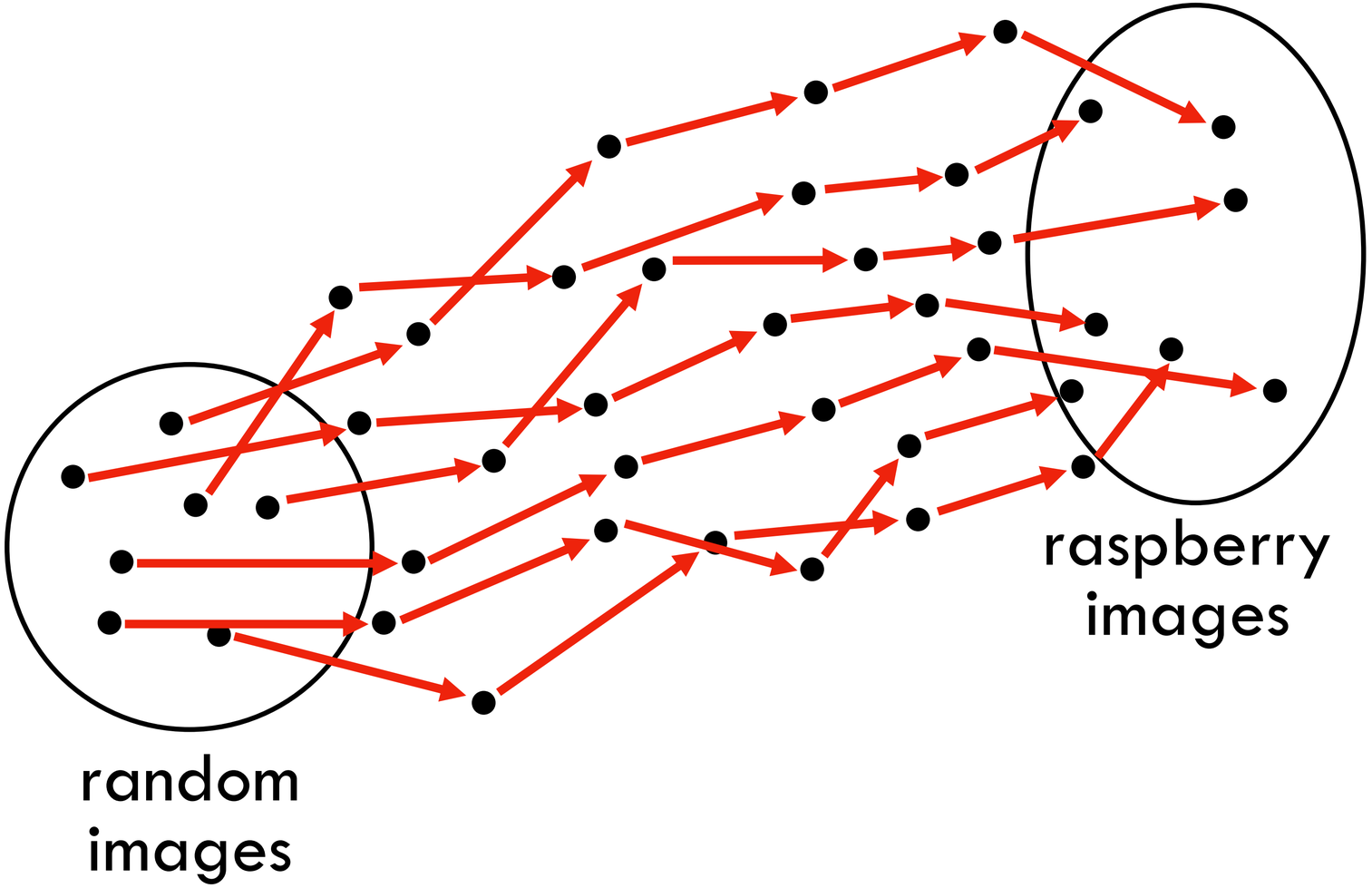

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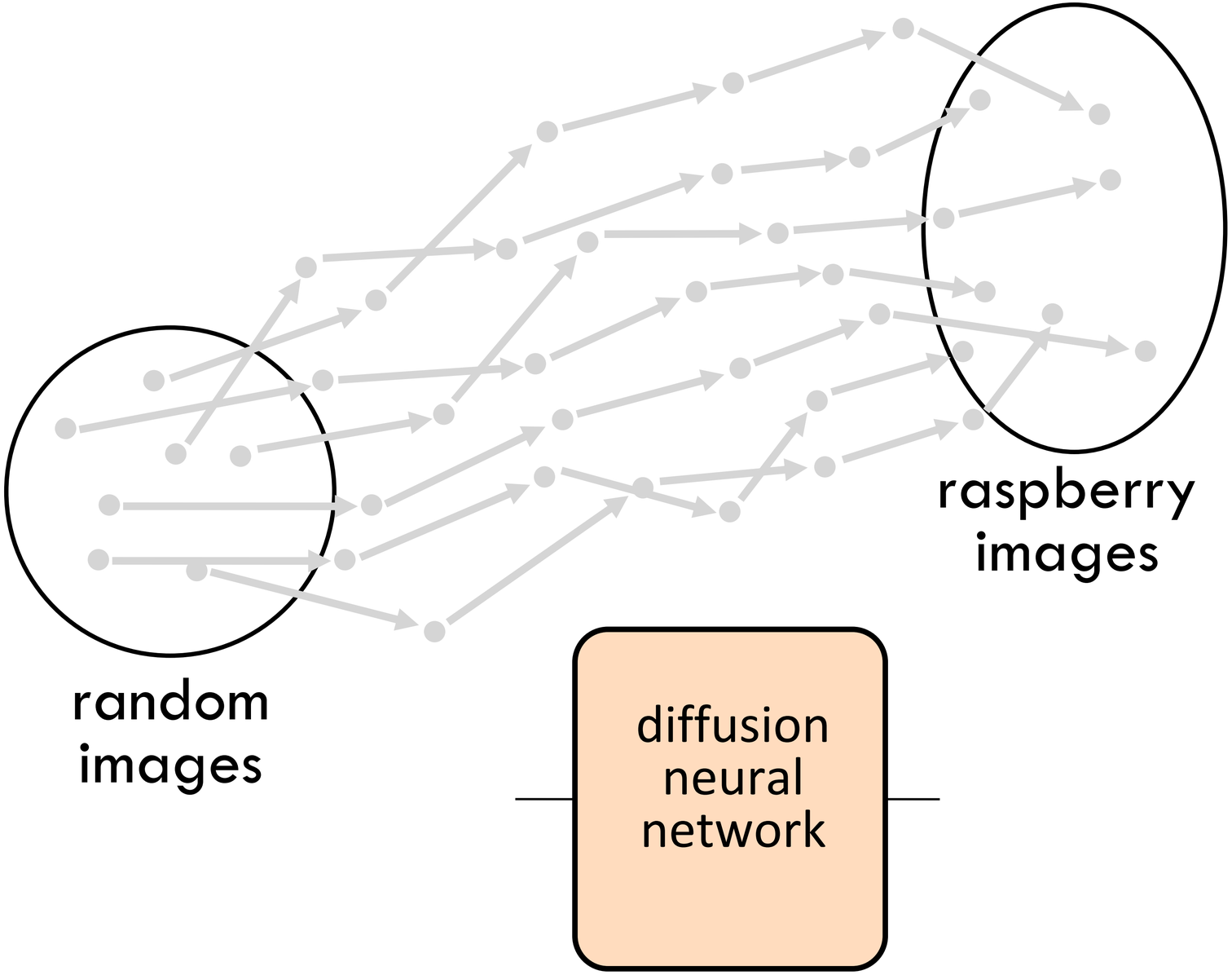

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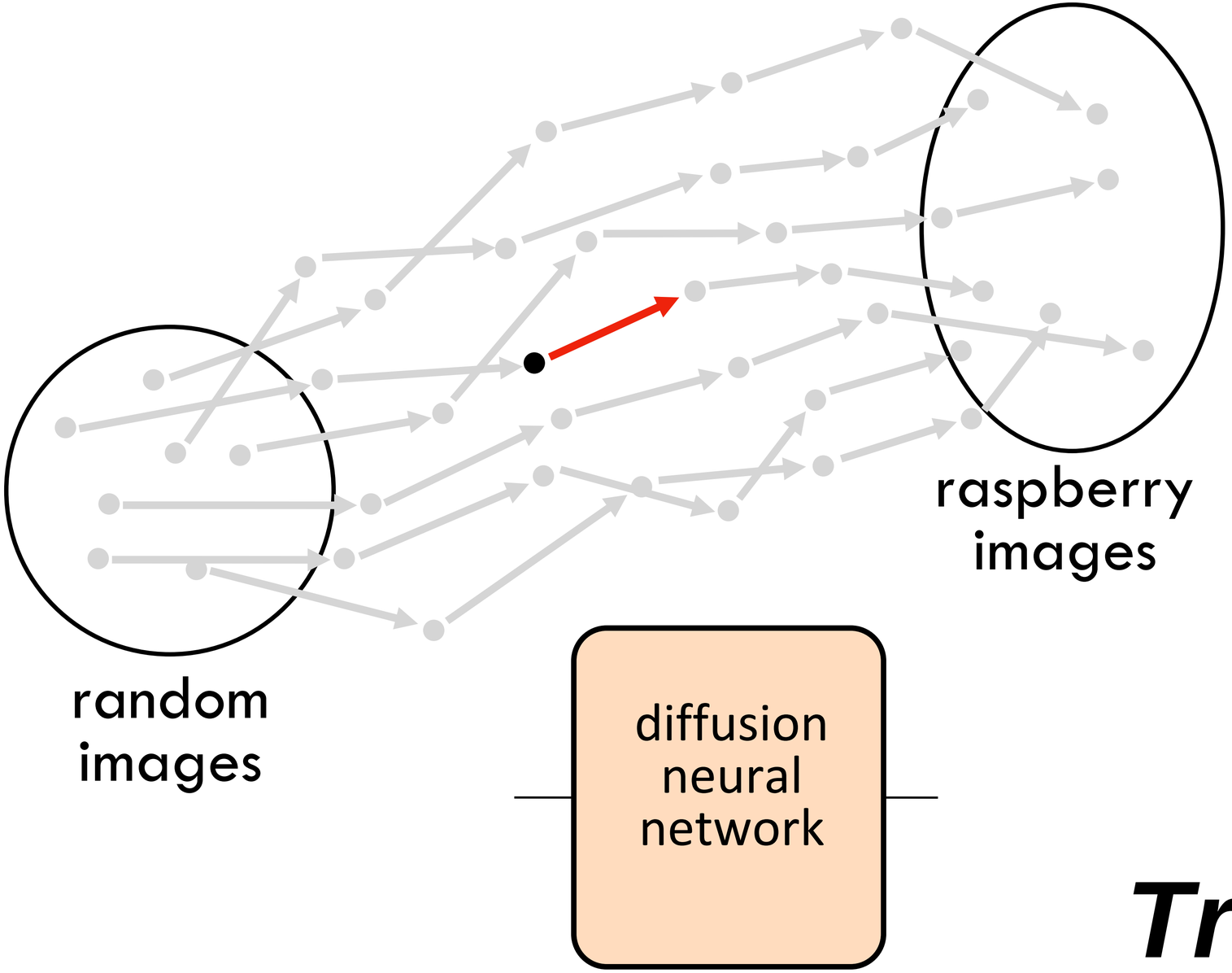

Training

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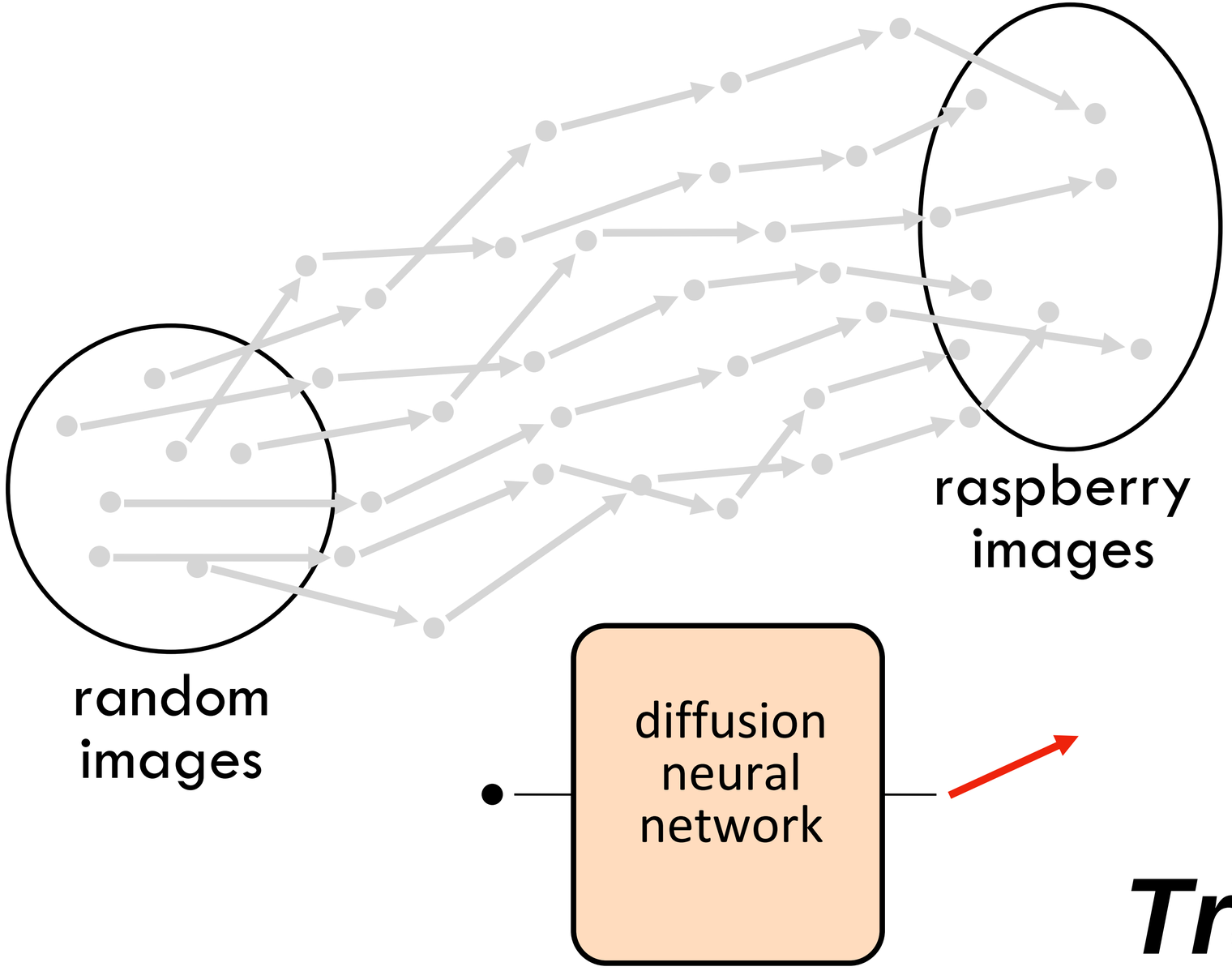

Training

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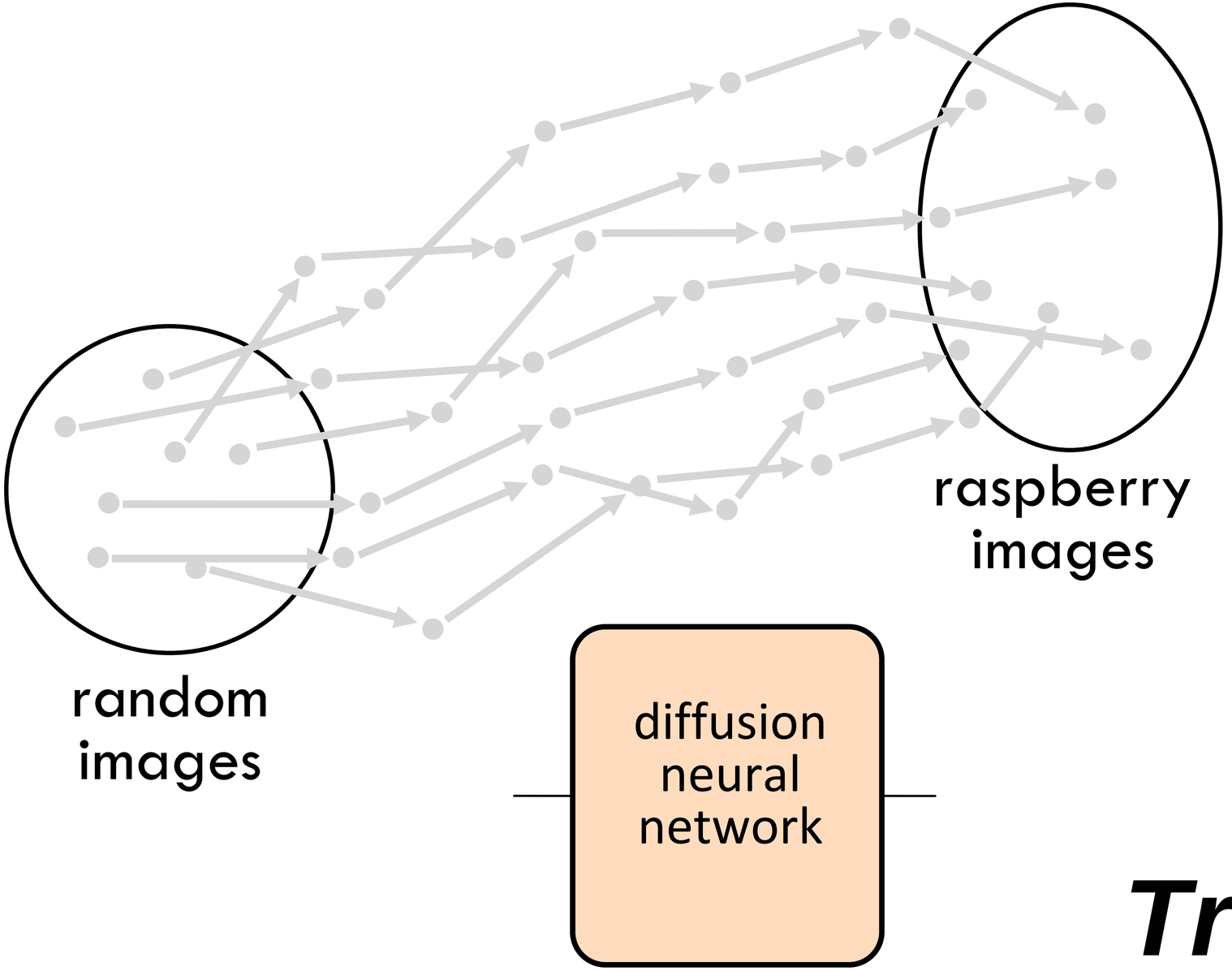

Training

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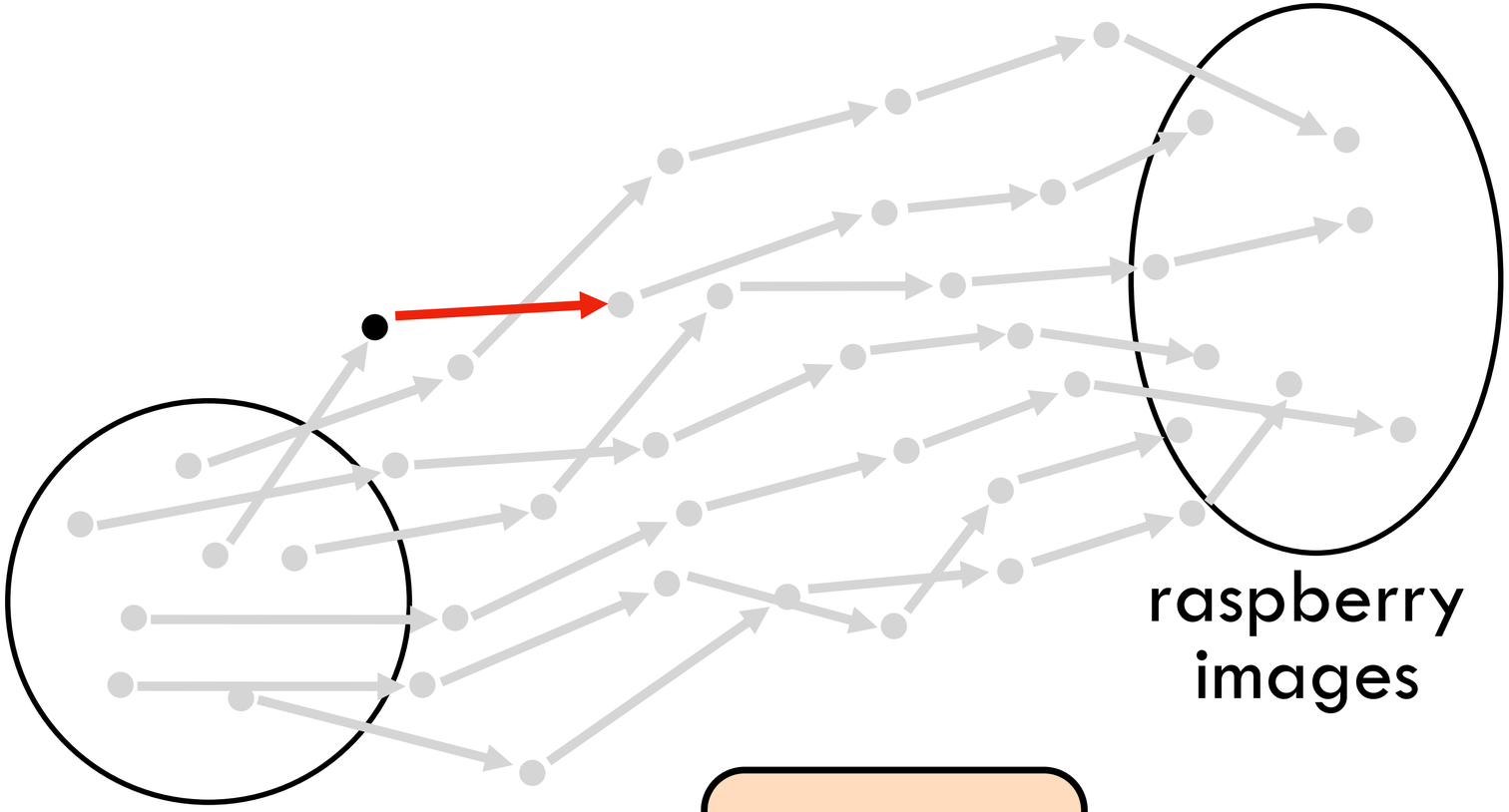

diffusion
neural
network

Training

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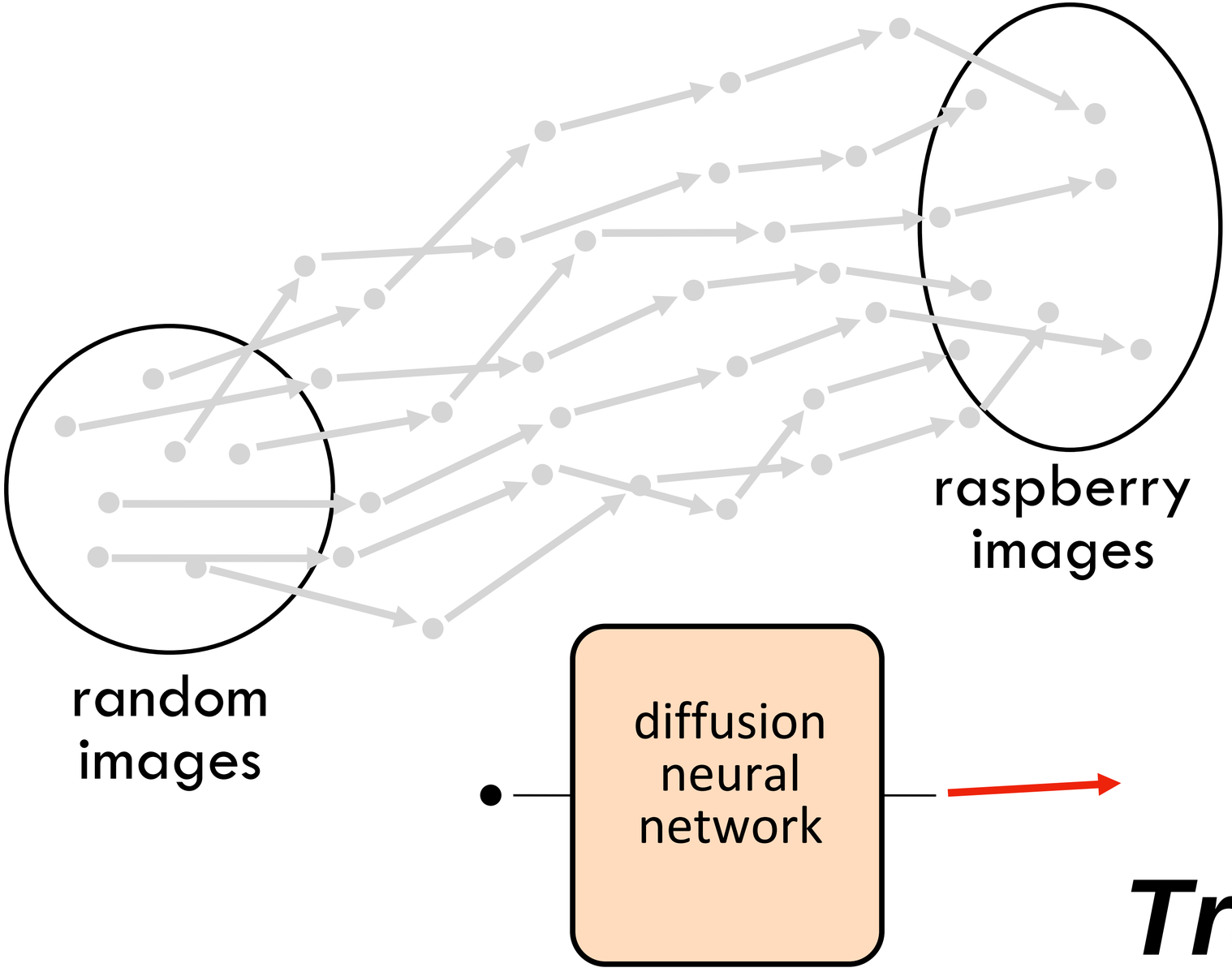

Training

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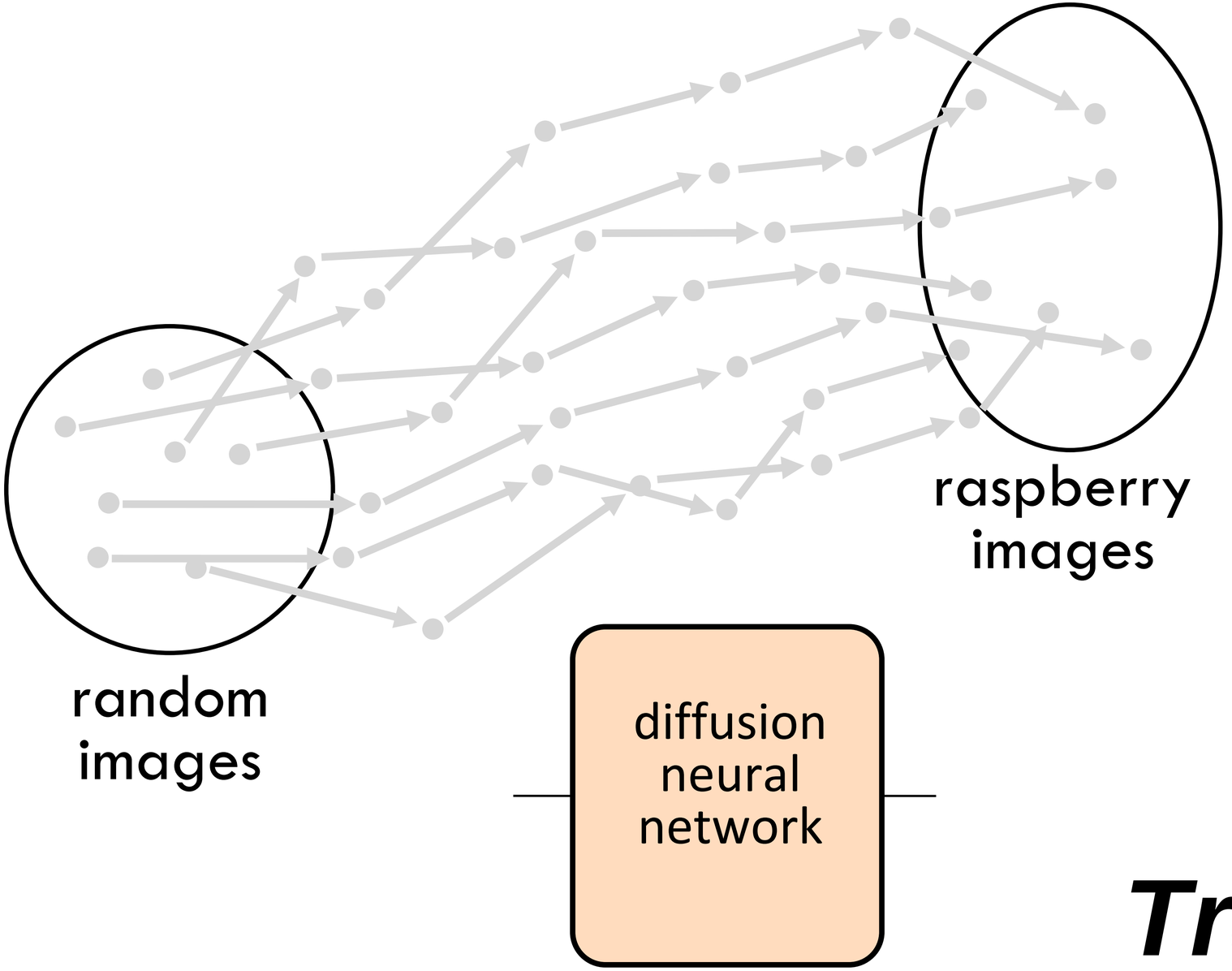

Training

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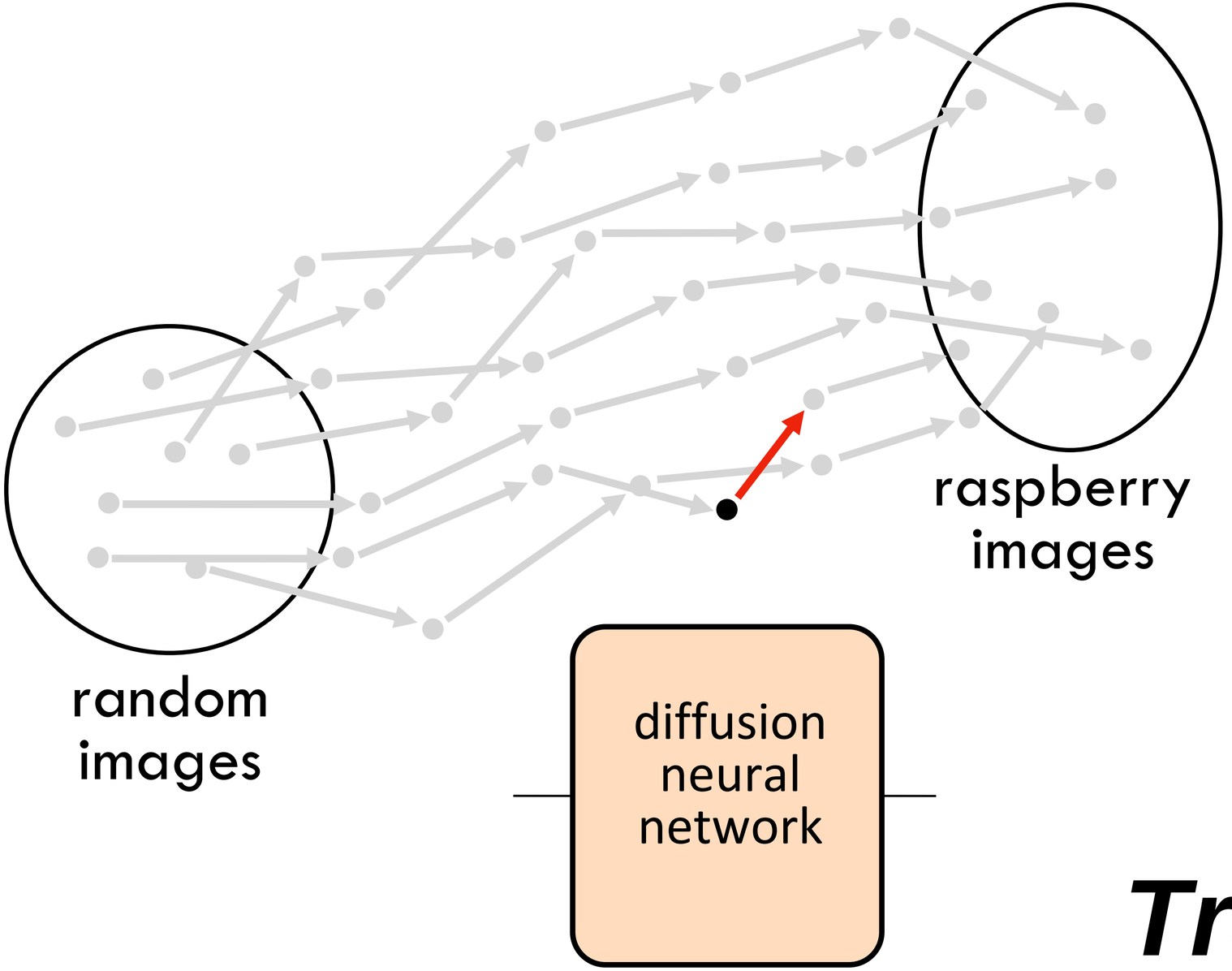

Training

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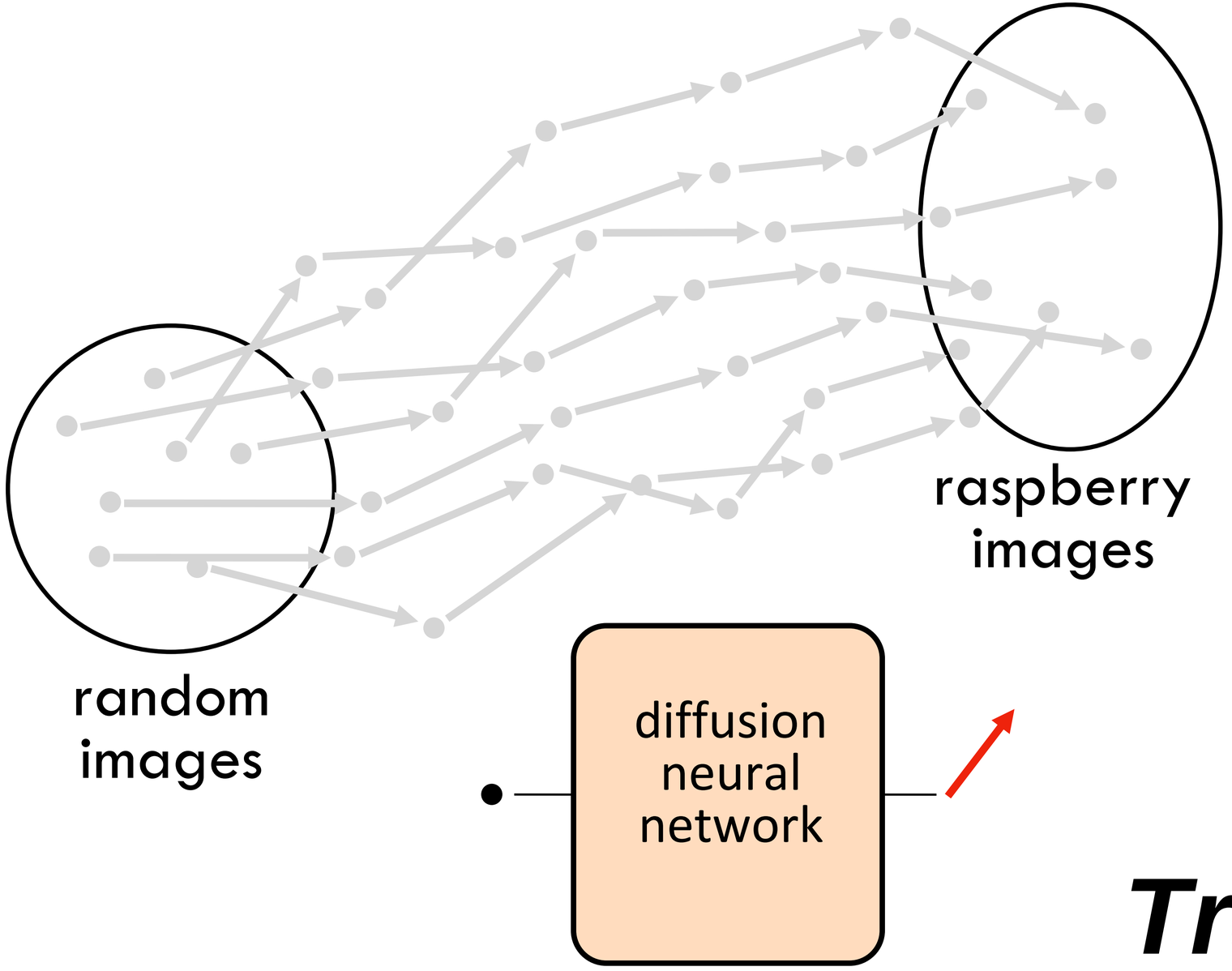

Training

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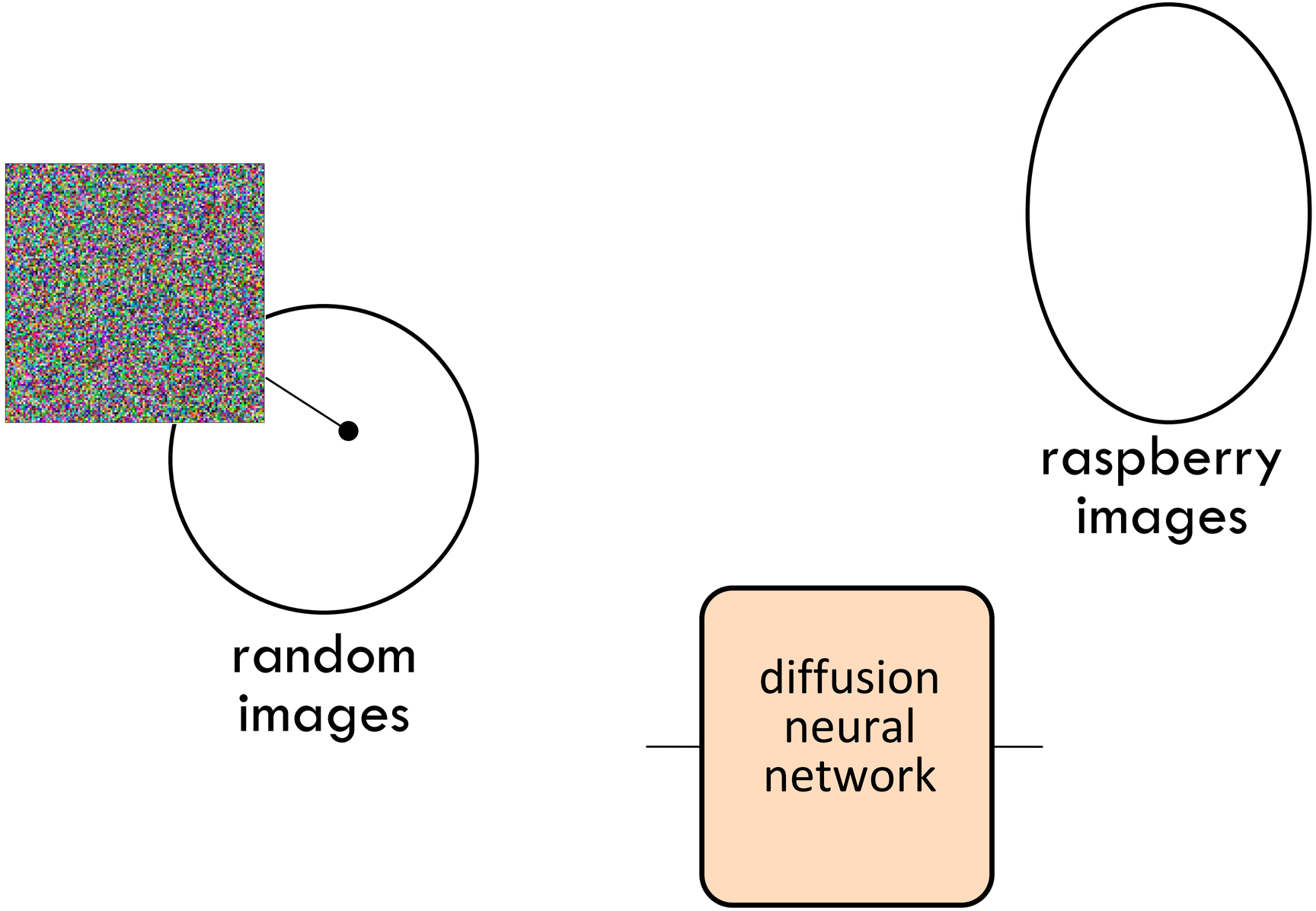

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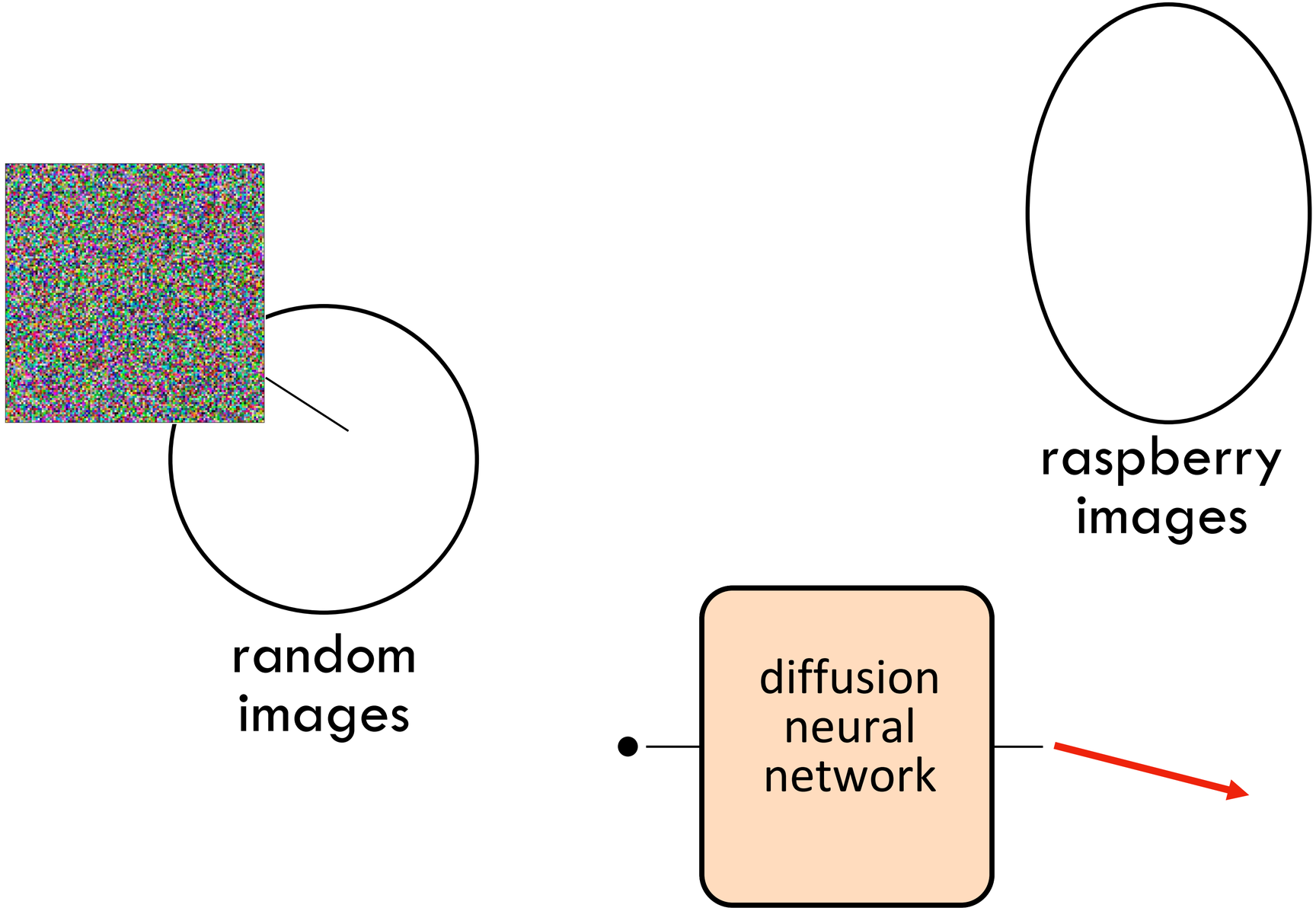

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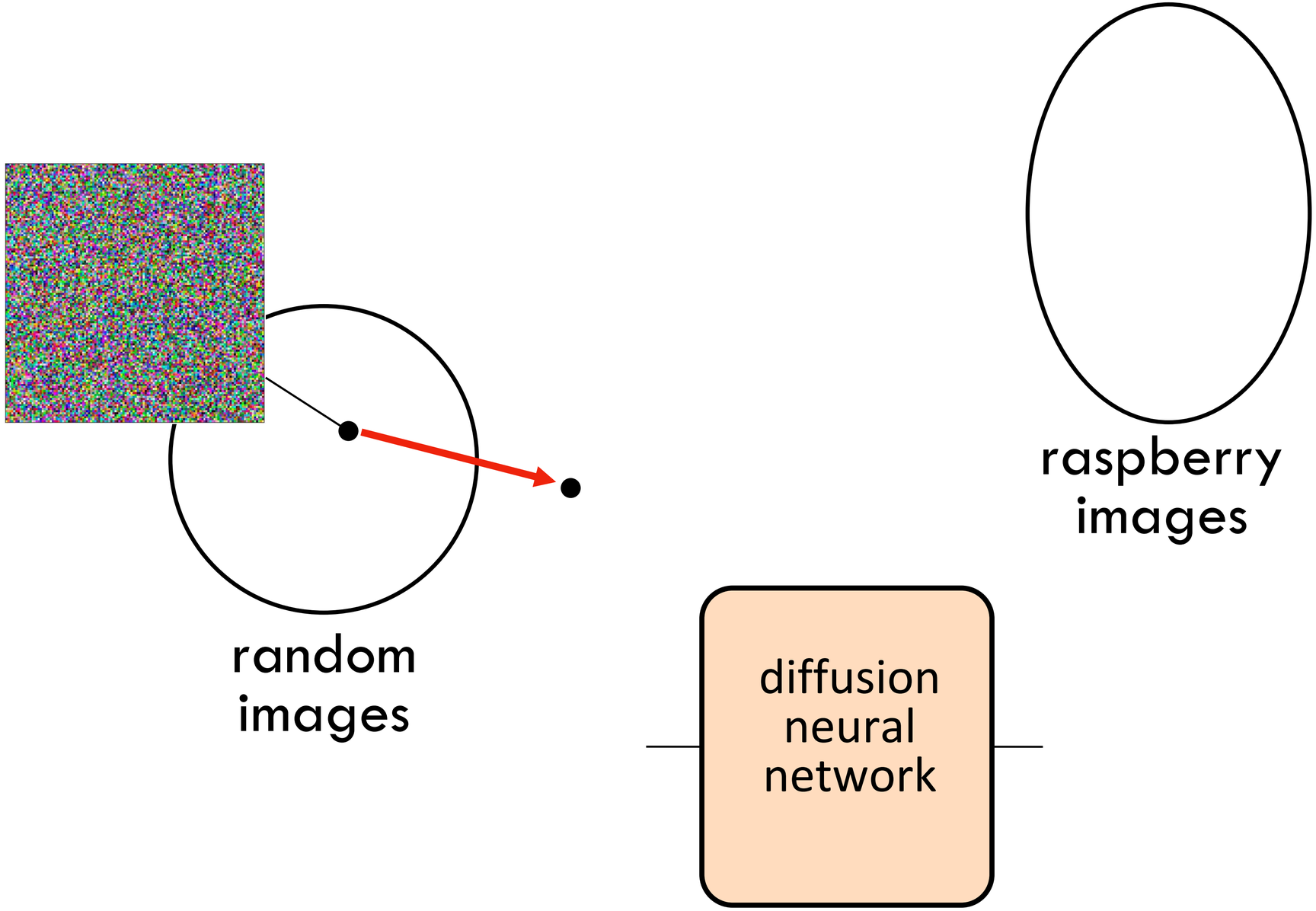

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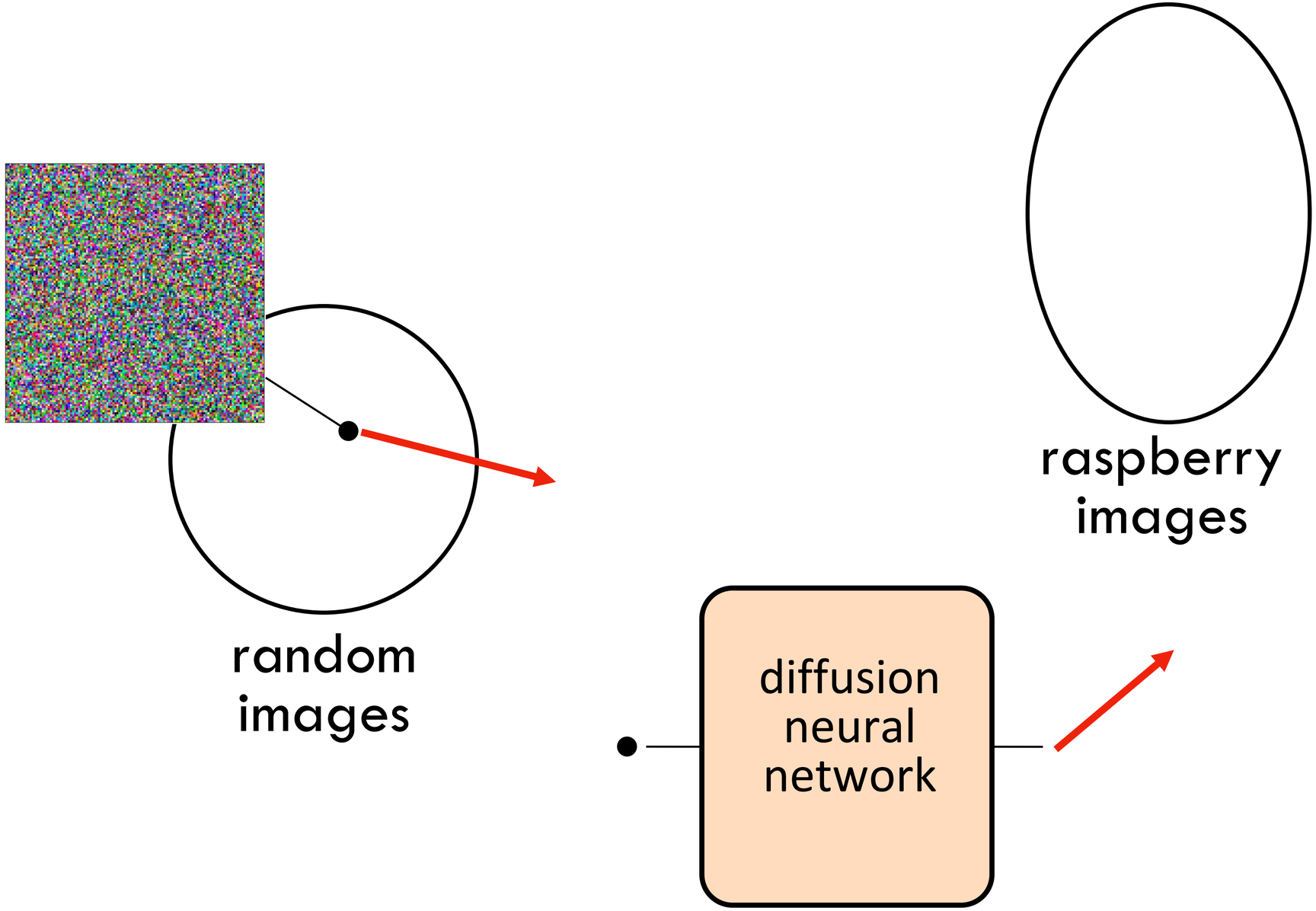

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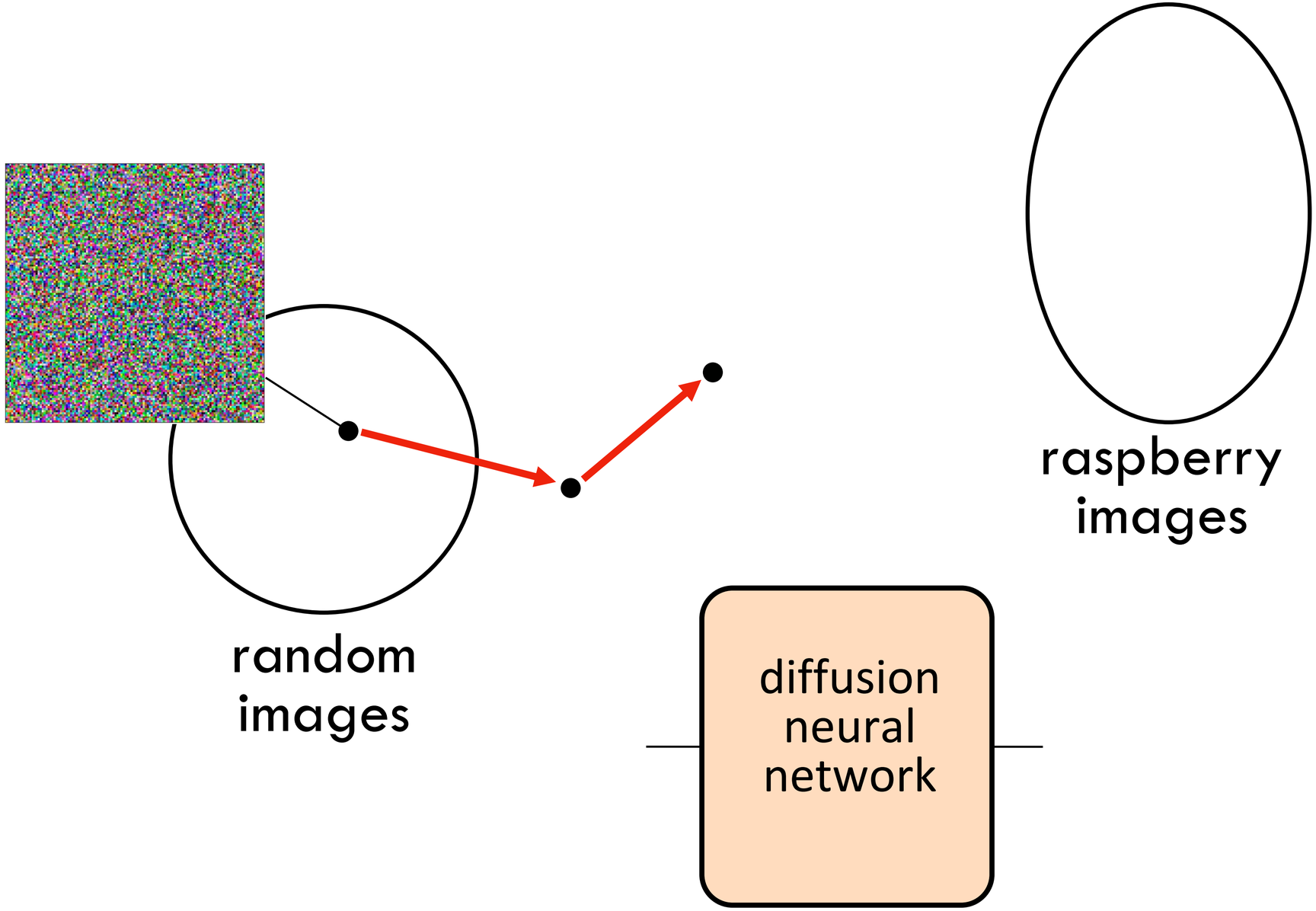

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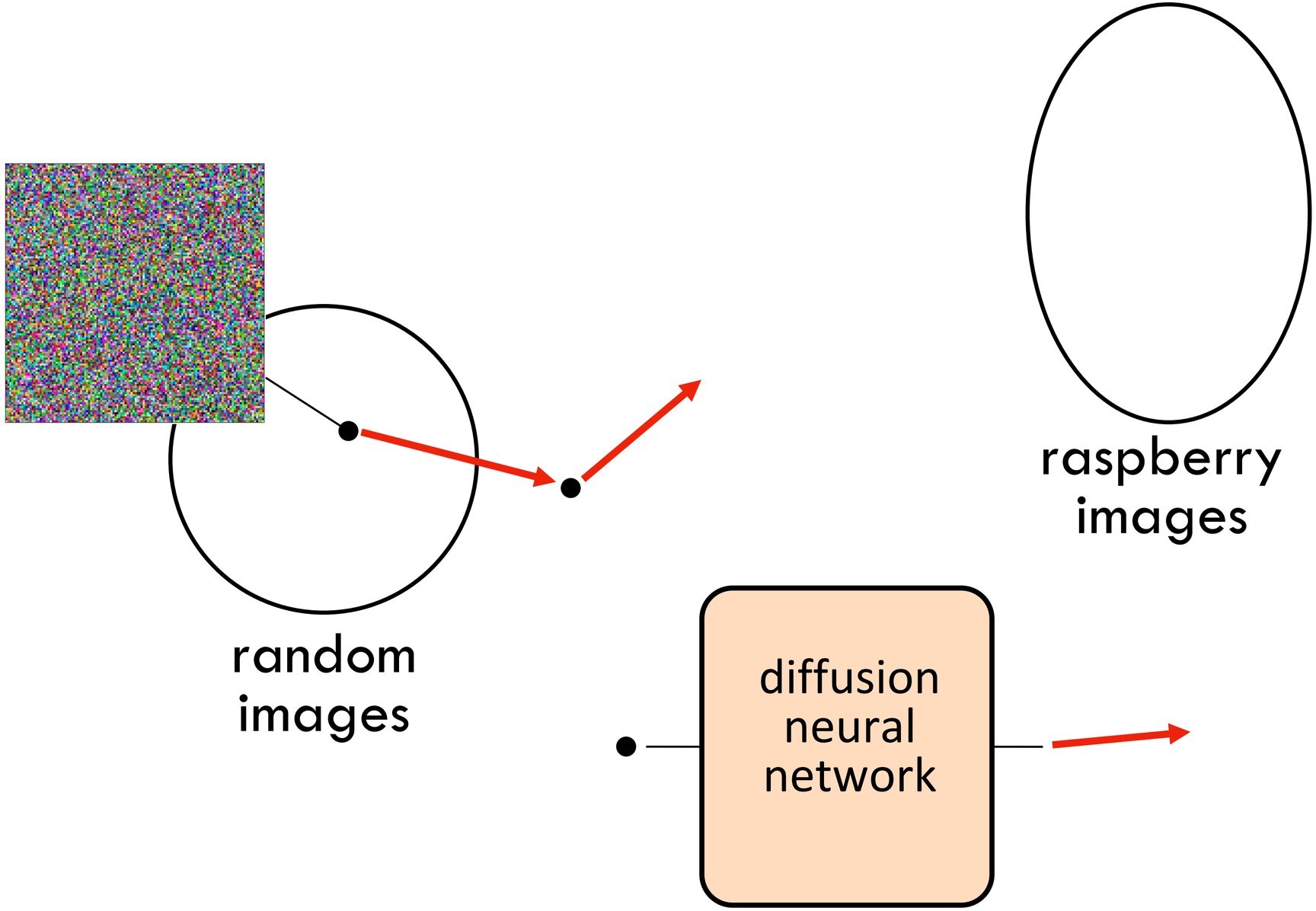

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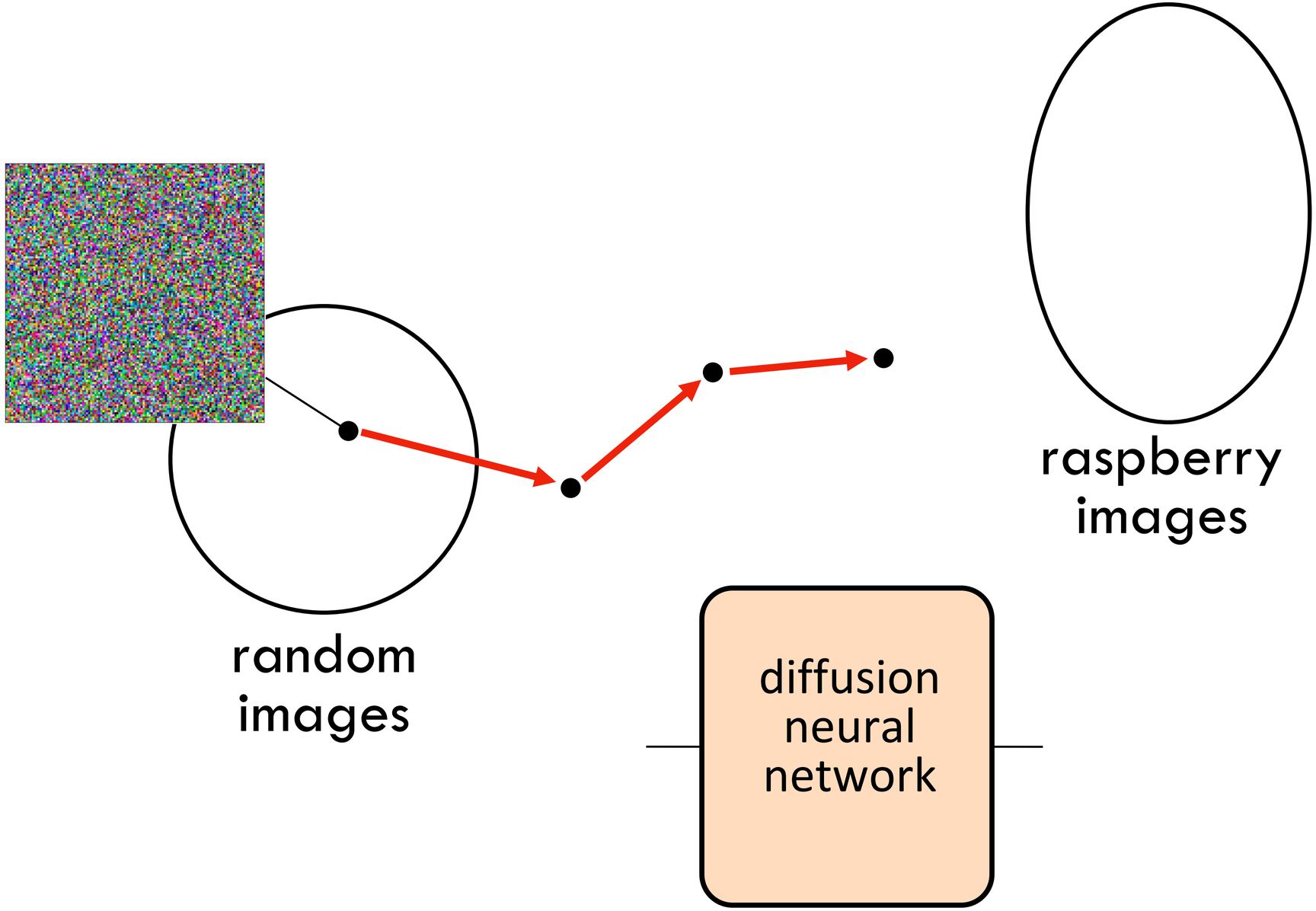

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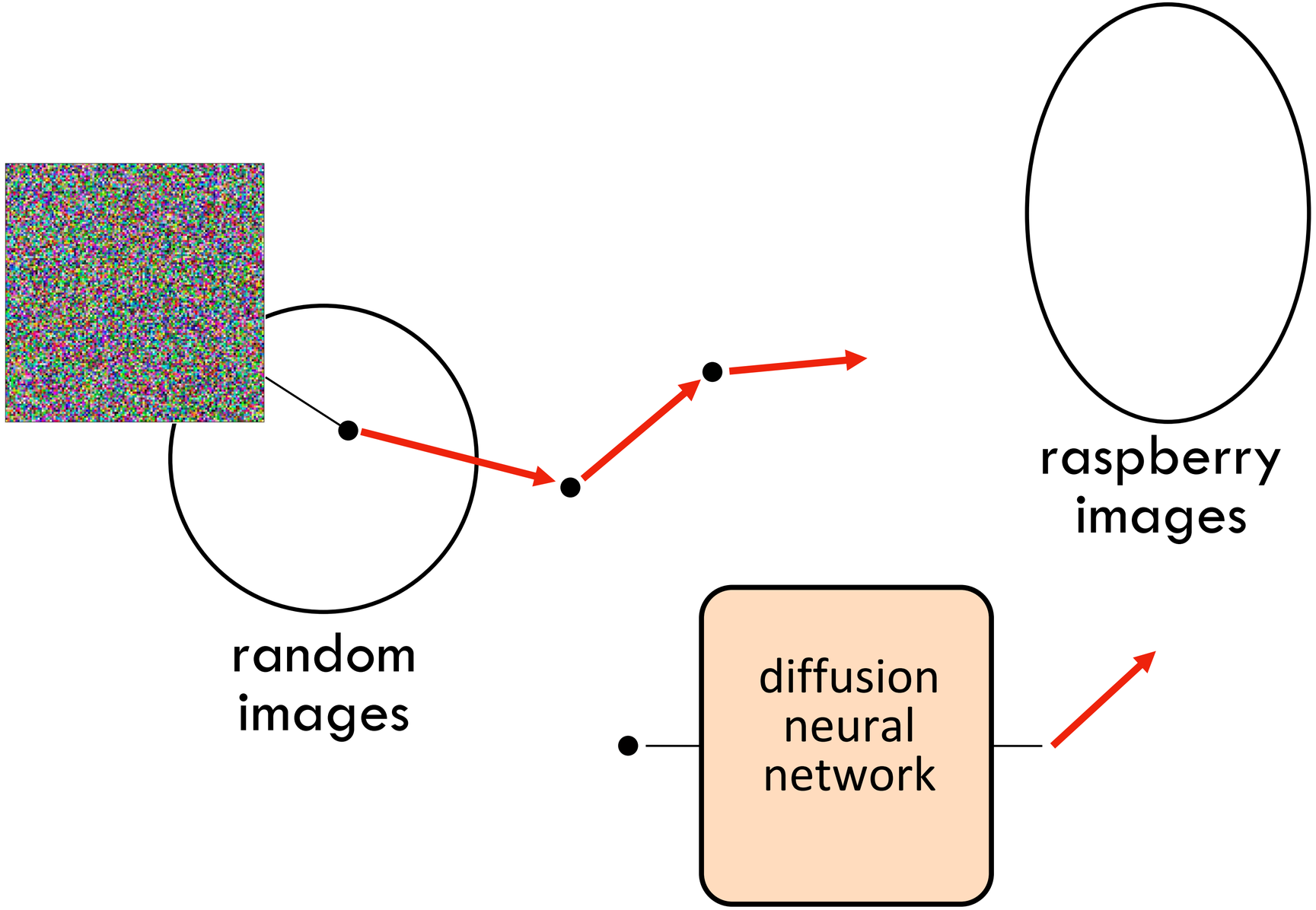

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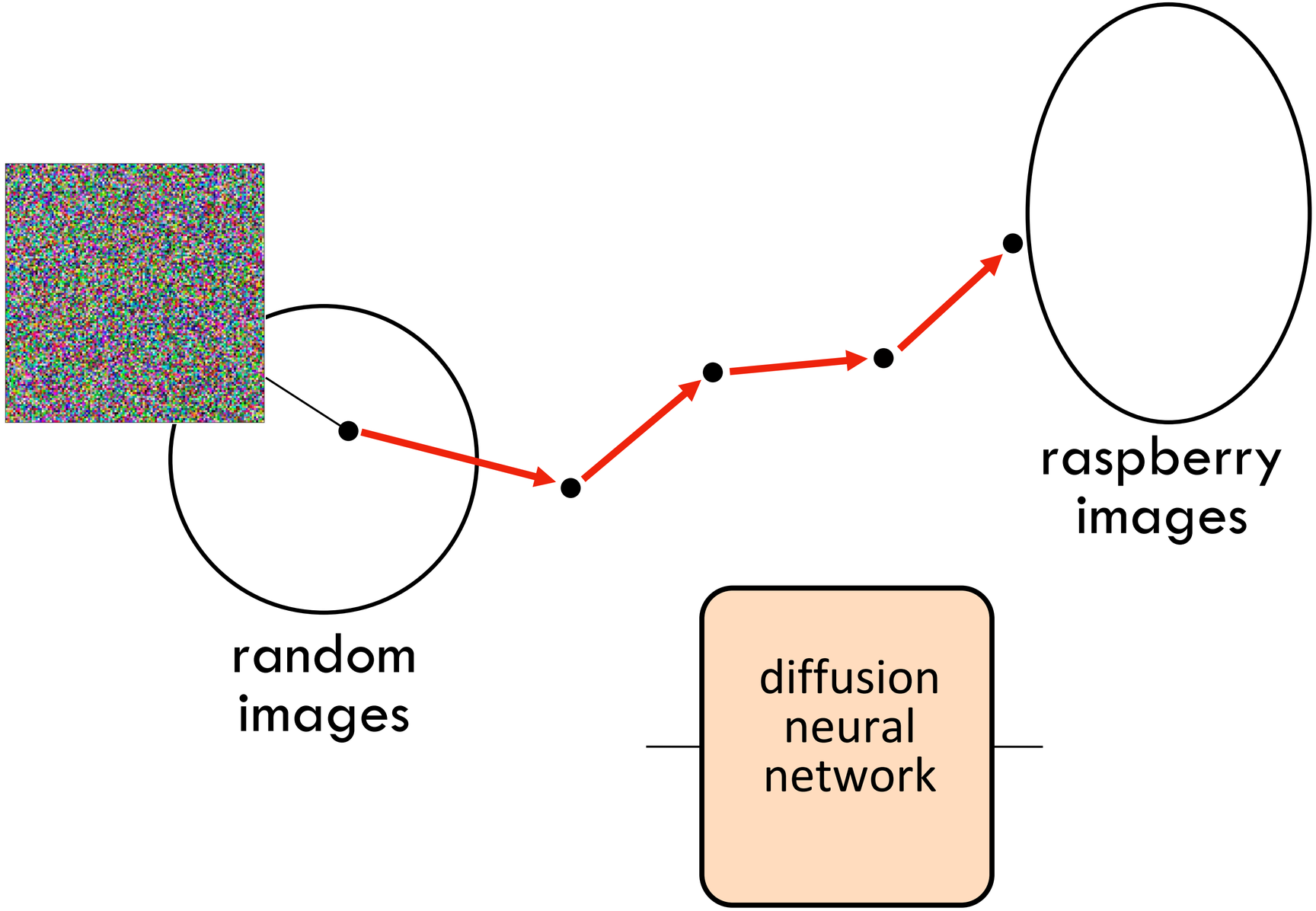

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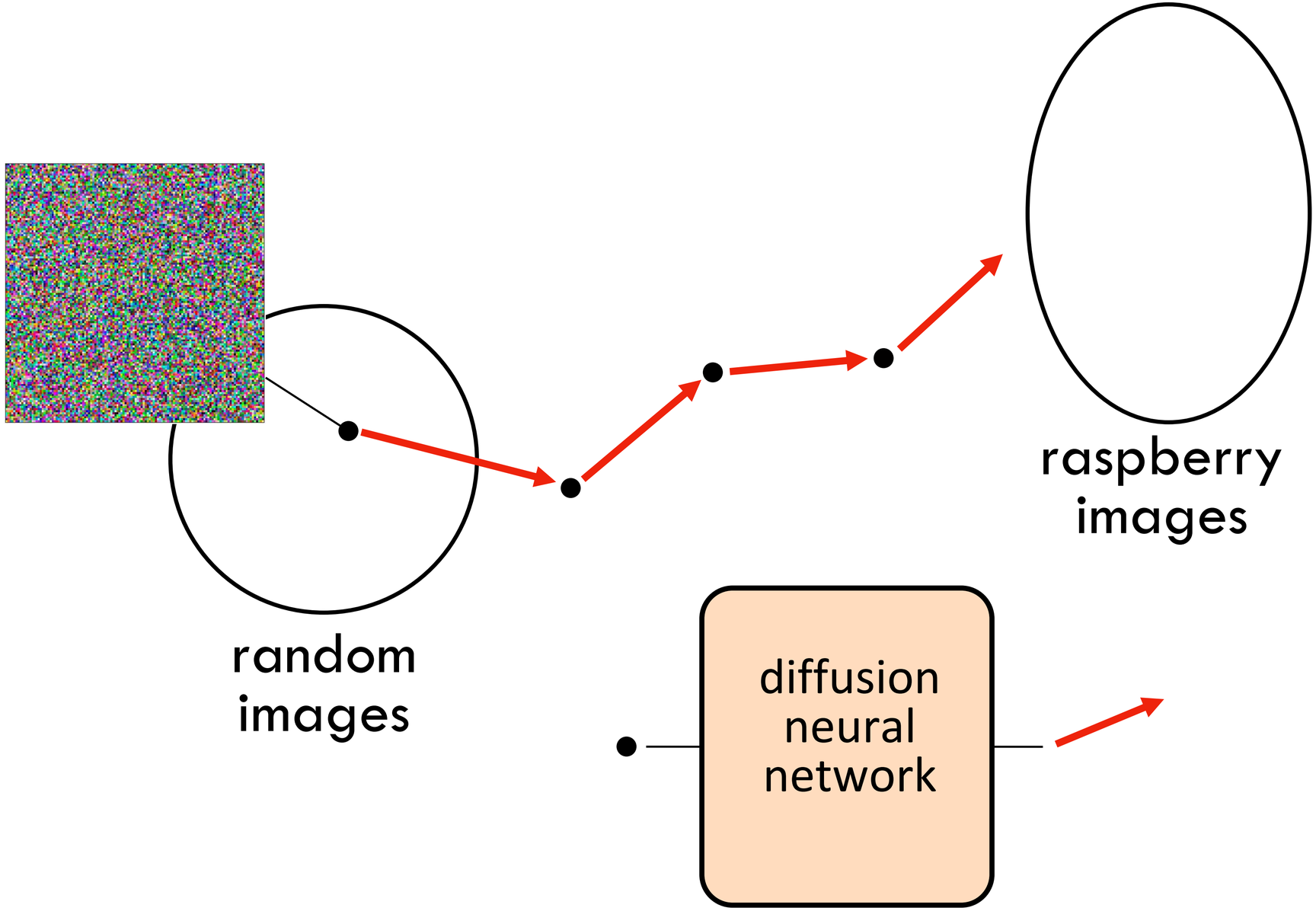

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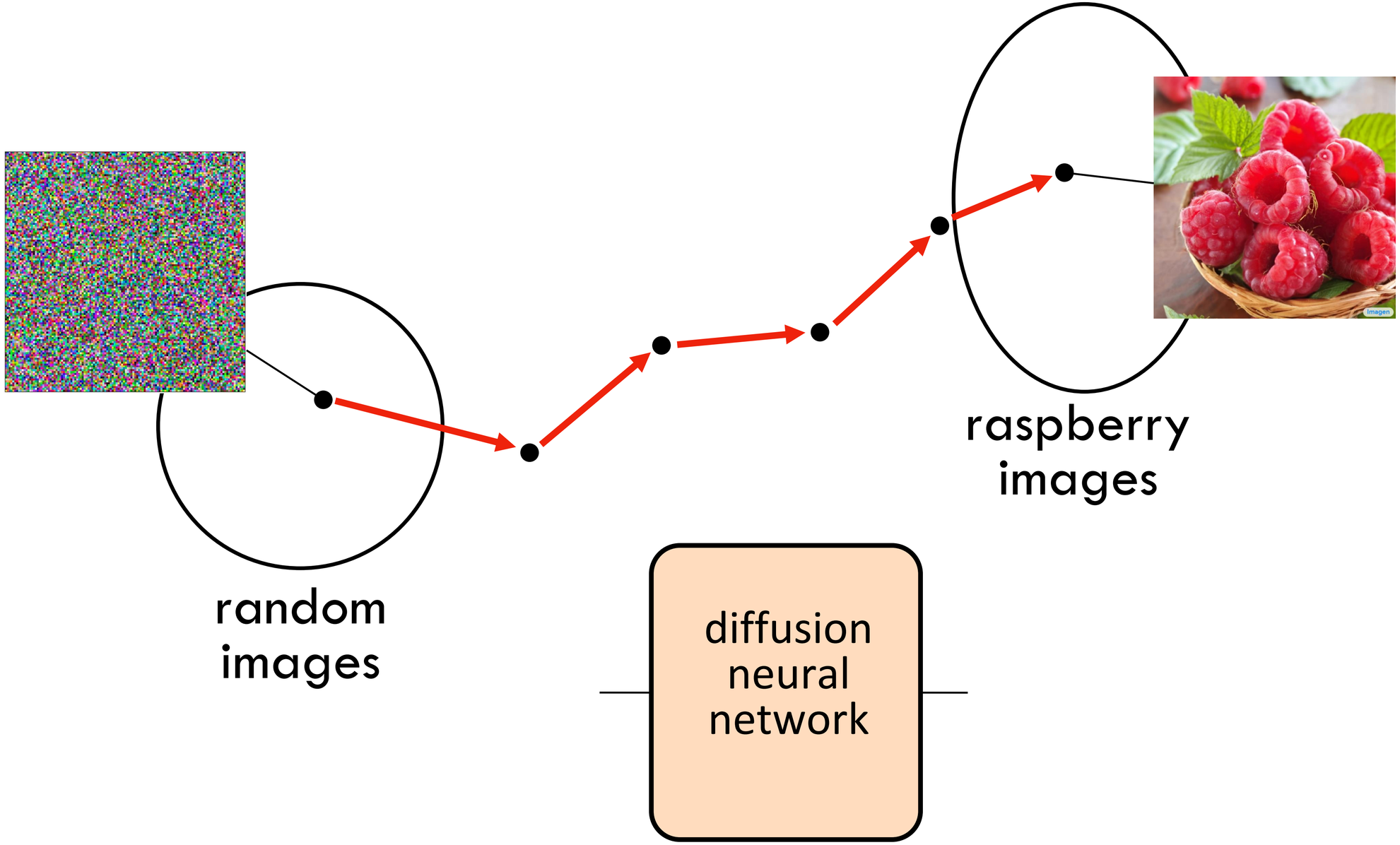

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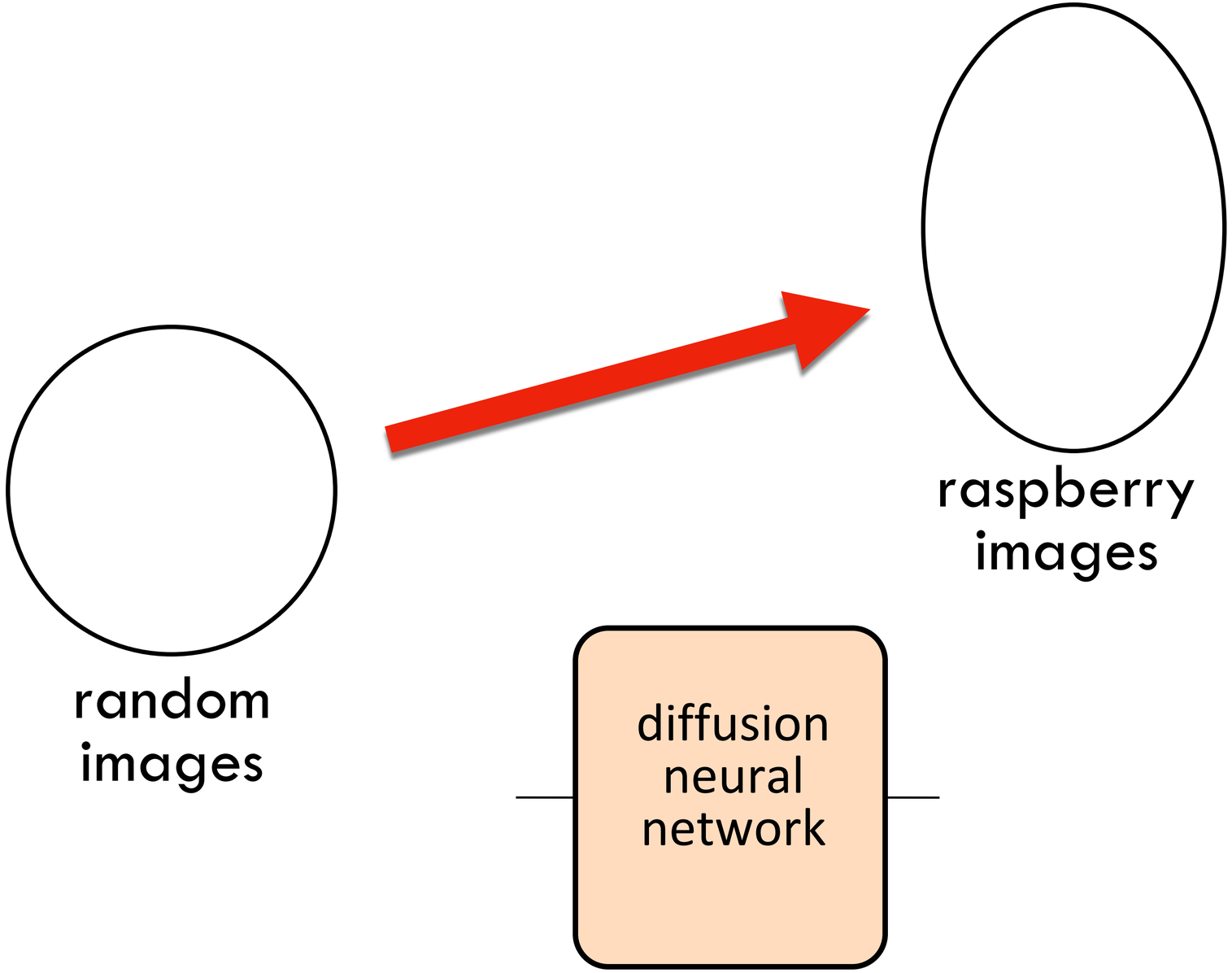

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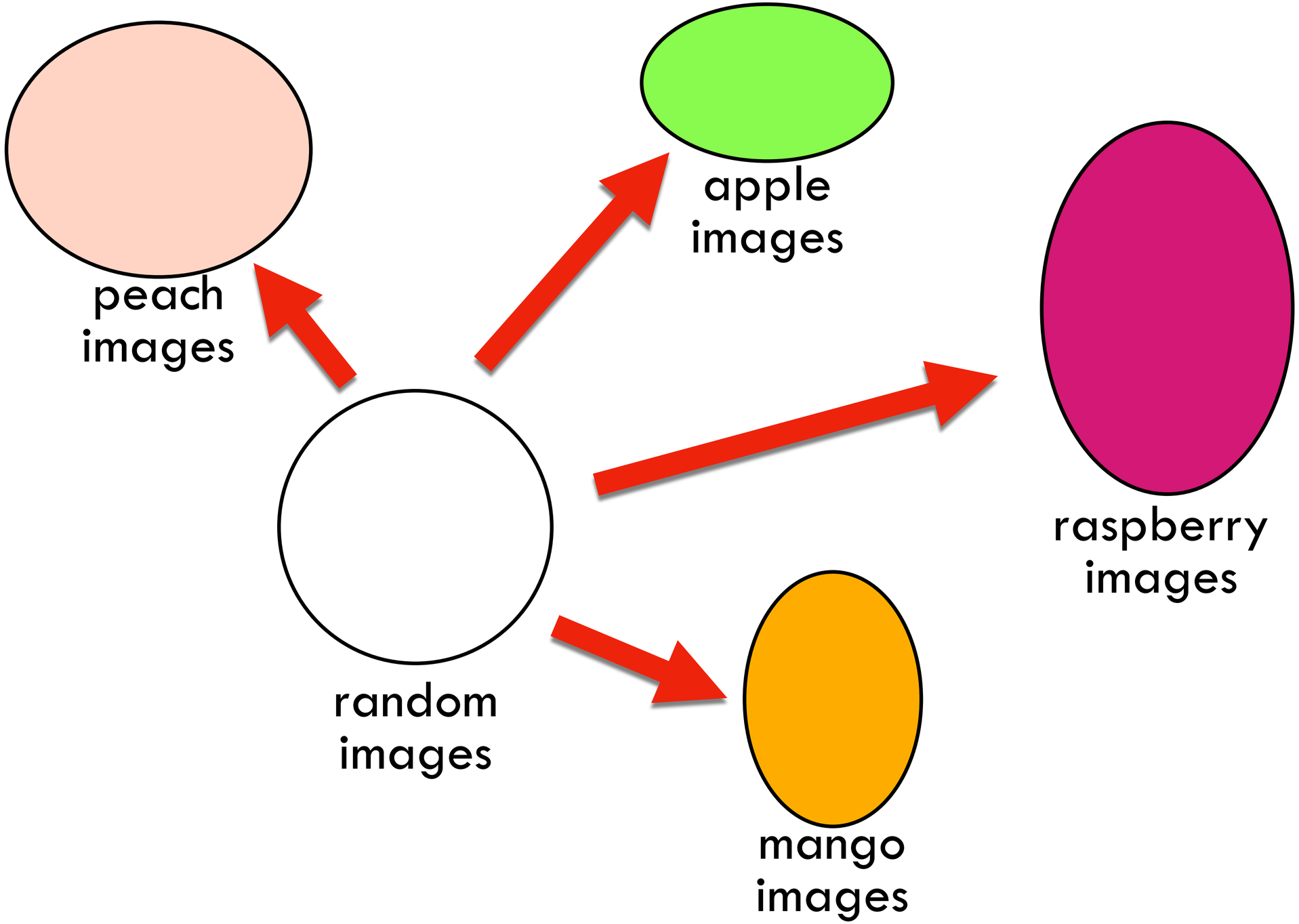

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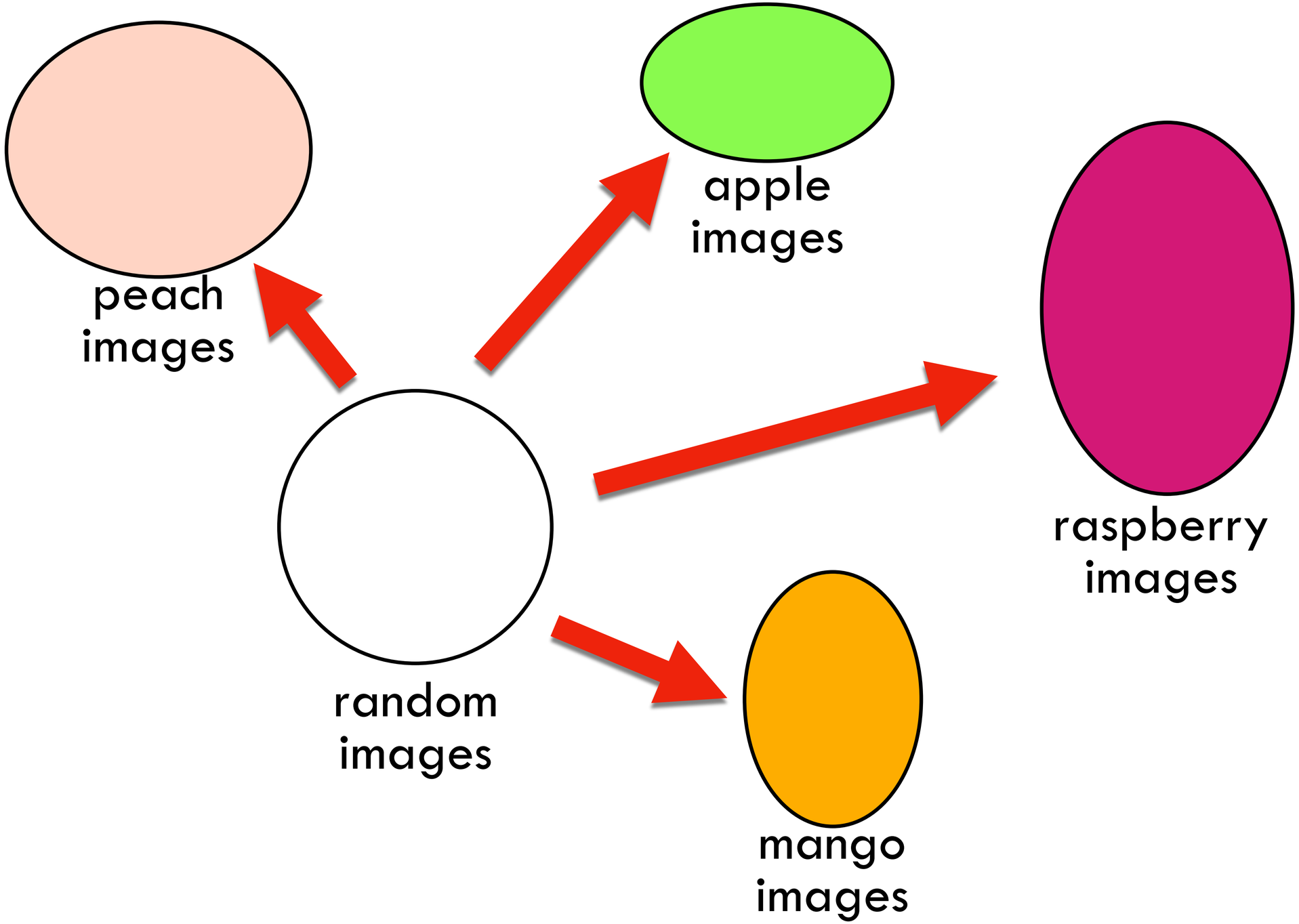

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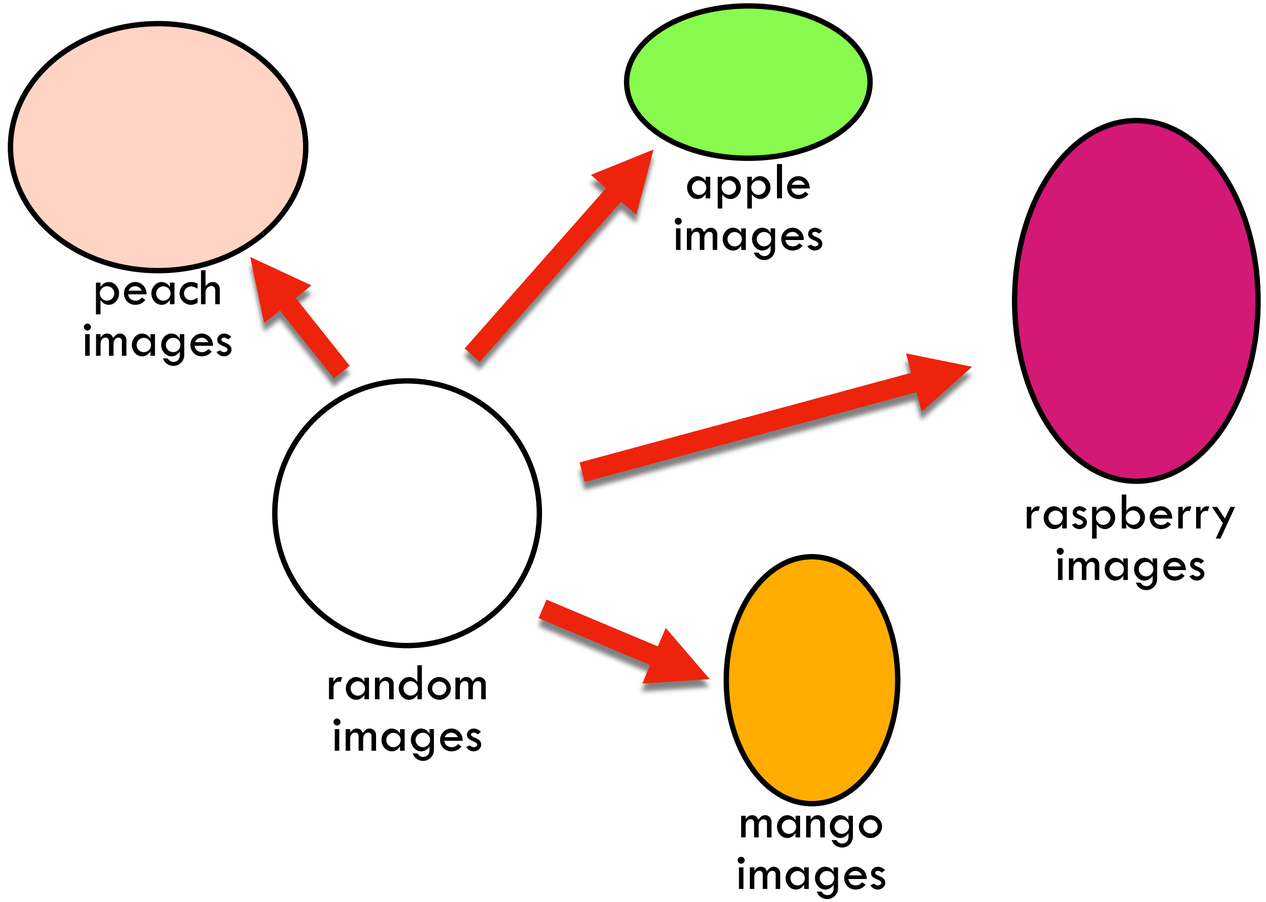

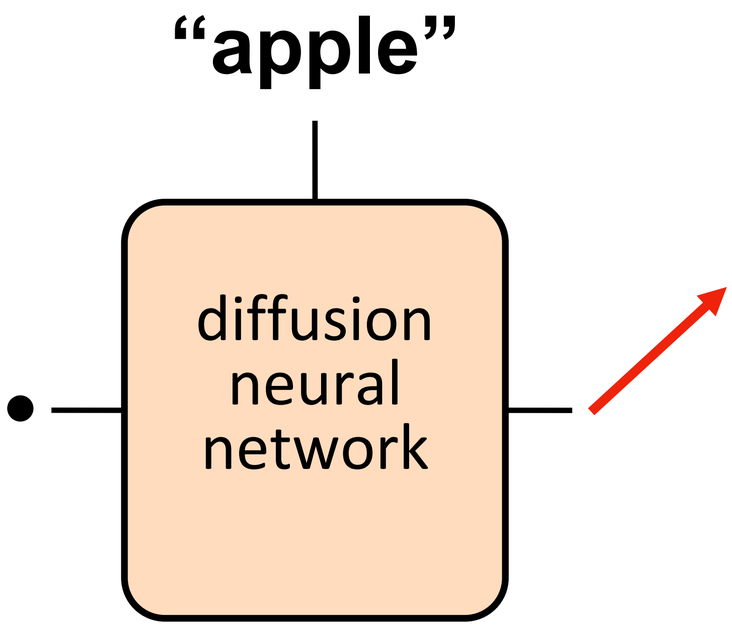

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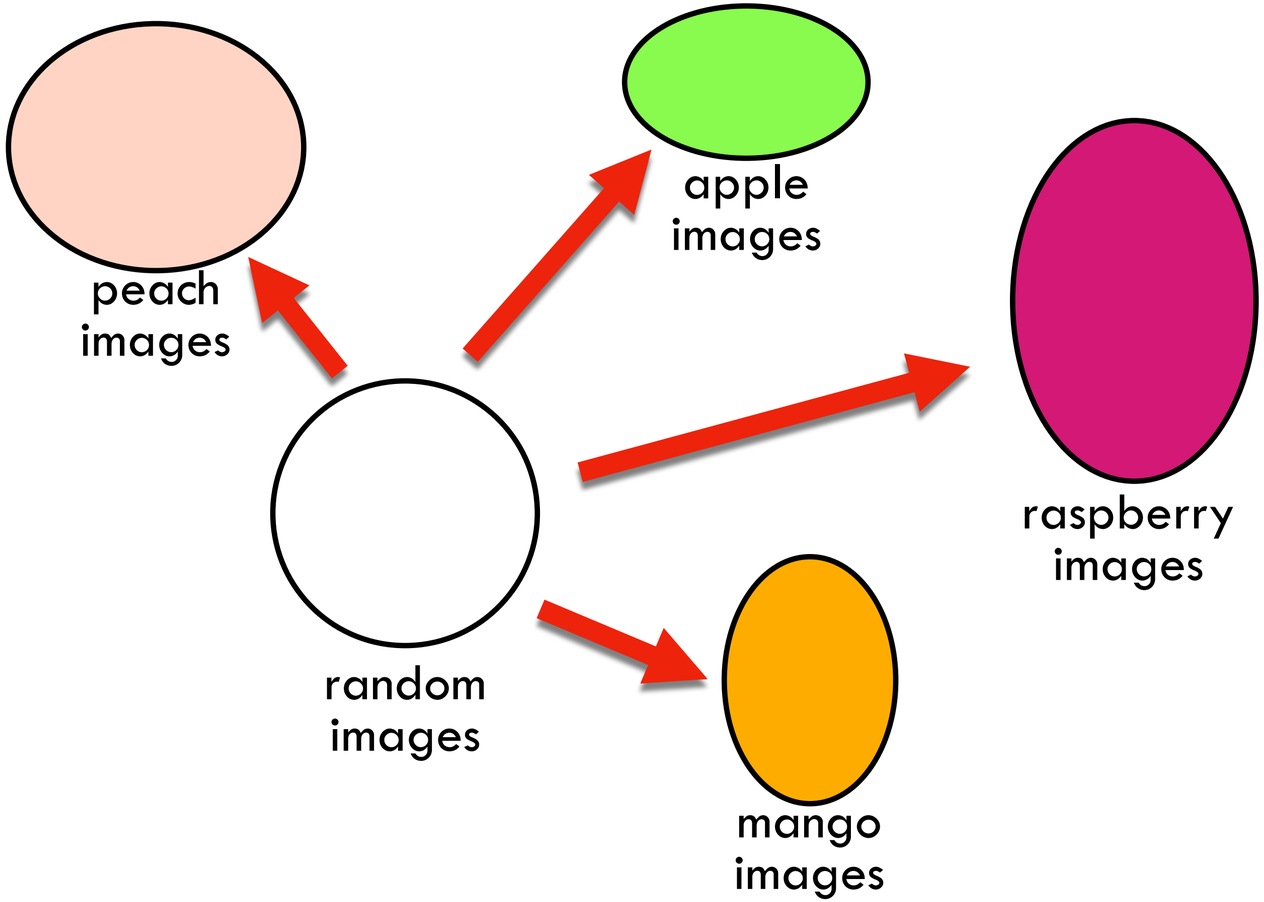

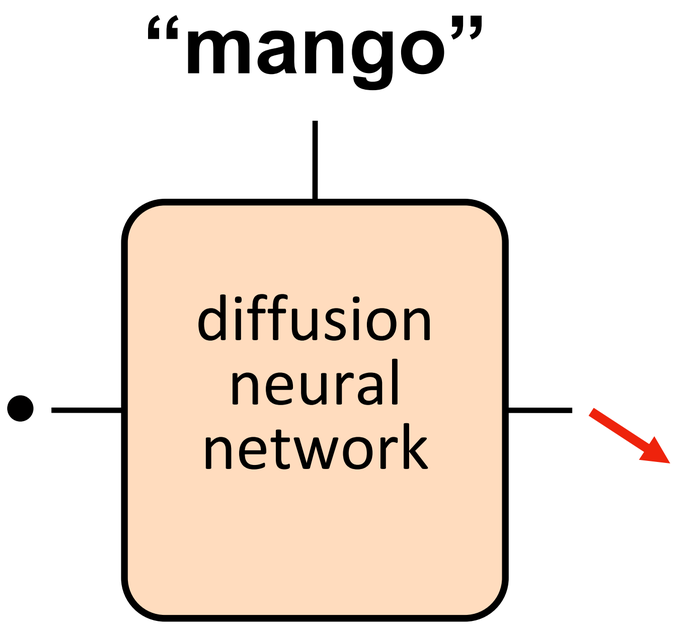

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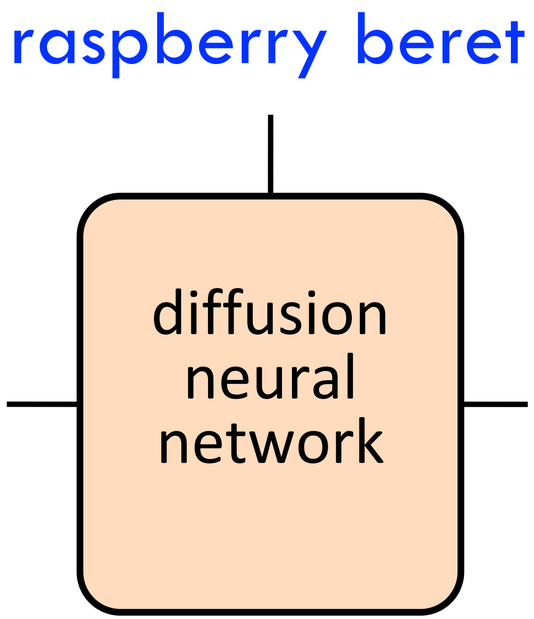

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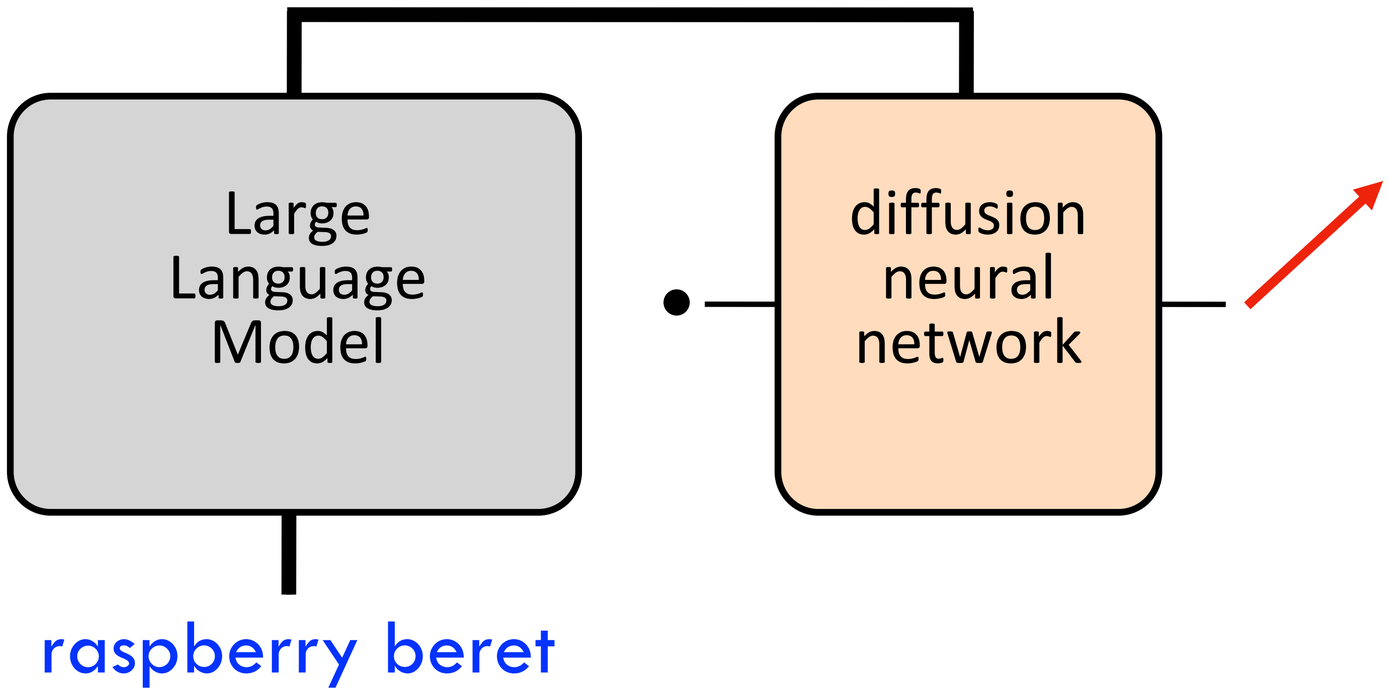

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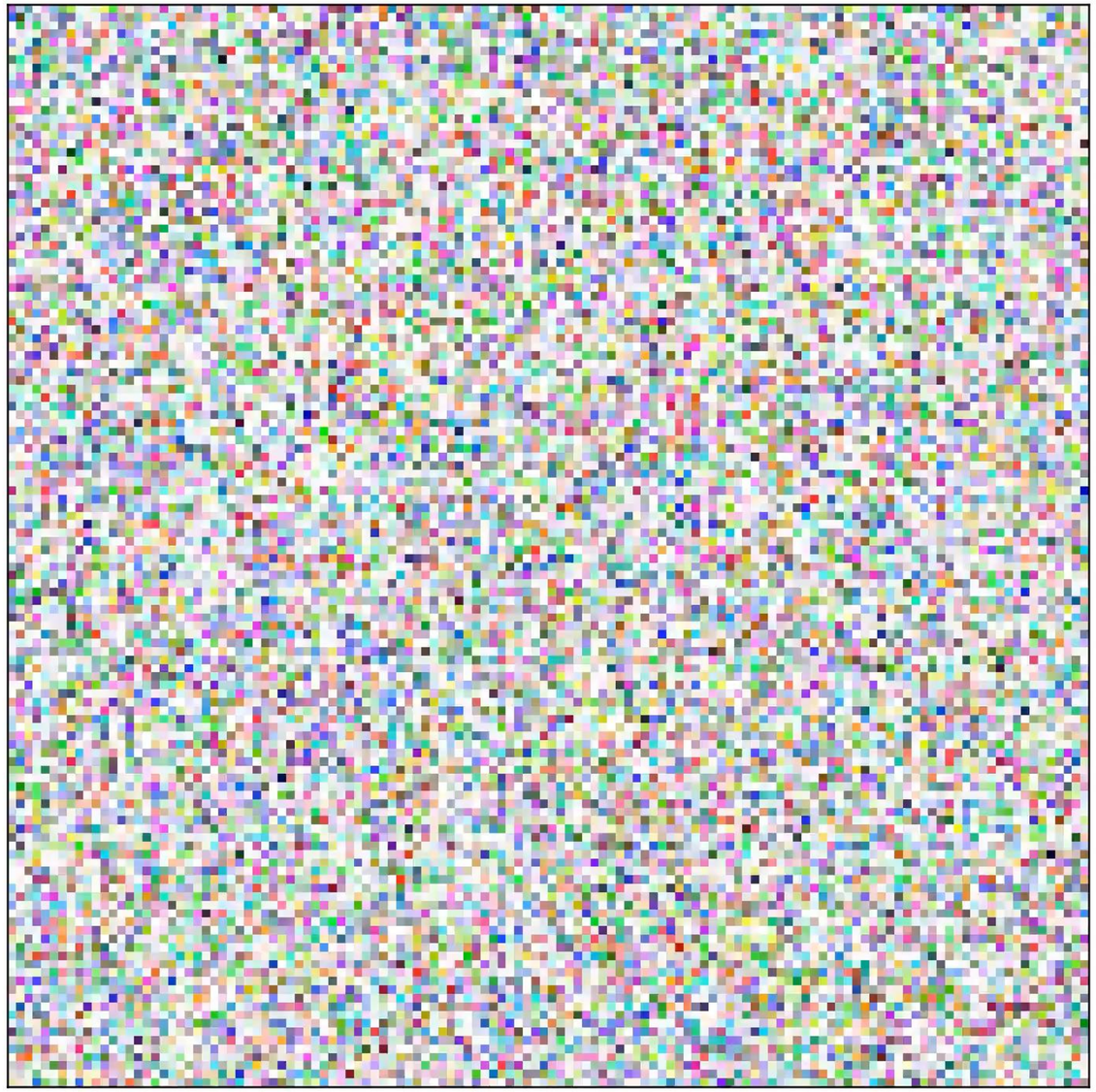

raspberry beret

slide from Steve Seitz's video

raspberry beret

slide from Steve Seitz's video

beret of raspberries

slide from Steve Seitz's video

beret of raspberries

slide from Steve Seitz's video

beret of raspberries

slide from Steve Seitz's video

chocolate guacamole pancakes

slide from Steve Seitz's video

squirrel inside
a nutshell

slide from Steve Seitz's video

An astronaut riding a horse in a photorealistic style (Dall-E 2)

slide from Steve Seitz's video

Language Generator

(+ pixels)

Diffusion

(+ language)

Parti

Imagen

slide from Steve Seitz's video

Language Generator

+

Diffusion

Dall-E 2

slide from Steve Seitz's video

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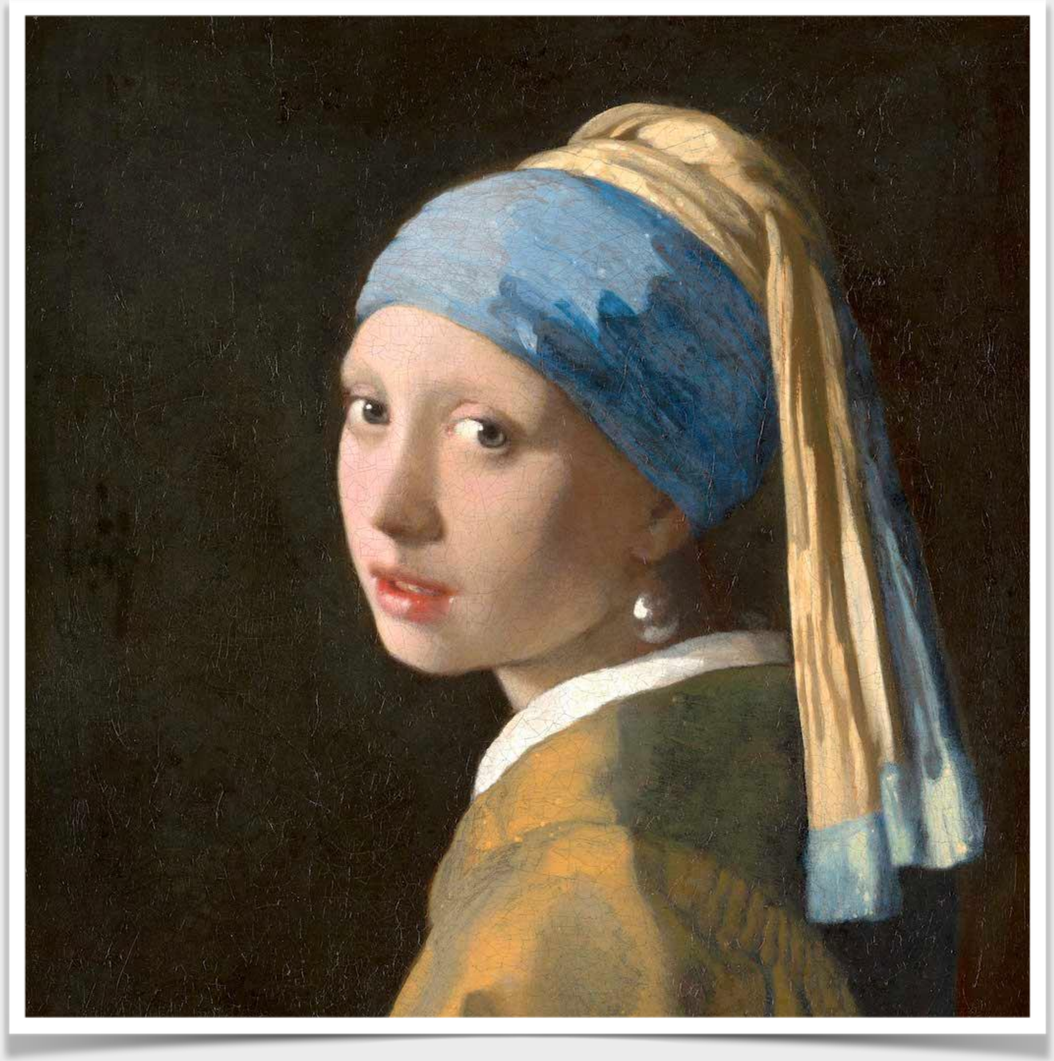
3	3	8	3	3	3	3	3	8	3	8	8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	8	8	8	8	8

Parti

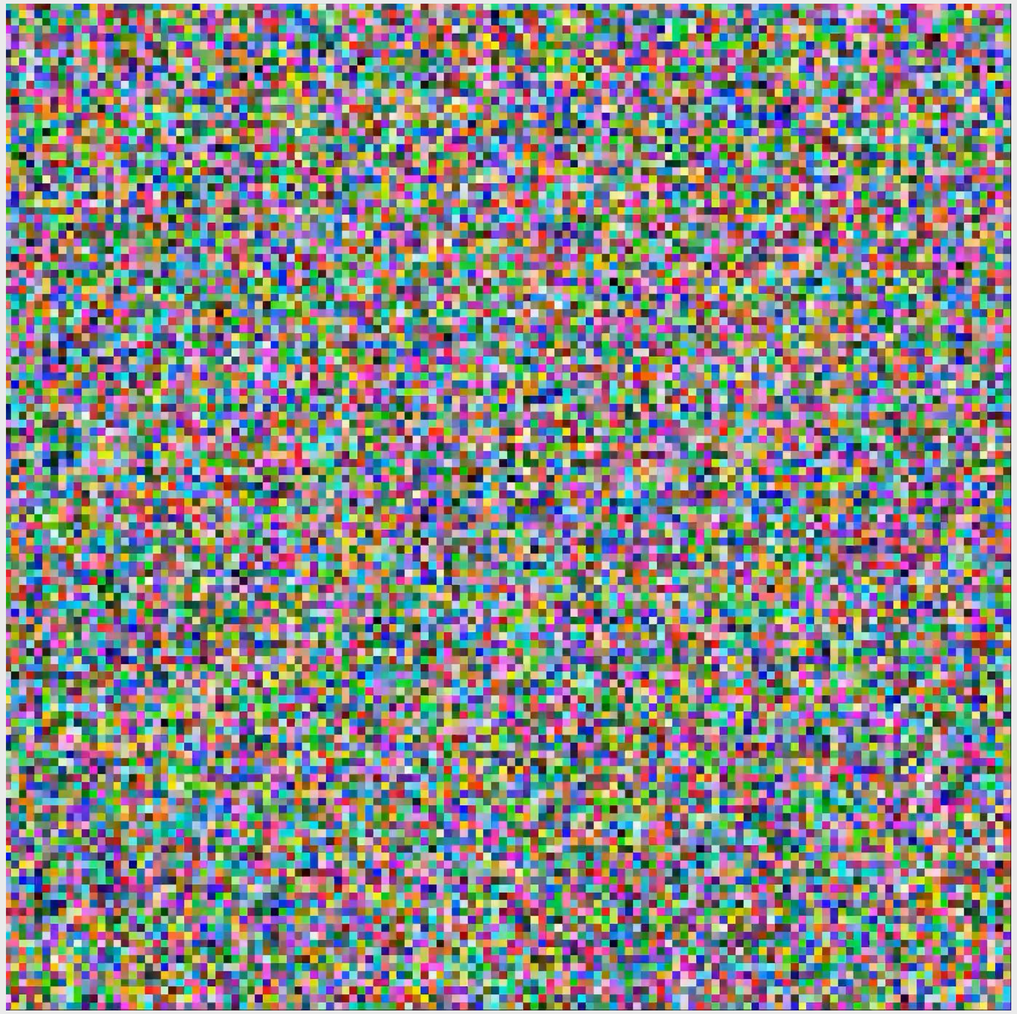
$$\begin{bmatrix} 734 \\ 37 \\ 520 \\ 323 \\ 1023 \\ 14 \\ 592 \\ 842 \\ 164 \\ 325 \\ 296 \\ 820 \\ 893 \\ 621 \\ 924 \\ 724 \\ 422 \\ 342 \\ 290 \\ 76 \\ \vdots \\ 891 \end{bmatrix}$$

Dall-E 2

slide from Steve Seitz's video

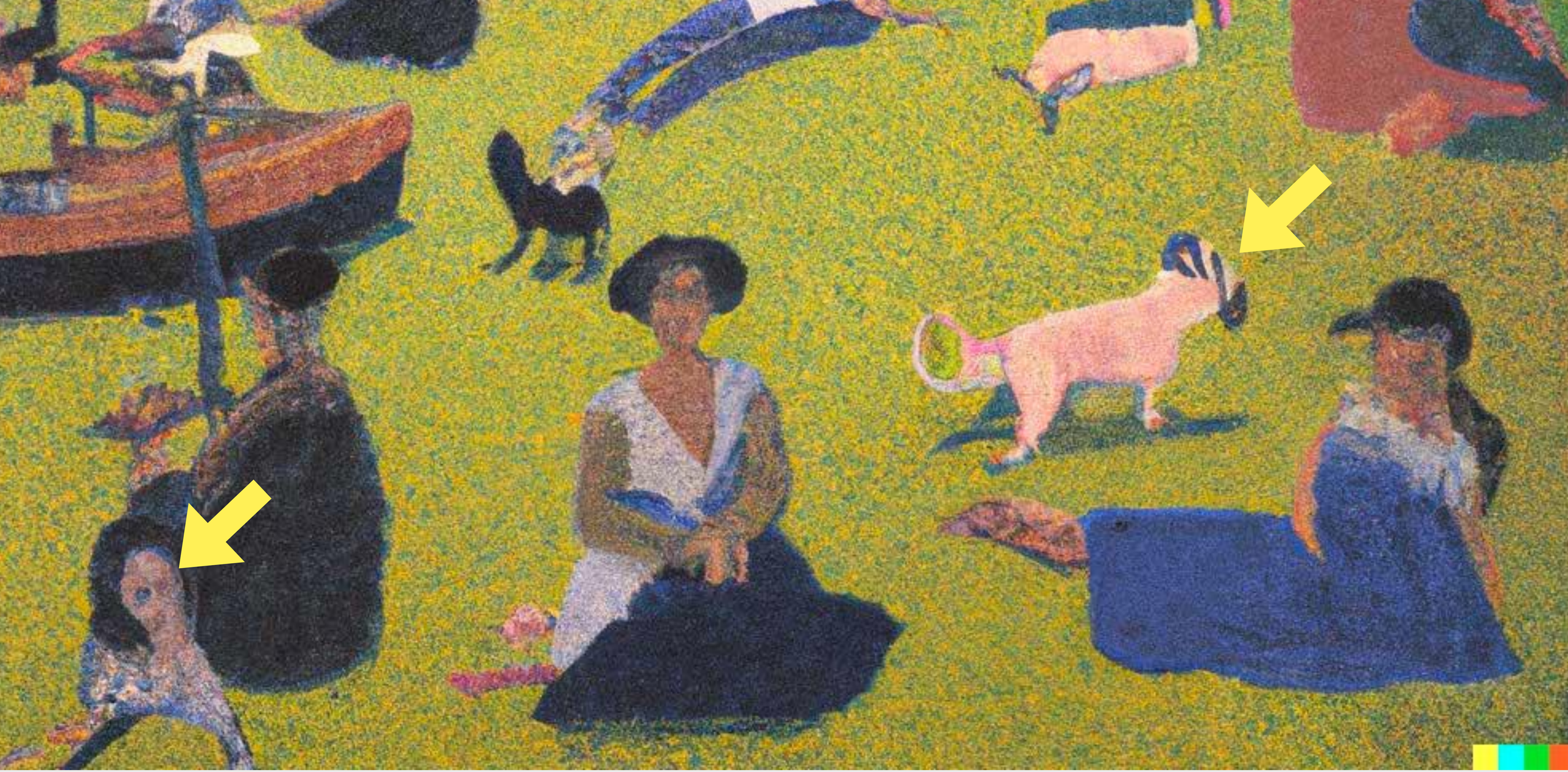


$$\begin{bmatrix} 734 \\ 37 \\ 520 \\ 323 \\ 1023 \\ 14 \\ 592 \\ 842 \\ 164 \\ 325 \\ 296 \\ 820 \\ 893 \\ 621 \\ 924 \\ 724 \\ 422 \\ 342 \\ 290 \\ 76 \\ 584 \\ \vdots \\ 891 \end{bmatrix}$$



slide from Steve Seitz's video

slide from Steve Seitz's video



slide from Steve Seitz's video

Squirrel reaching for a nut. Latte art

slide from Steve Seitz's video

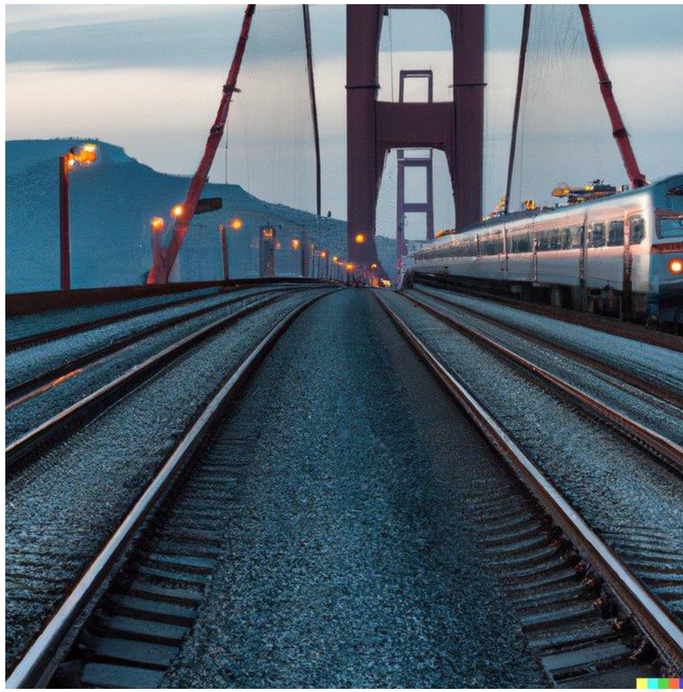
A teddy bear making chocolate guacamole pancakes

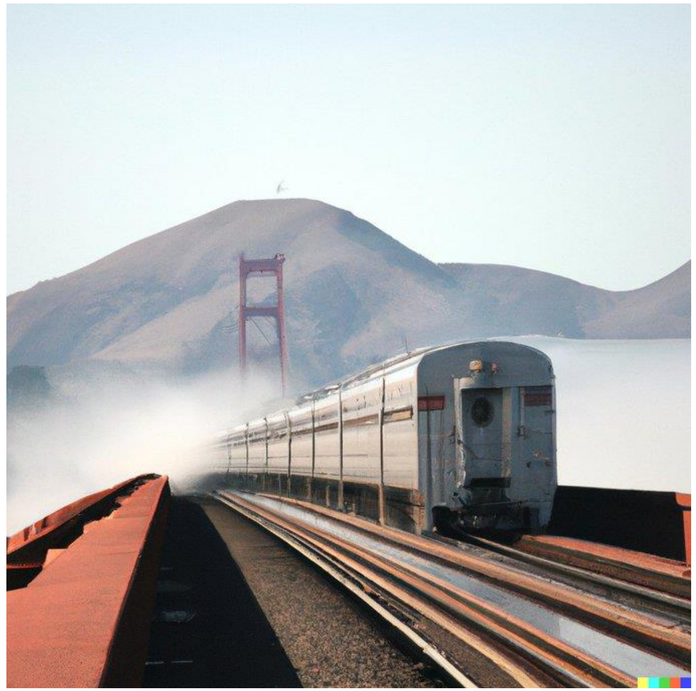
slide from Steve Seitz's video

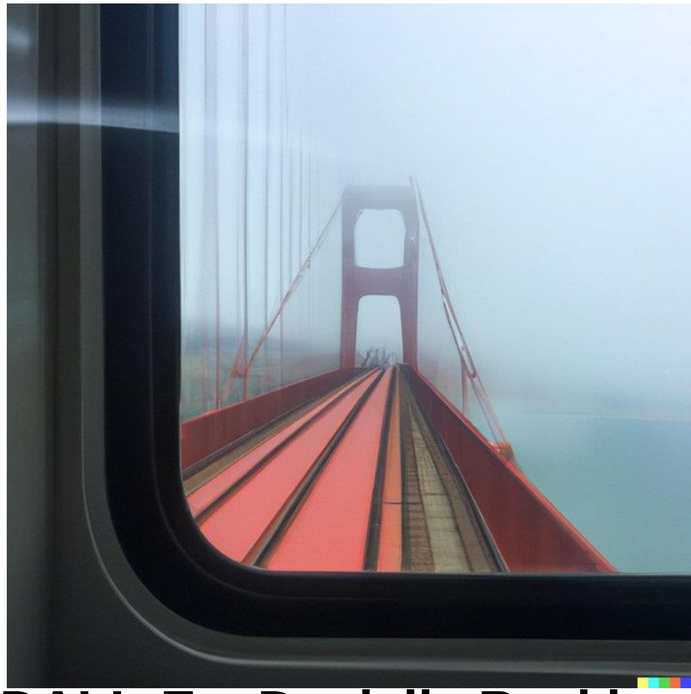
A dog looks curious in the mirror,
seeing a cat

A bowl of soup
that looks like a monster
knitted out of wool

Impressive compositionality:



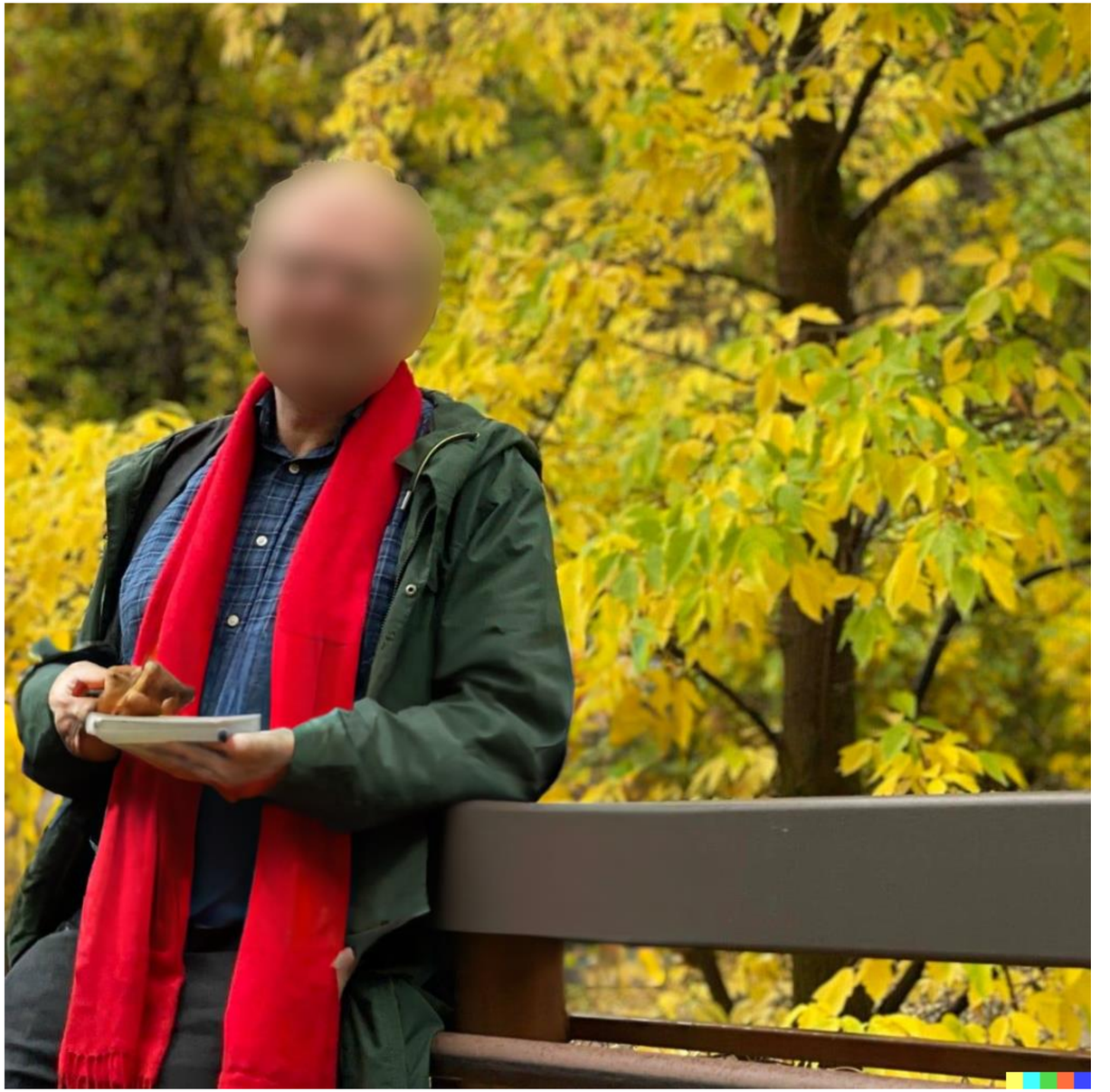




DALL-E + Danielle Baskin

“Person holding a heavy box”

“Person holding a laptop”



“Person holding birthday cake”

“Person offering tea”

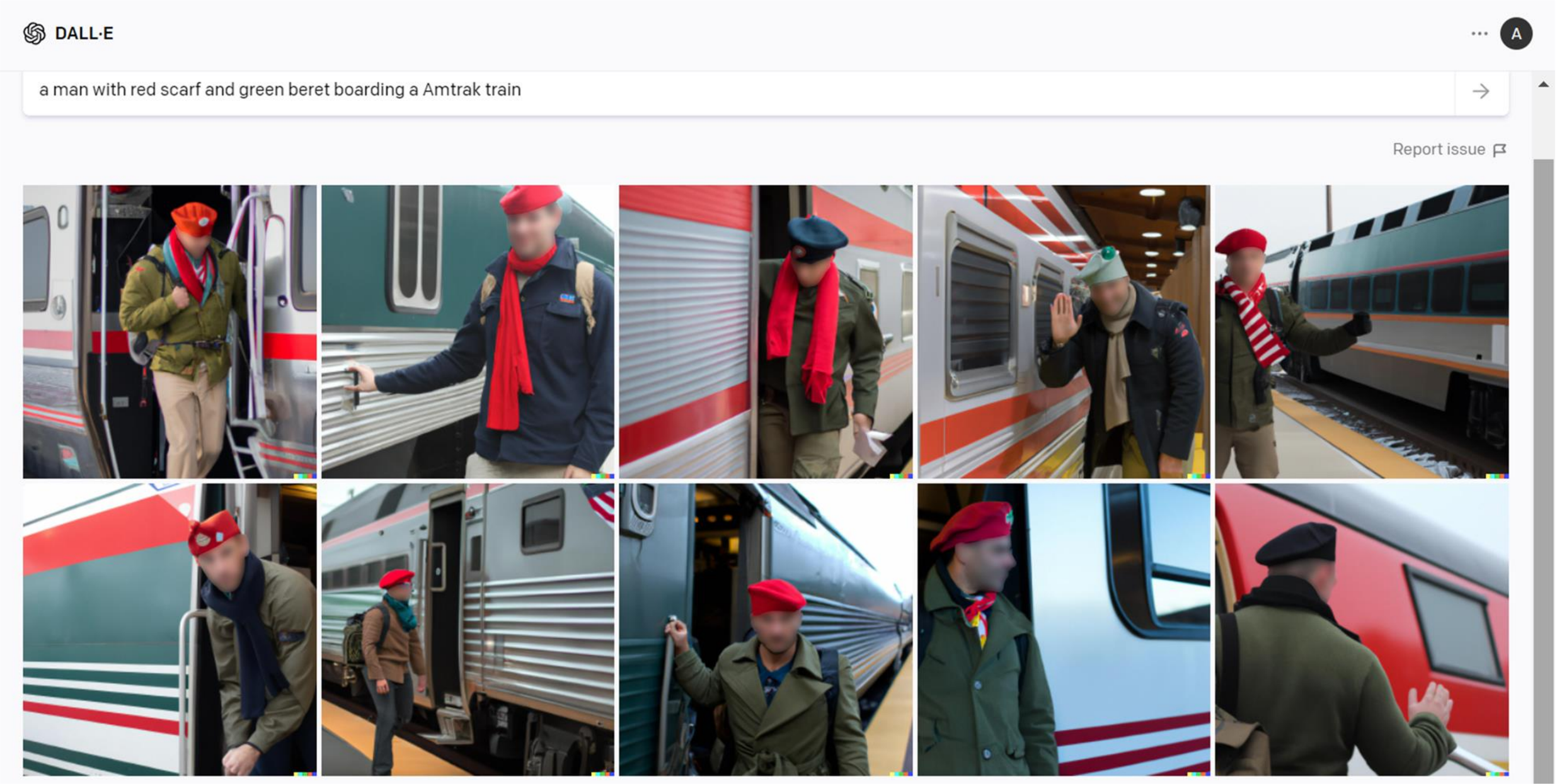
“Person holding a watermelon”

“Person holding a self-portrait”

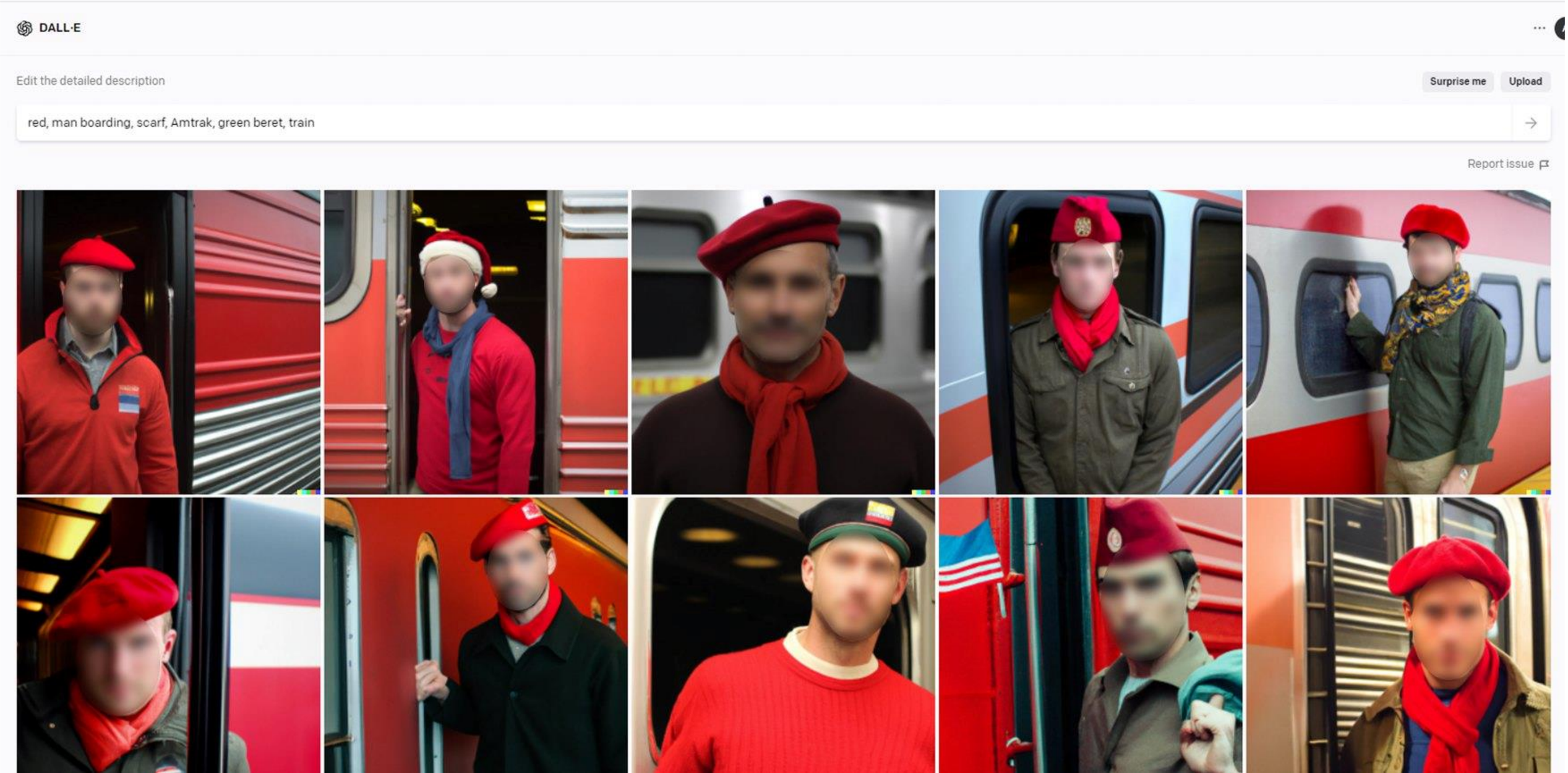
“Person holding a photo of himself”

“Person holding a painting of himself”

Language seems the weakest part…



“Bag of words” seems to work as well



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labs.openai.com/e/zRpVKCfi0mMC0V471QCTK9LQ

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Surprise me | Upload

five grapes

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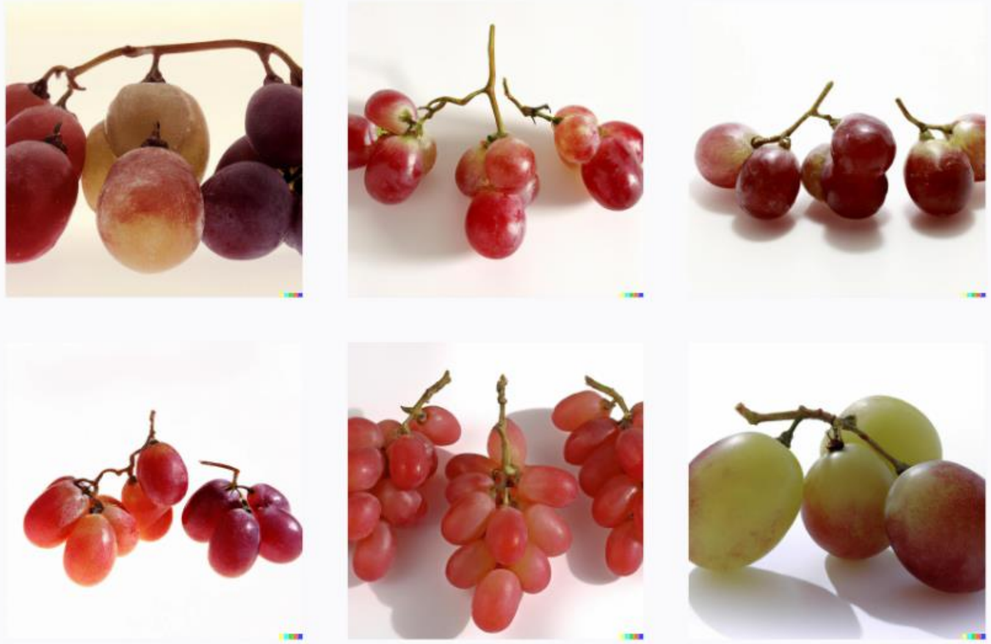
three grapes

Generate



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chair with three legs

Generate

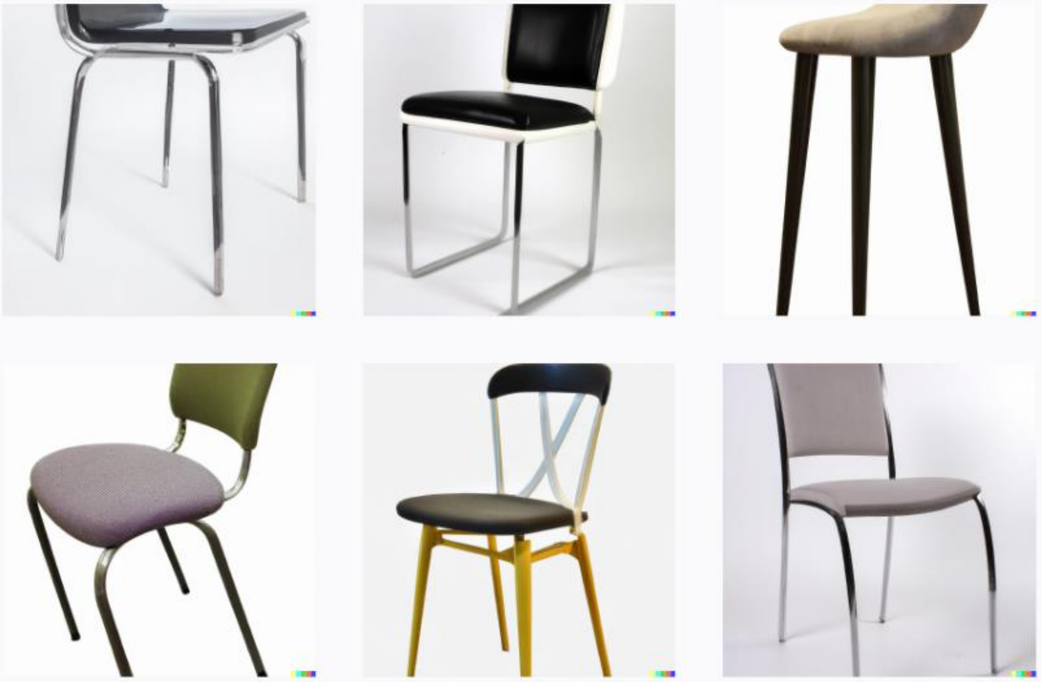

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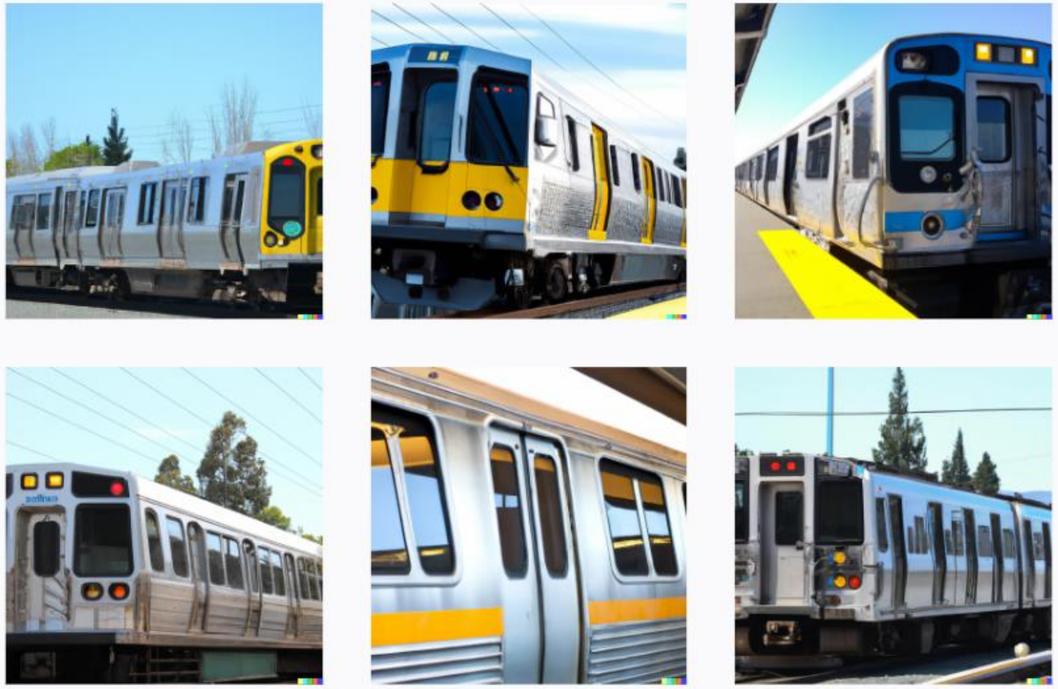
photo of bart train with wings

Generate



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fish that has human hands

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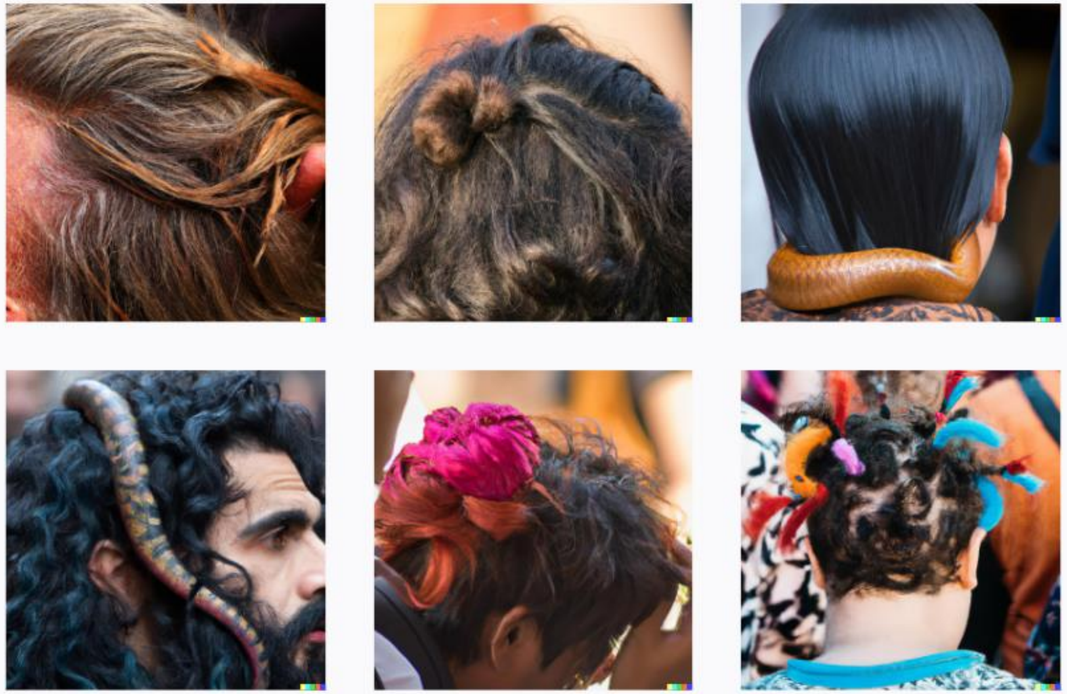
person with hair of snakes

Generate



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whatever you do, don't draw a purple elephant

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Luxembourg palace with triangular windows

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Luxembourg palace with circle windows

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