Generating Images from Noise

CS180: Intro to Comp. Vision and Comp. Photo

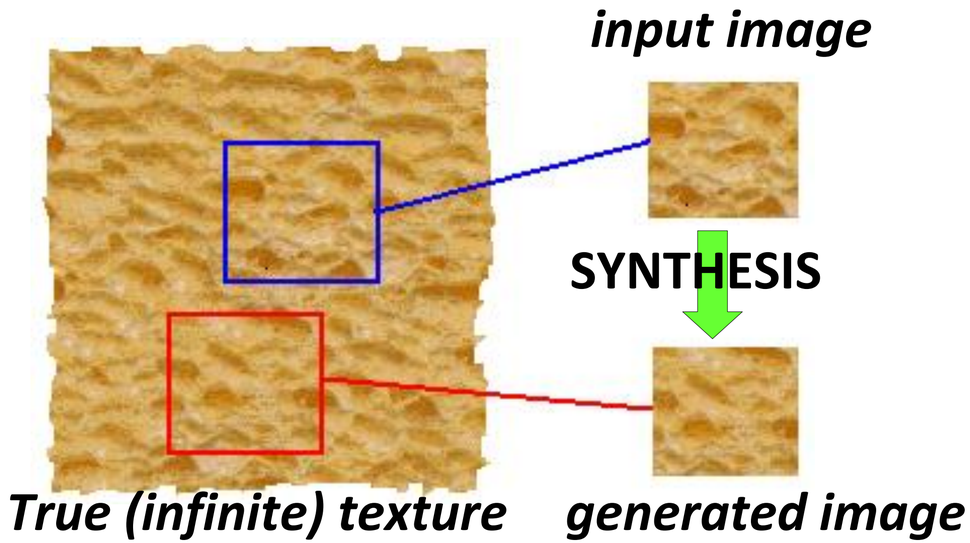
Alexei Efros, UC Berkeley, Fall 2023

Texture as samples from distribution



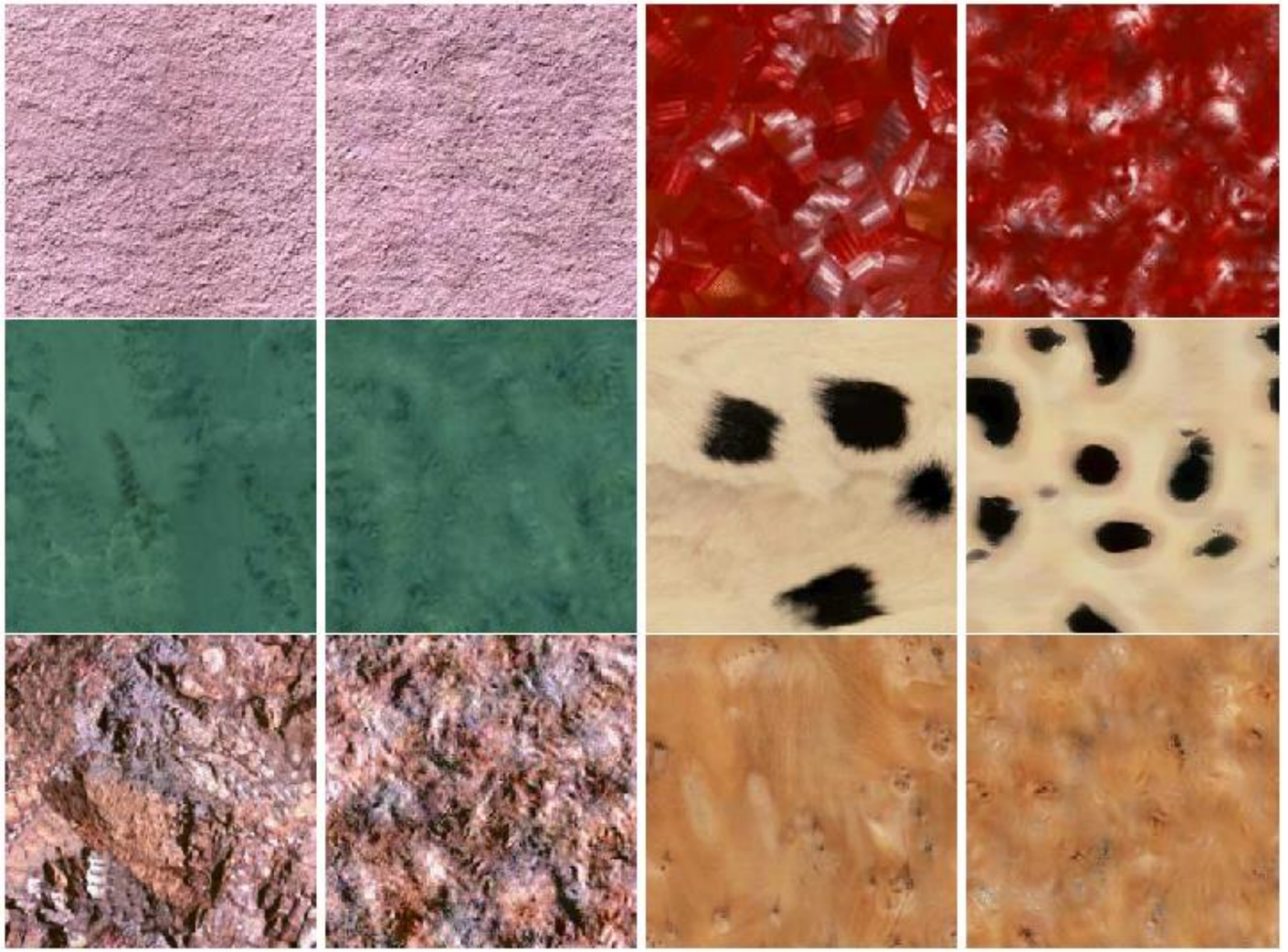


Parametric Texture Synthesis

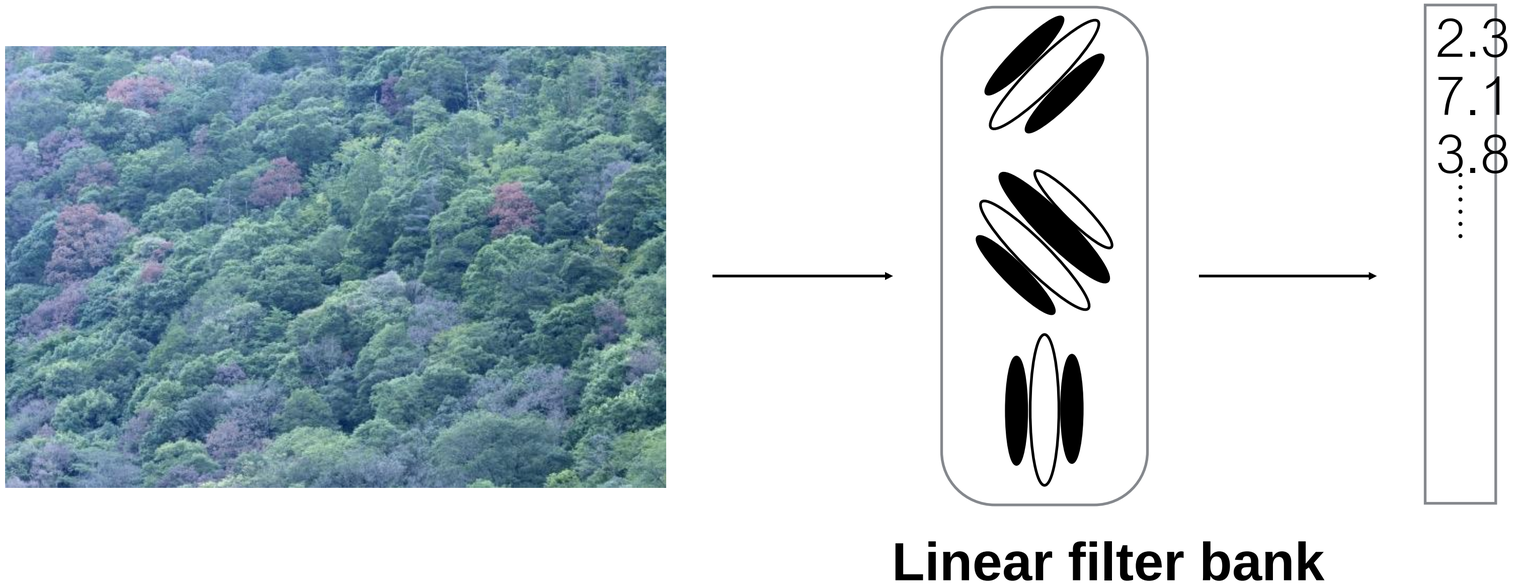


Goal: parametric **generative model** of the “infinite texture”

Heeger & Bergen, SIGGRAPH‘95



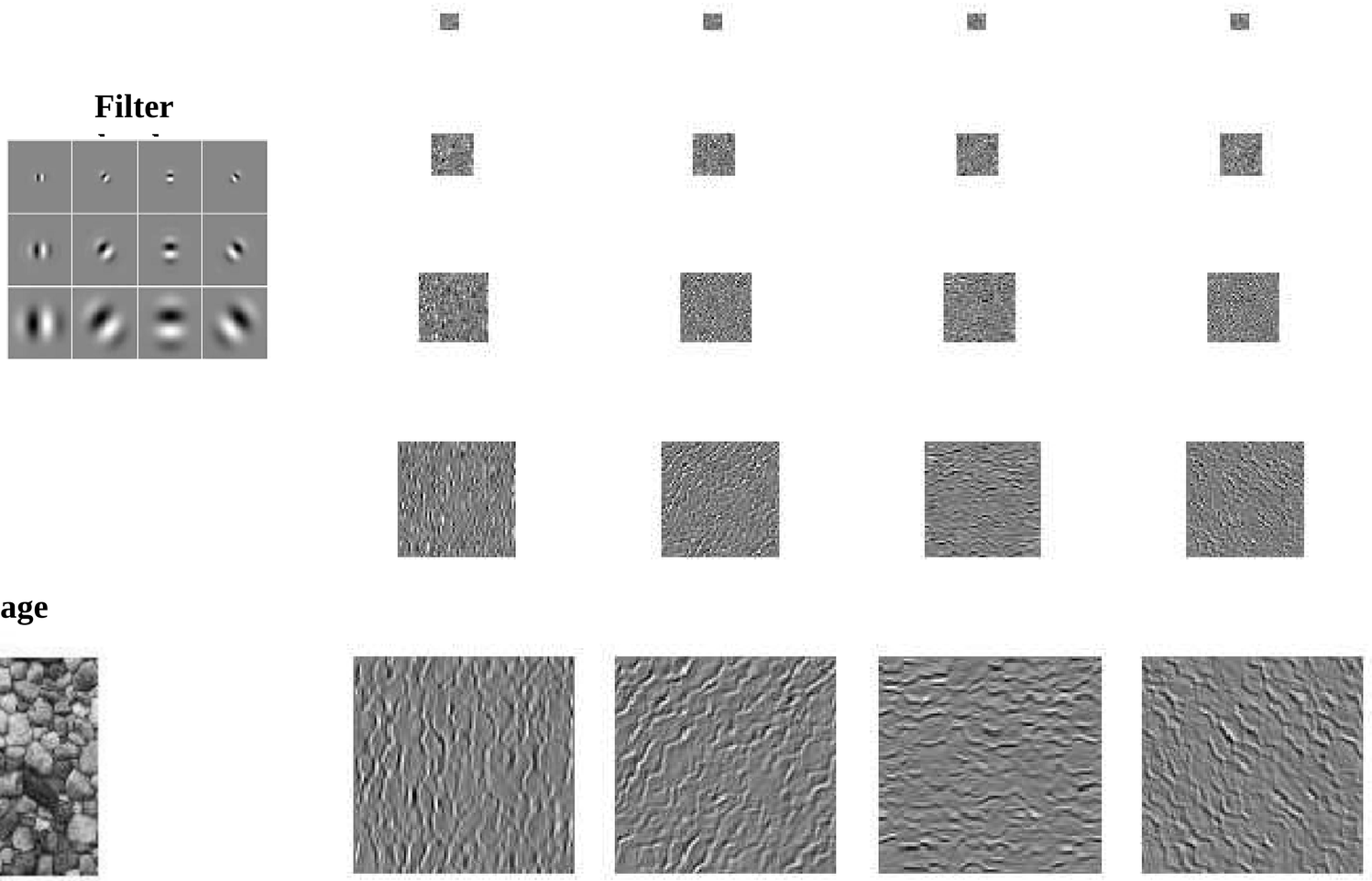
Early Vision Texture Models



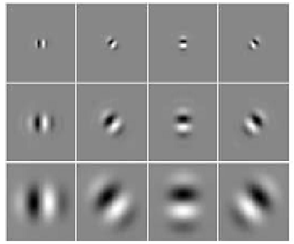
Linear filter bank

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

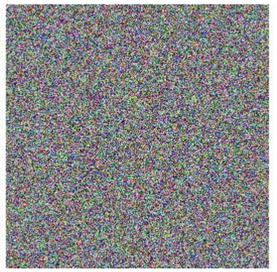
Multi-scale filter decomposition (steerable pyramid)



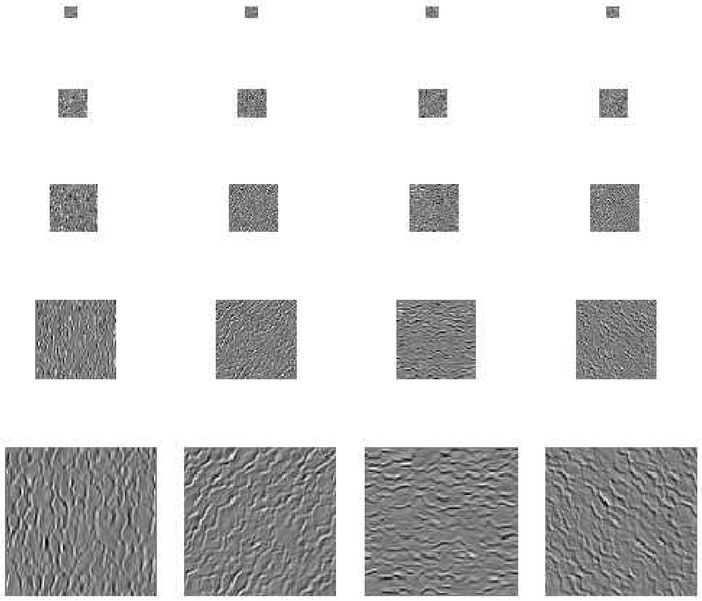
Step 1: Convolve with filterbank

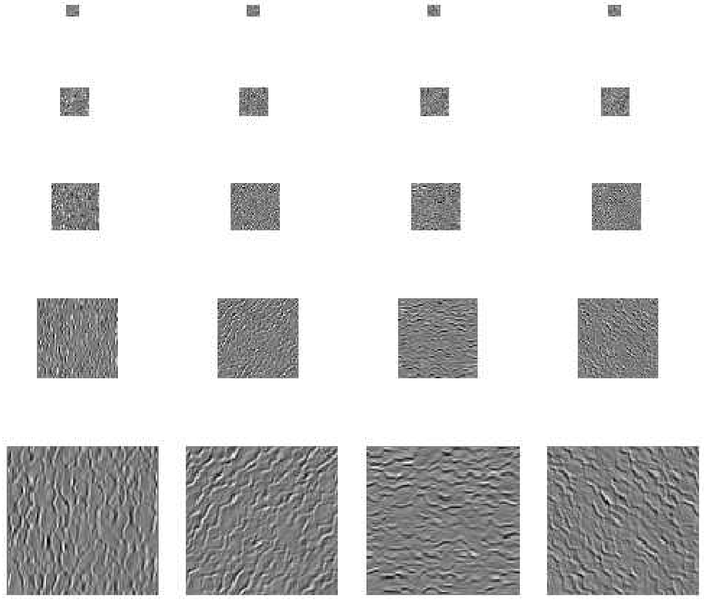


input



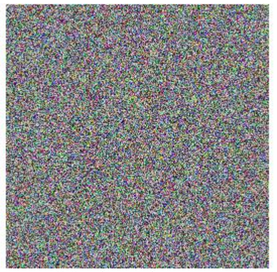
Noise image



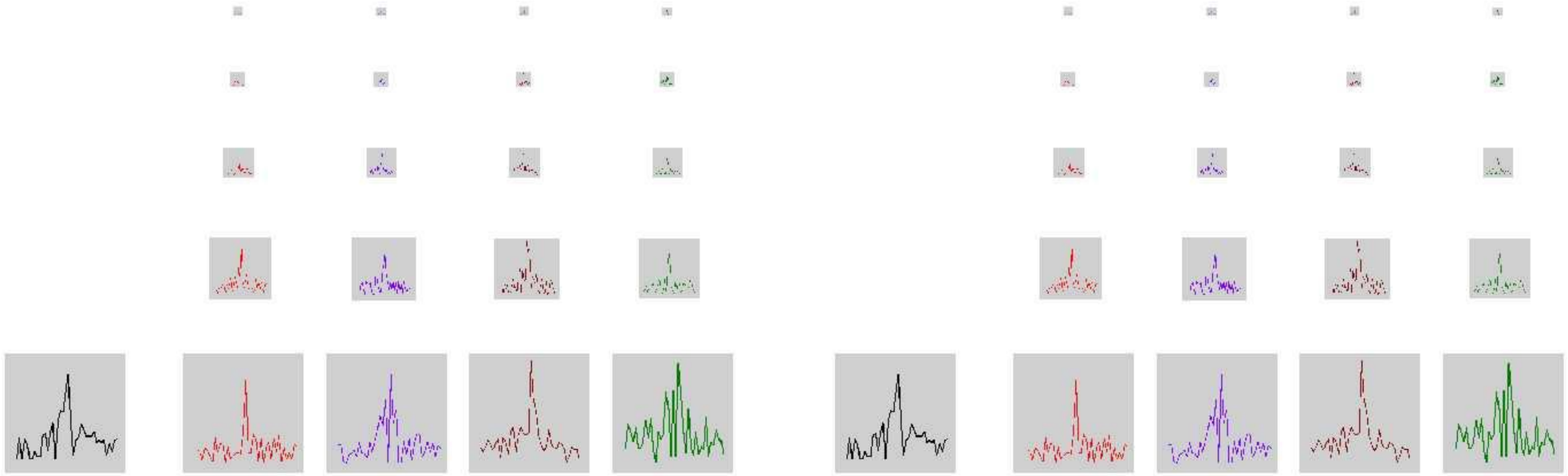


Step 2: match per--channel histograms

input



Noise image

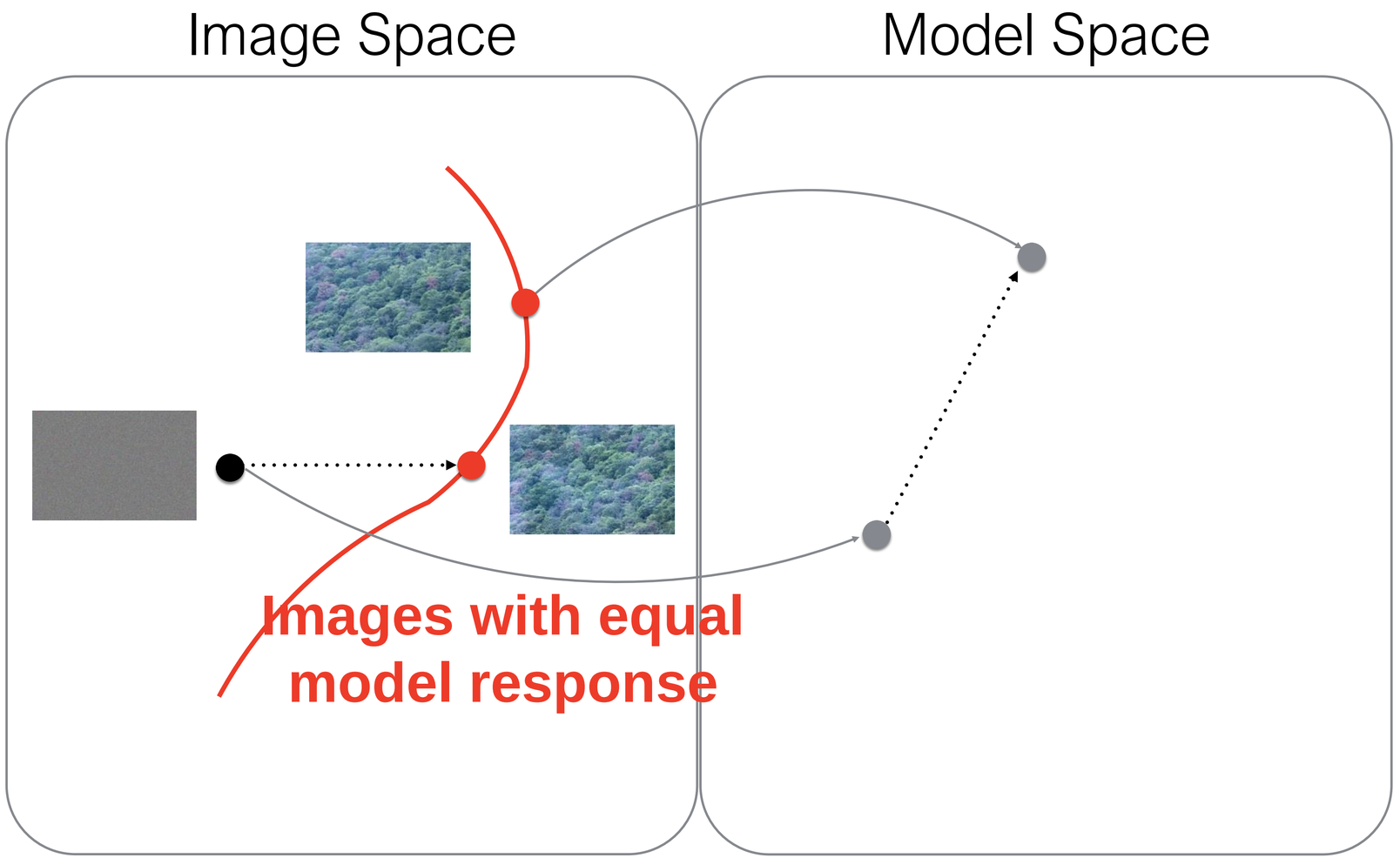


Step 3: collapse pyramid and repeat!

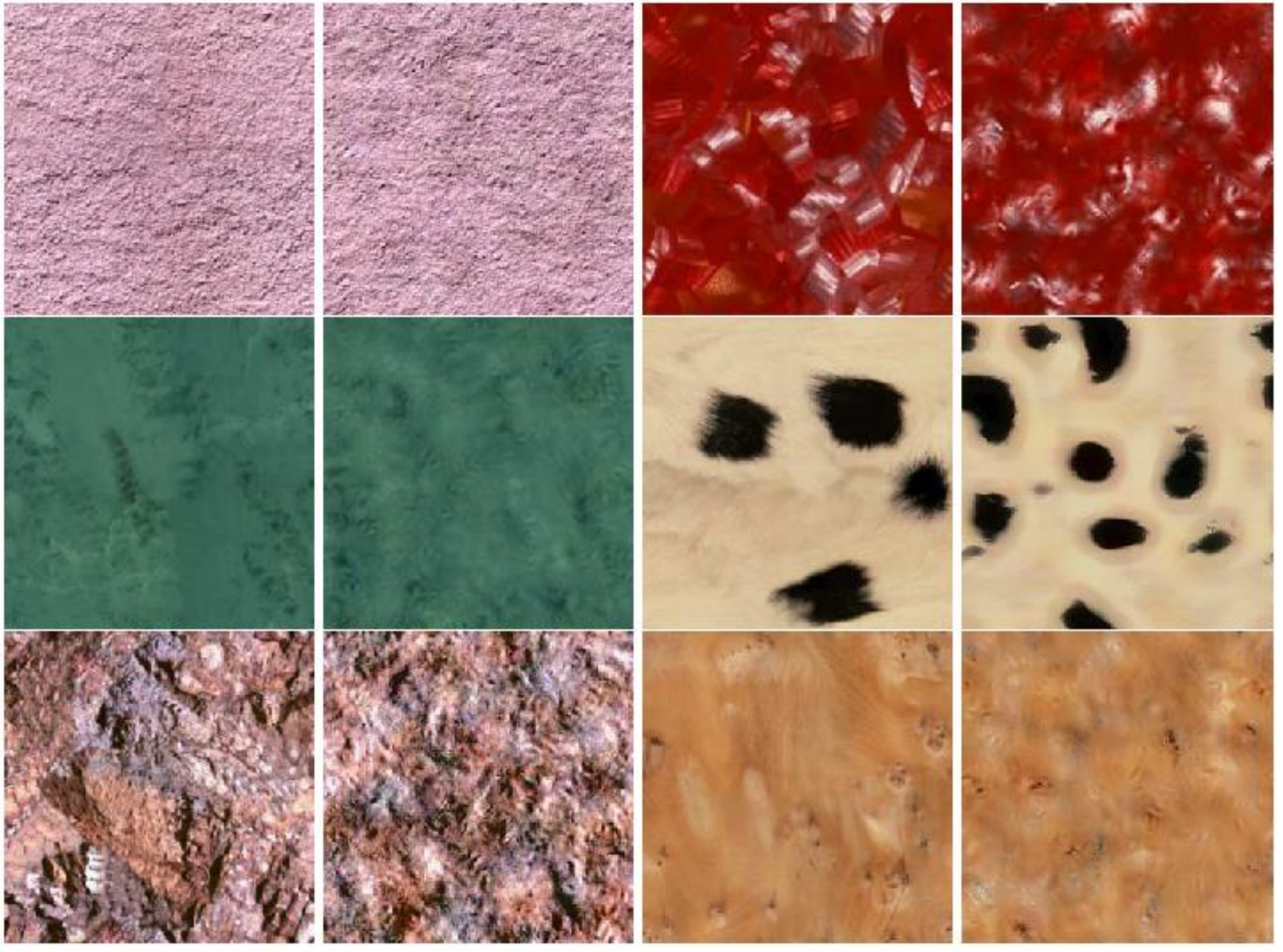
input

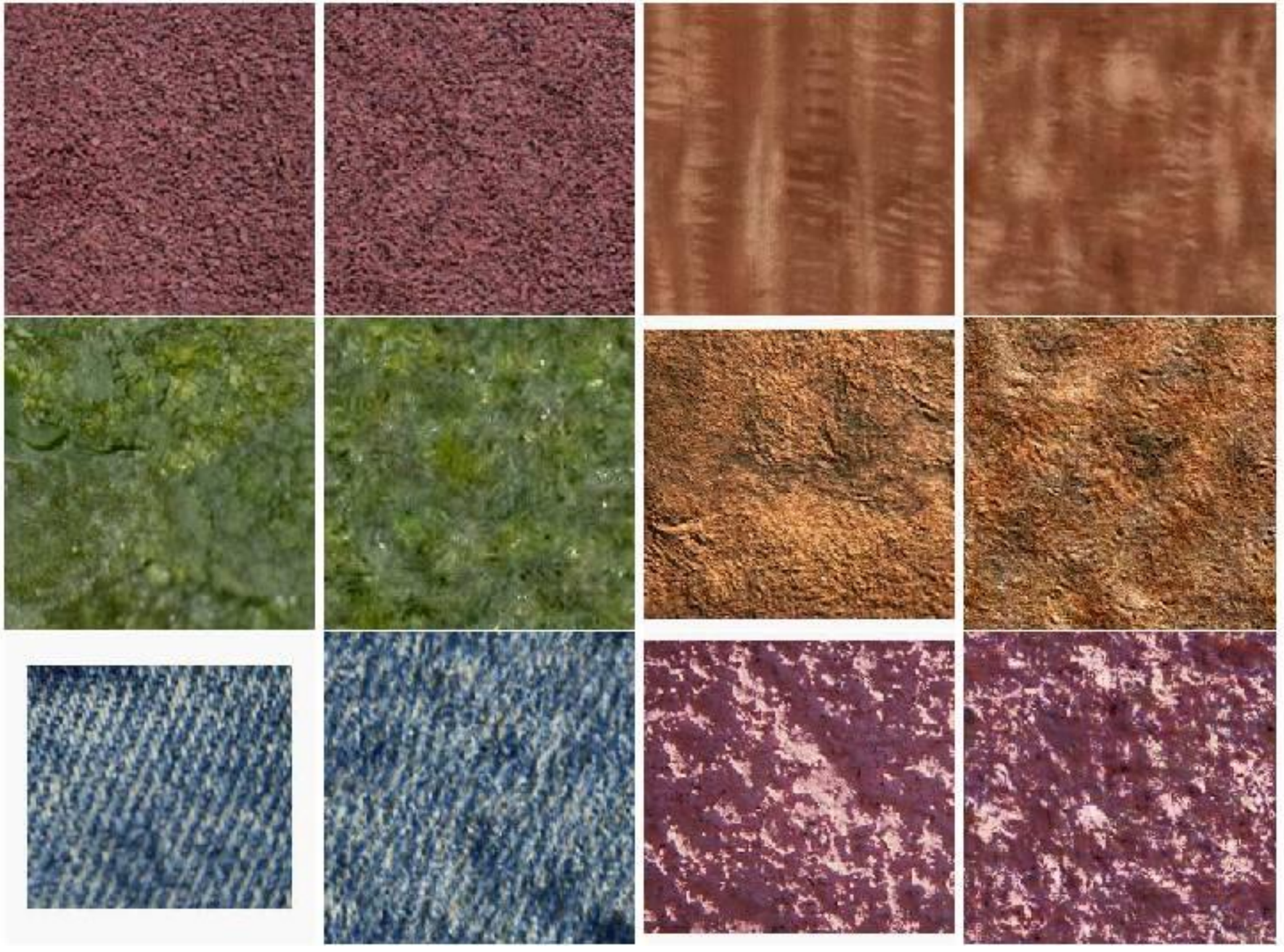
Noise image

Texture Synthesis



Portilla & Simoncelli (2000)





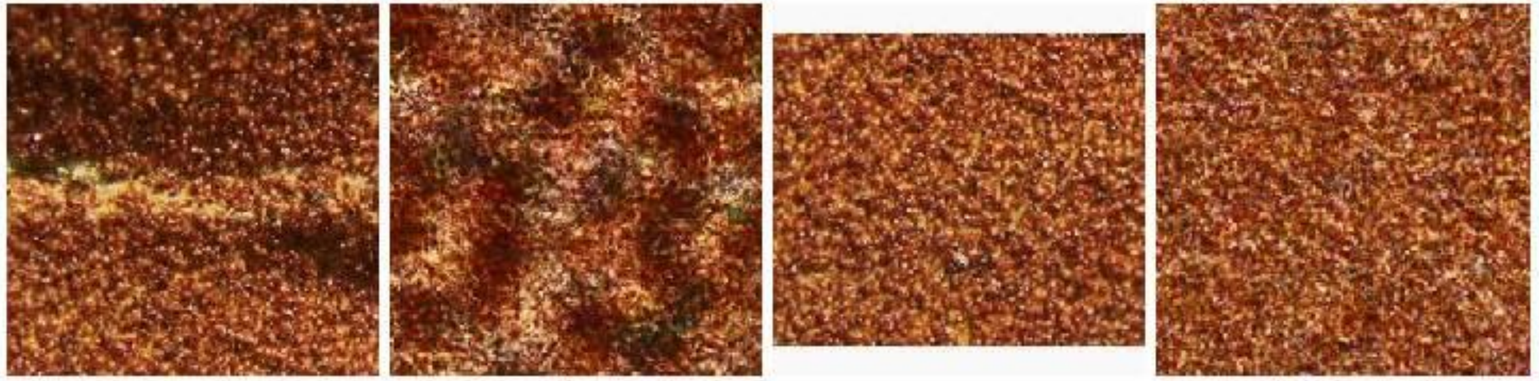


Figure 7: (Left pair) Inhomogeneous input texture produces blotchy synthetic texture. (Right pair) Homogeneous input.

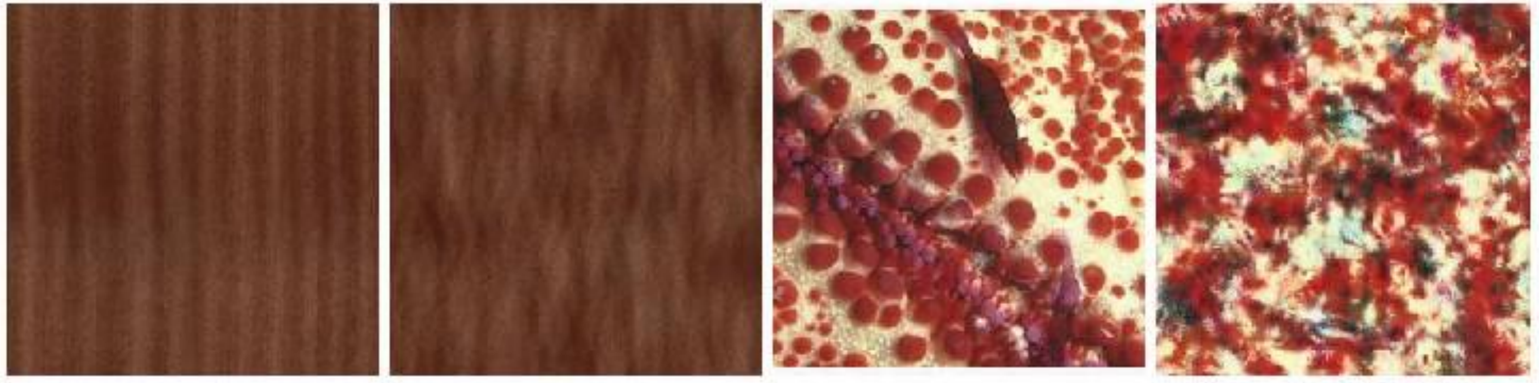


Figure 8: Examples of failures: wood grain and red coral.

Figure 9: More failures: hay and marble.

Simoncelli & Portilla ’98+

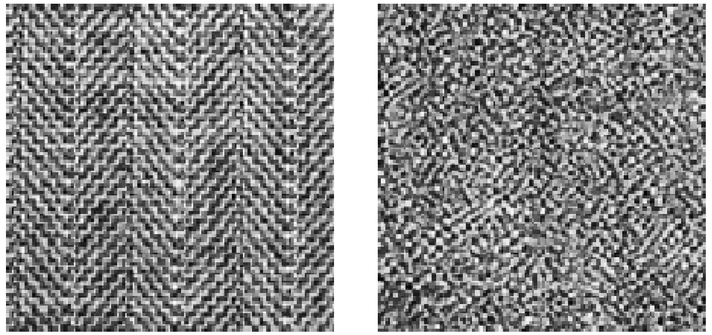
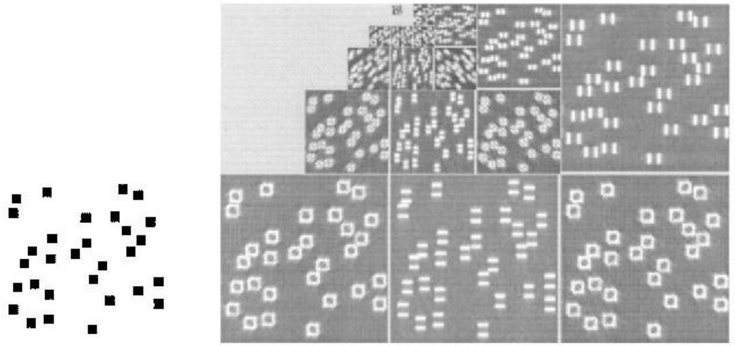


Figure 1. Textures with matching marginal statistics.

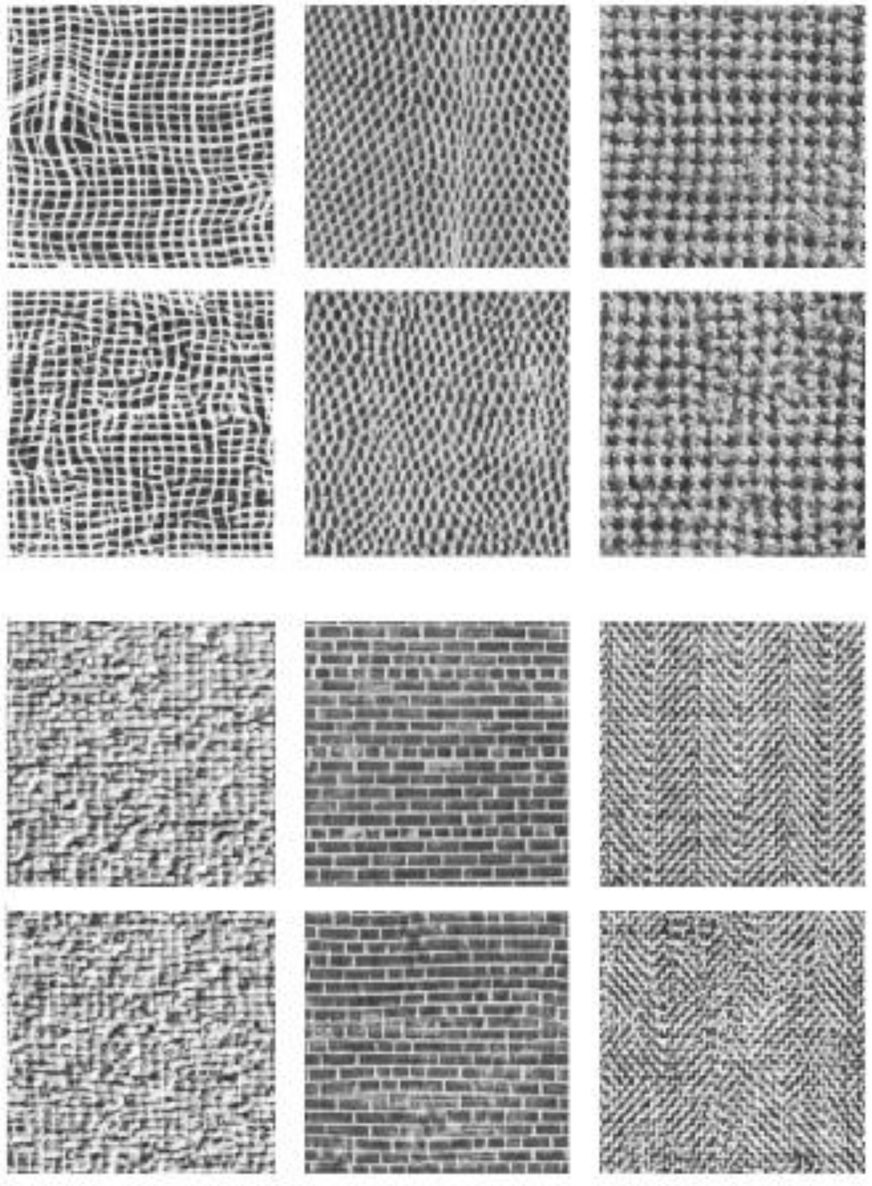
- Marginal statistics are not enough
- Neighboring filter responses are highly correlated
  - an edge at low-res will cause an edge at high-res
- Let’s match 2nd order statistics too!

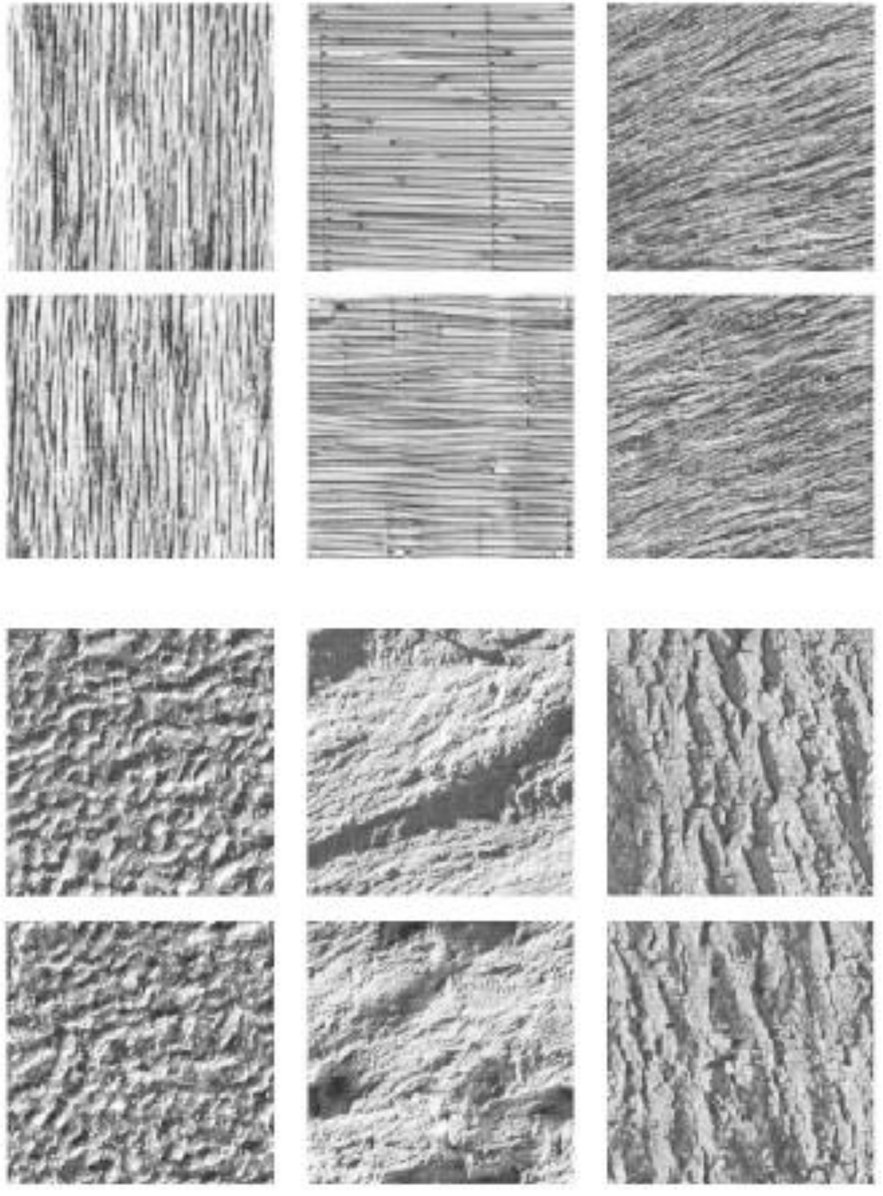
- J Portilla and E P Simoncelli. *A Parametric Texture Model based on Joint Statistics of Complex Wavelet Coefficients.* Int'l Journal of Computer Vision. 40(1):49-71, October, 2000.

Simoncelli & Portilla ’98+

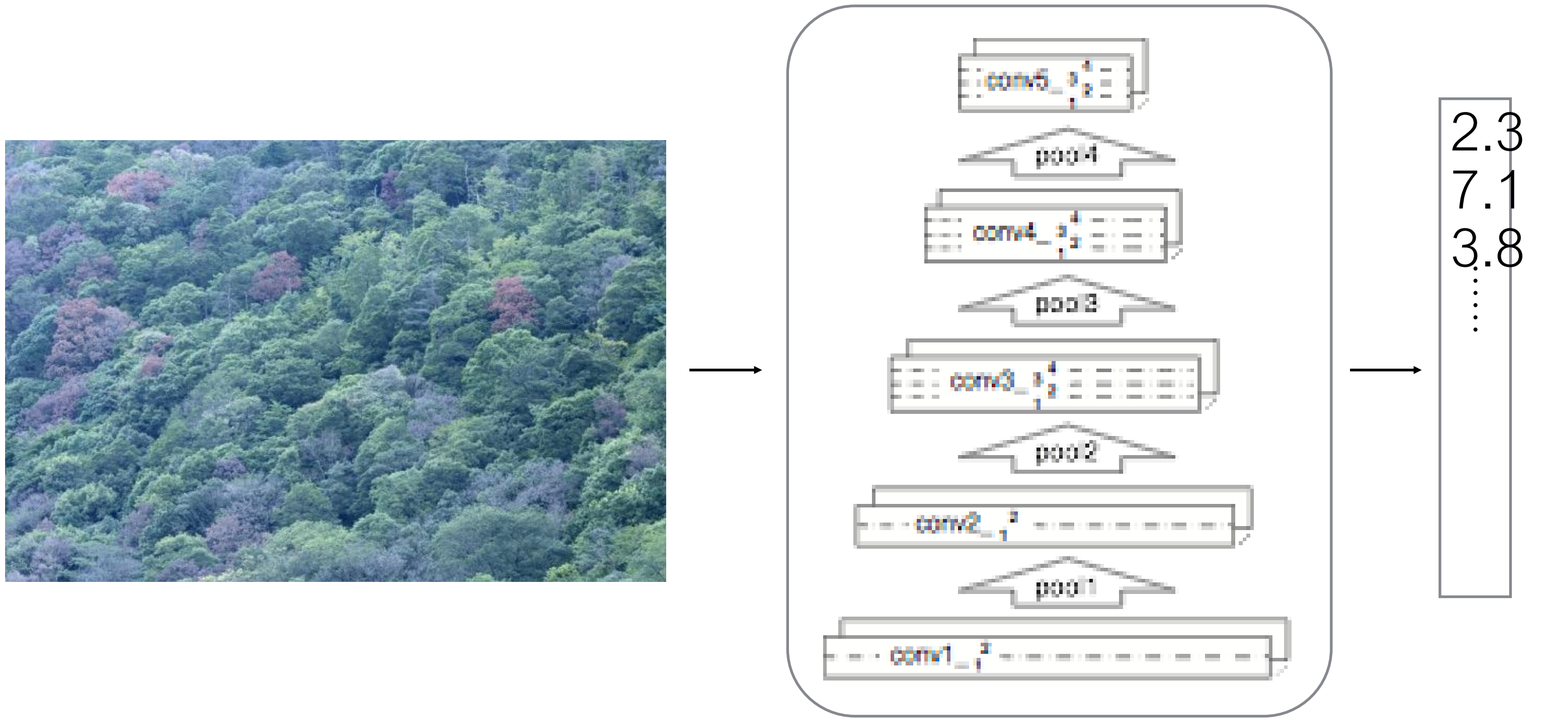


- Match joint histograms of pairs of filter responses at adjacent spatial locations, orientations, and scales.
- Optimize using repeated projections onto statistical constraint sufraces





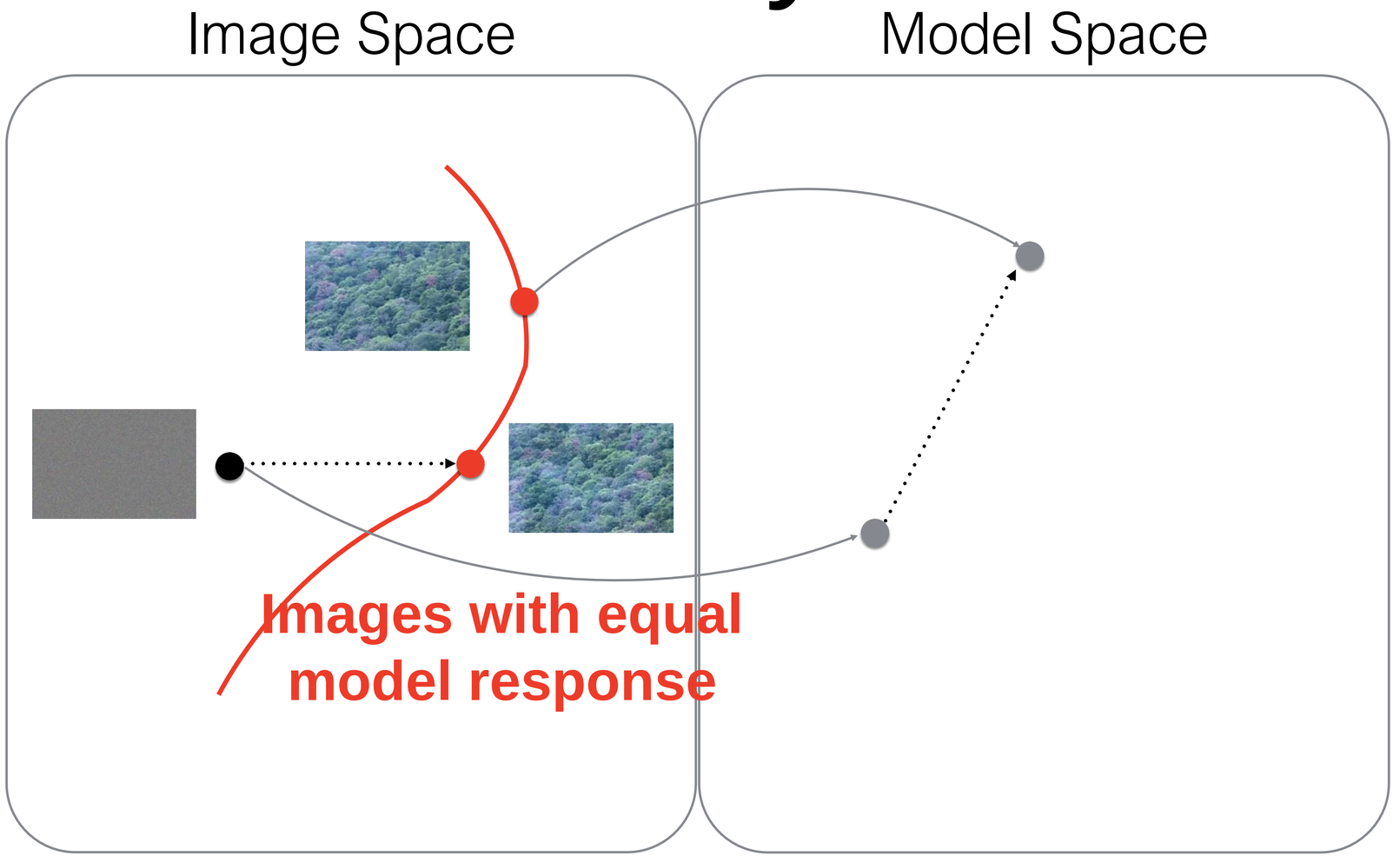
Convolutional Neural Network Texture Model



Convolutional Neural Network

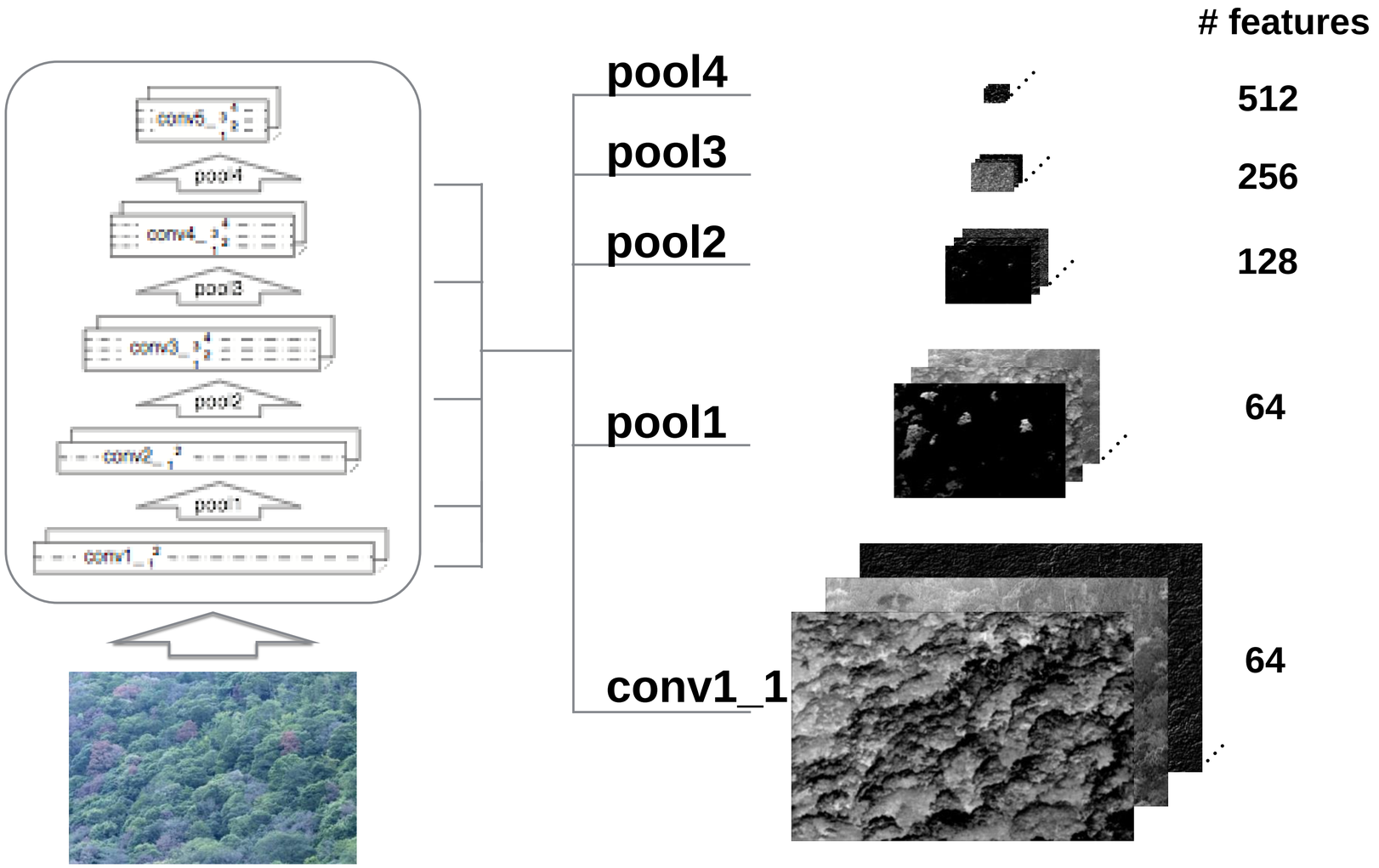
Gatys et al. (NIPS 2015)

Texture Synthesis

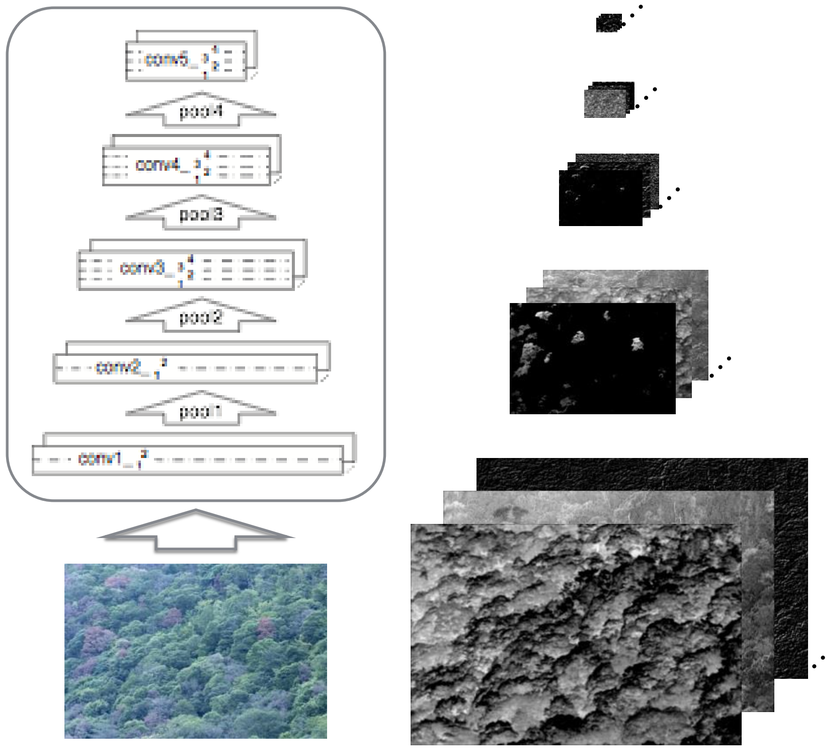


Portilla & Simoncelli (2000)

CNN - Multiscale Filter Bank



CNN - Texture Features



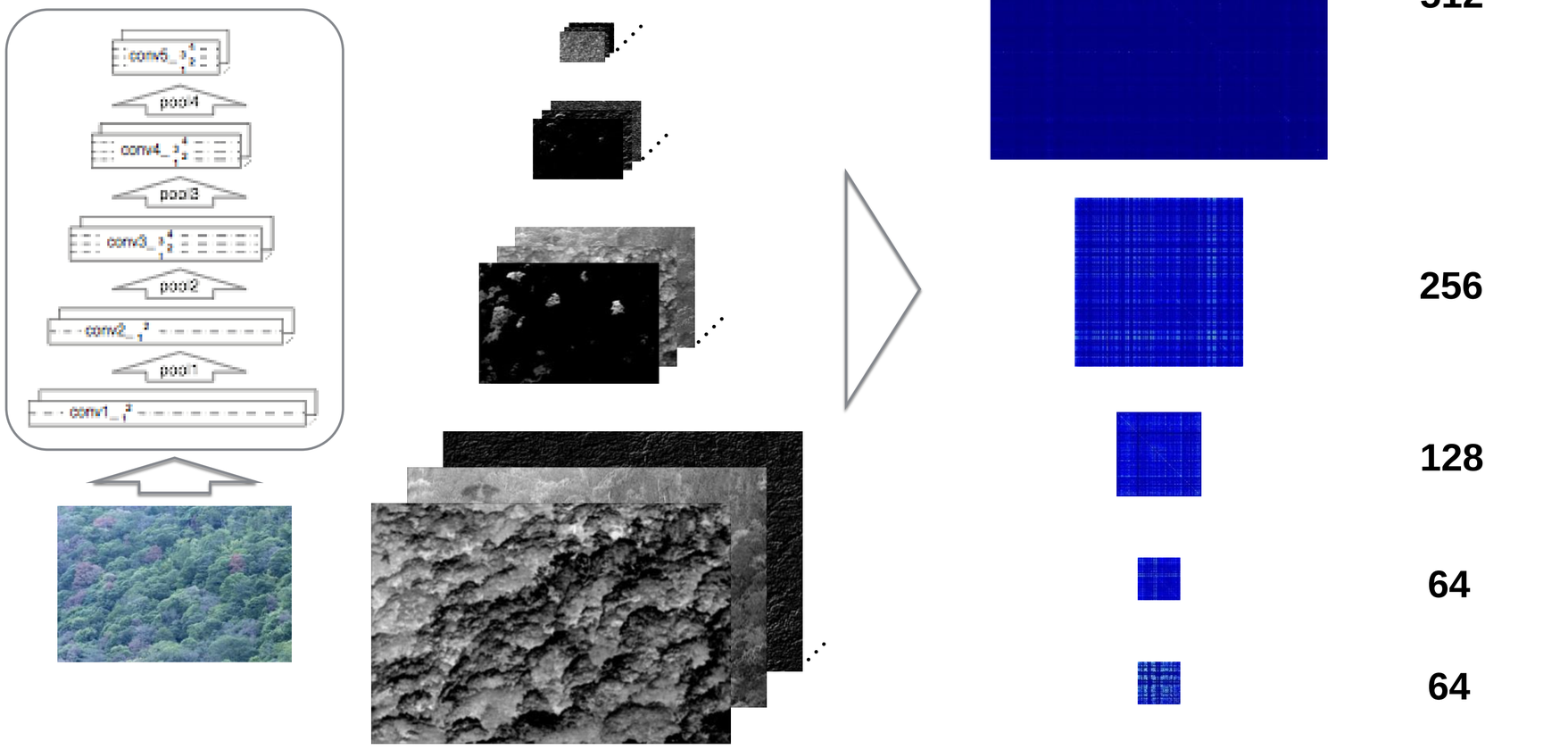
$$F = \left[\bar{f}_1, \bar{f}_2, \bar{f}_3, ..., \bar{f}_N\right]^T$$

$$G = FF^T$$

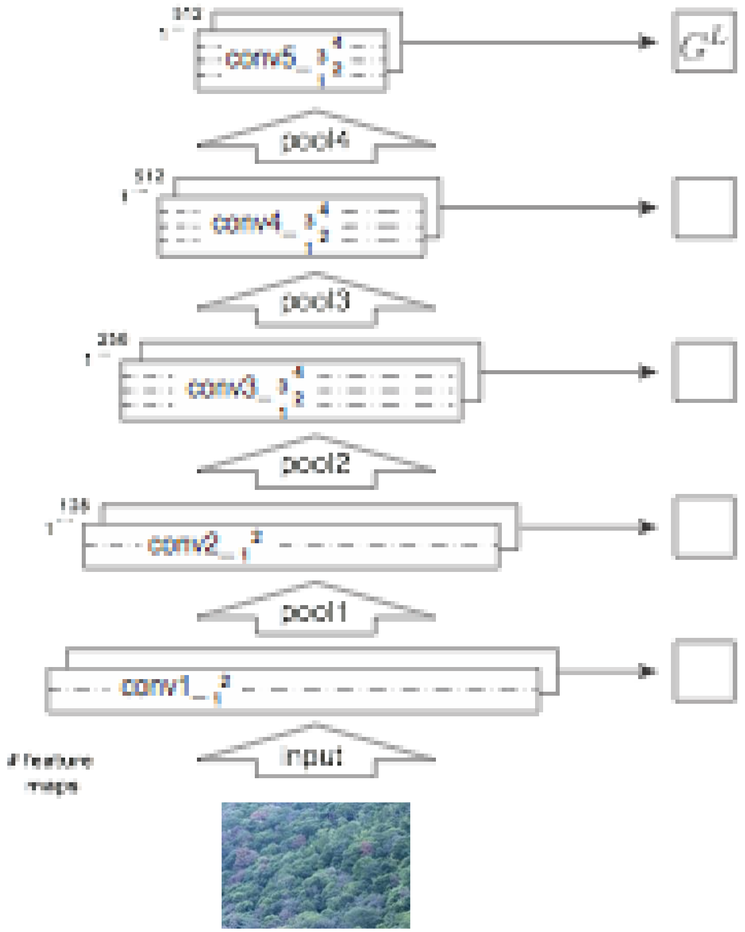
$$= \begin{pmatrix} \langle \bar{f}_1, \bar{f}_1 \rangle & \cdots & \langle \bar{f}_1, \bar{f}_N \rangle \\ \langle \bar{f}_2, \bar{f}_1 \rangle & & \vdots \\ \vdots & \ddots & \vdots \\ \langle \bar{f}_N, \bar{f}_1 \rangle & \cdots & \langle \bar{f}_N, \bar{f}_N \rangle \end{pmatrix}$$

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

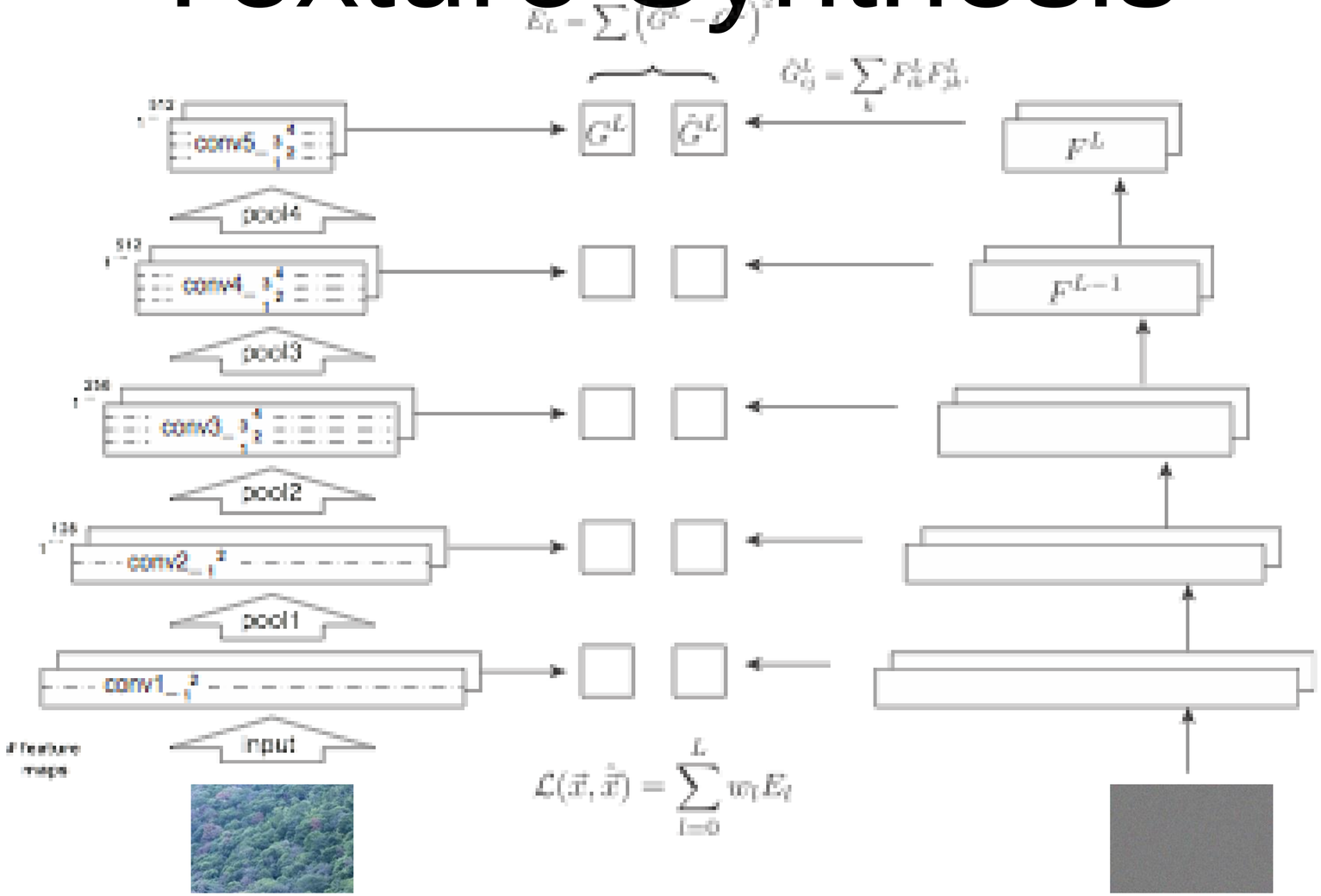
CNN-Texture Features



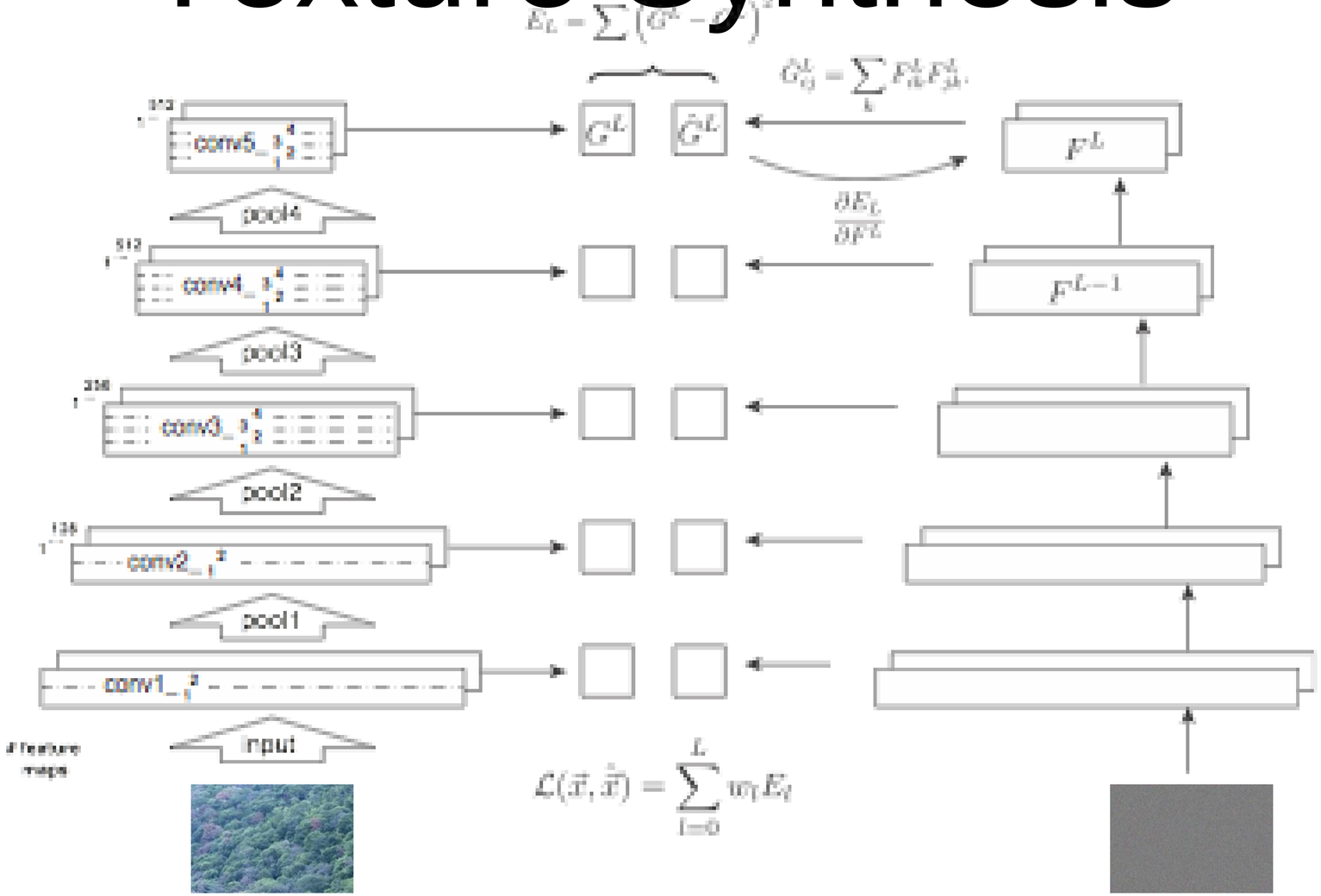
Texture Synthesis



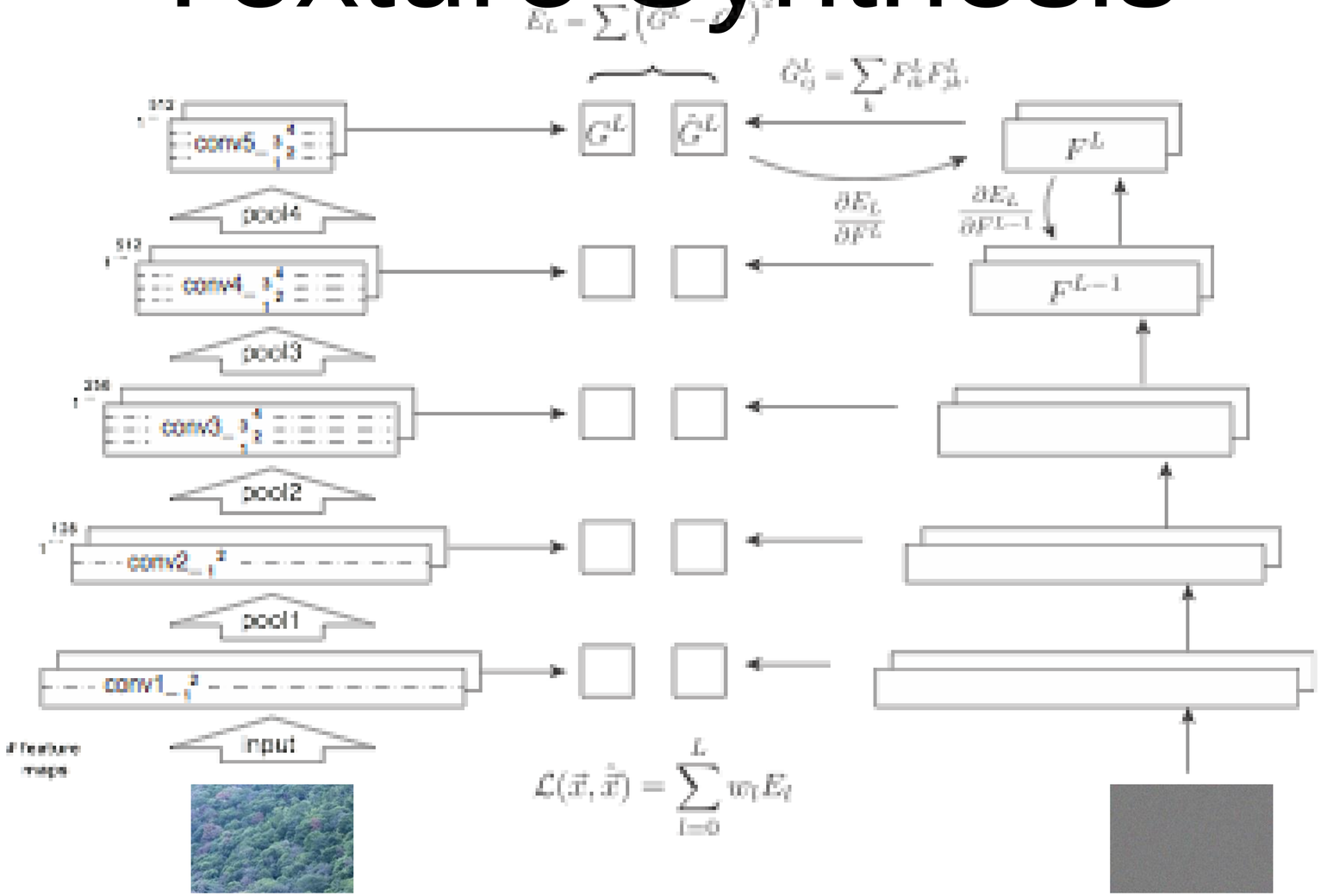
Texture Synthesis



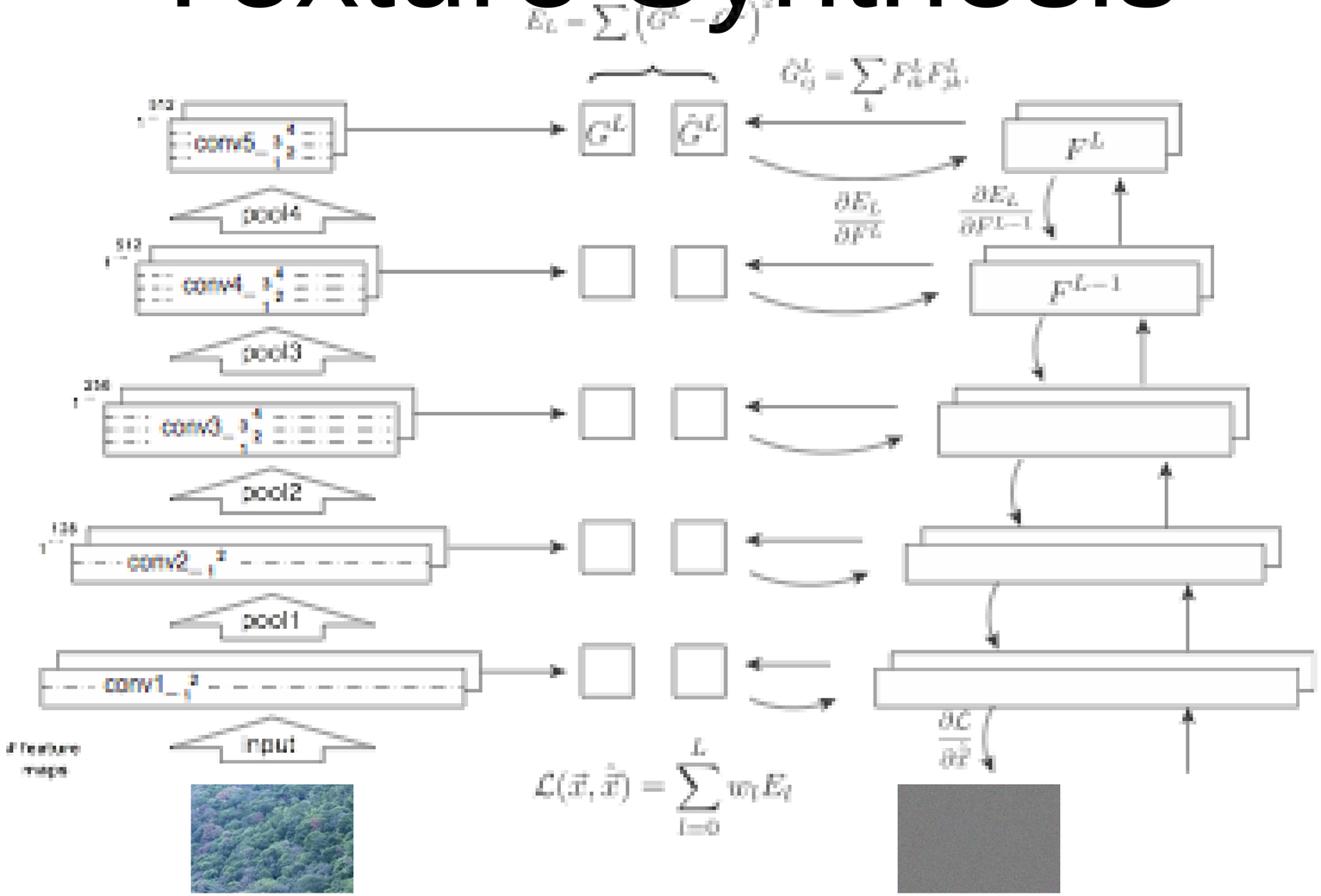
Texture Synthesis



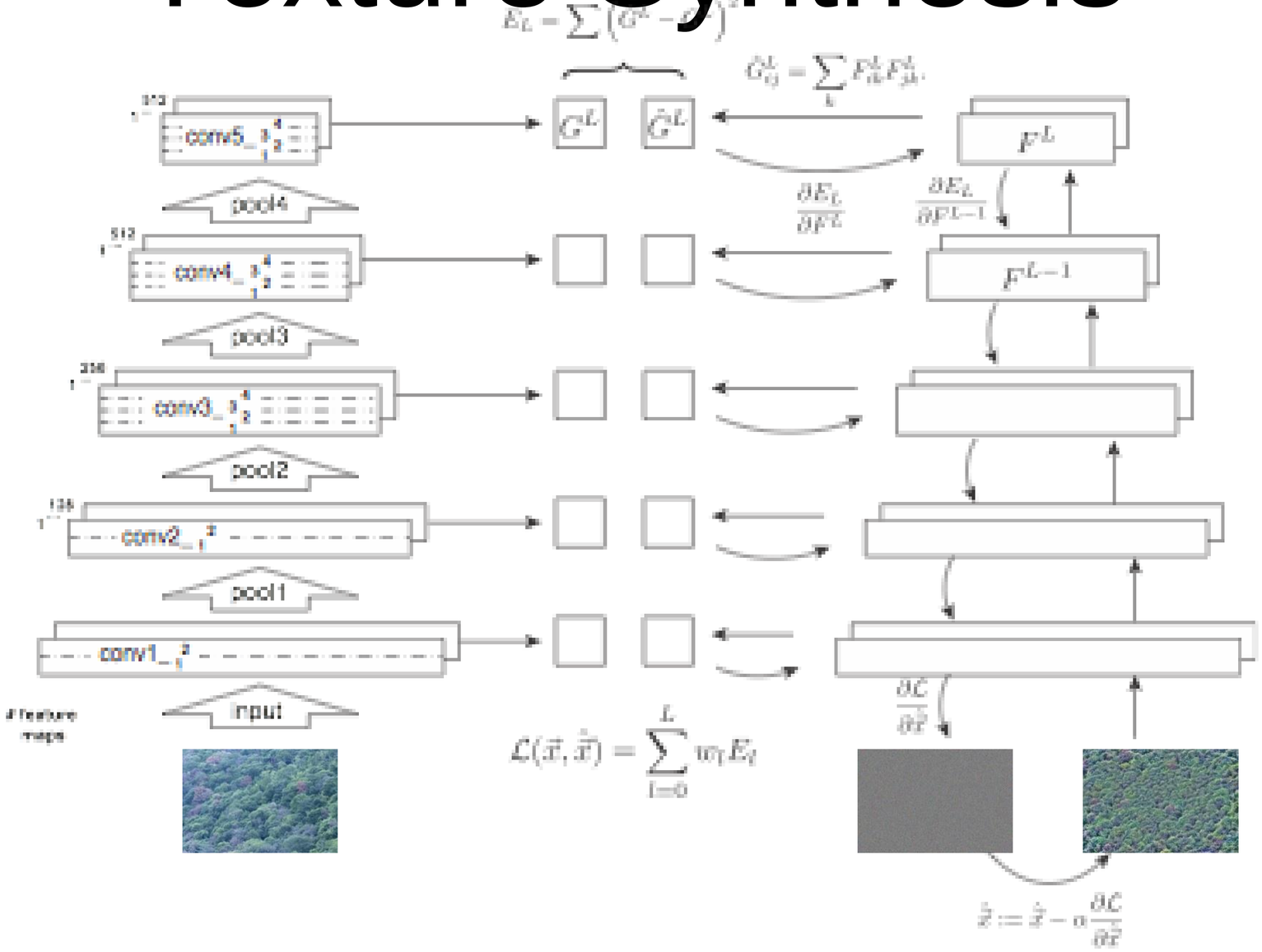
Texture Synthesis



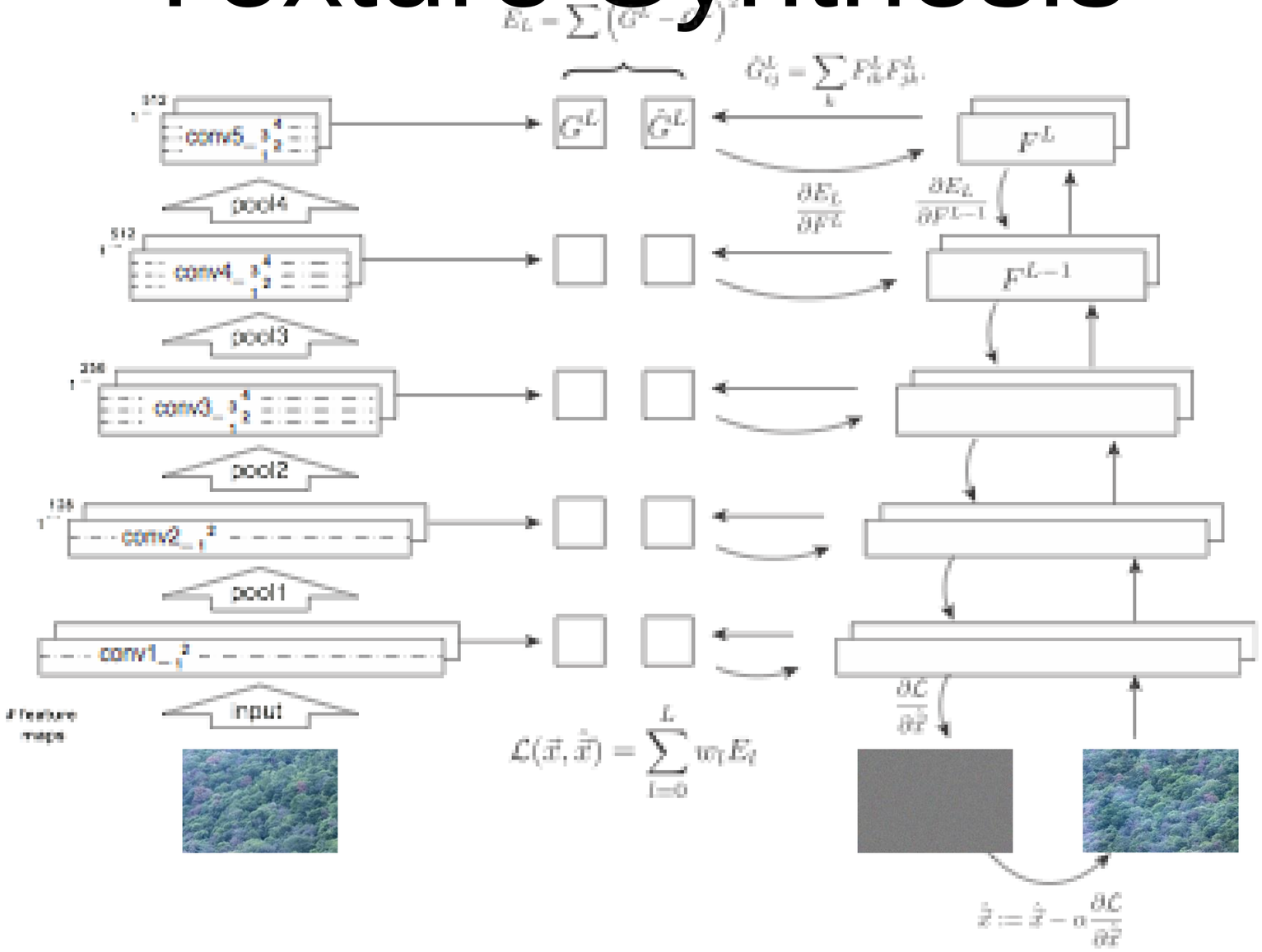
Texture Synthesis



Texture Synthesis



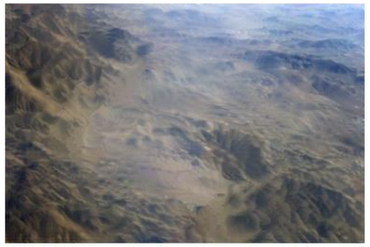
Texture Synthesis



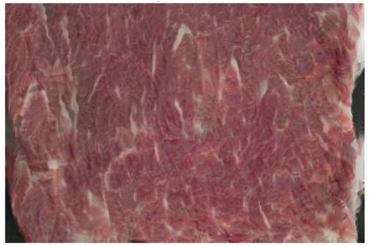
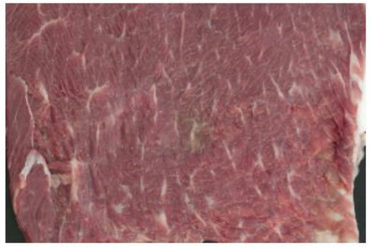
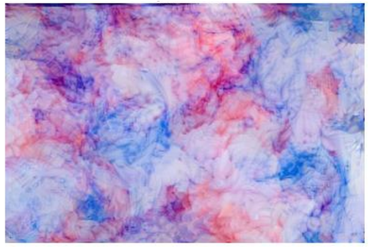
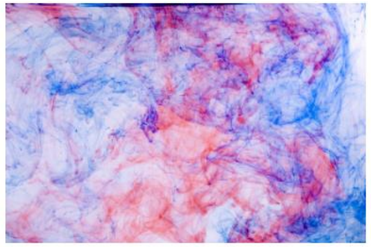
Test Julesz' Conjecture





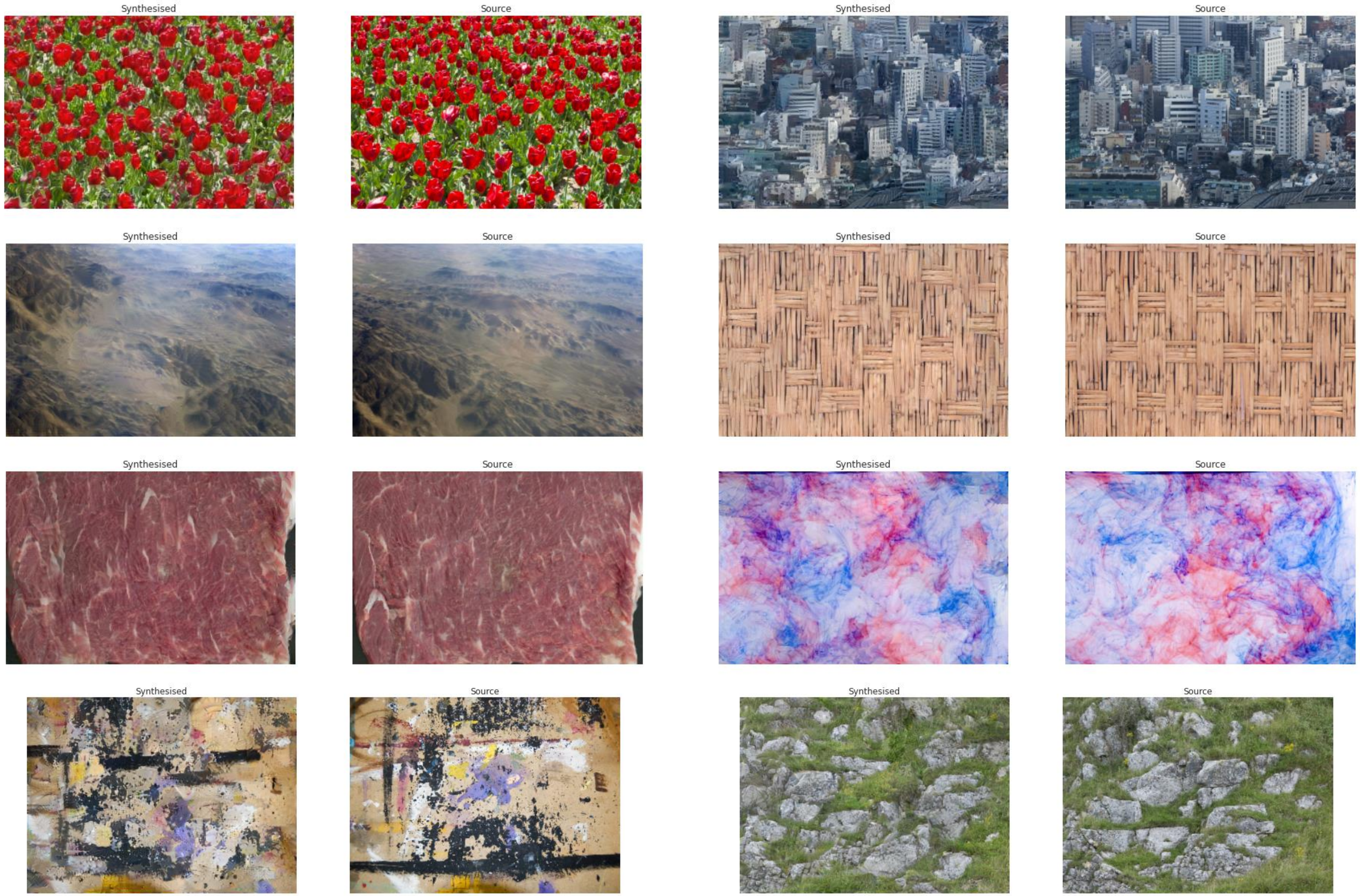




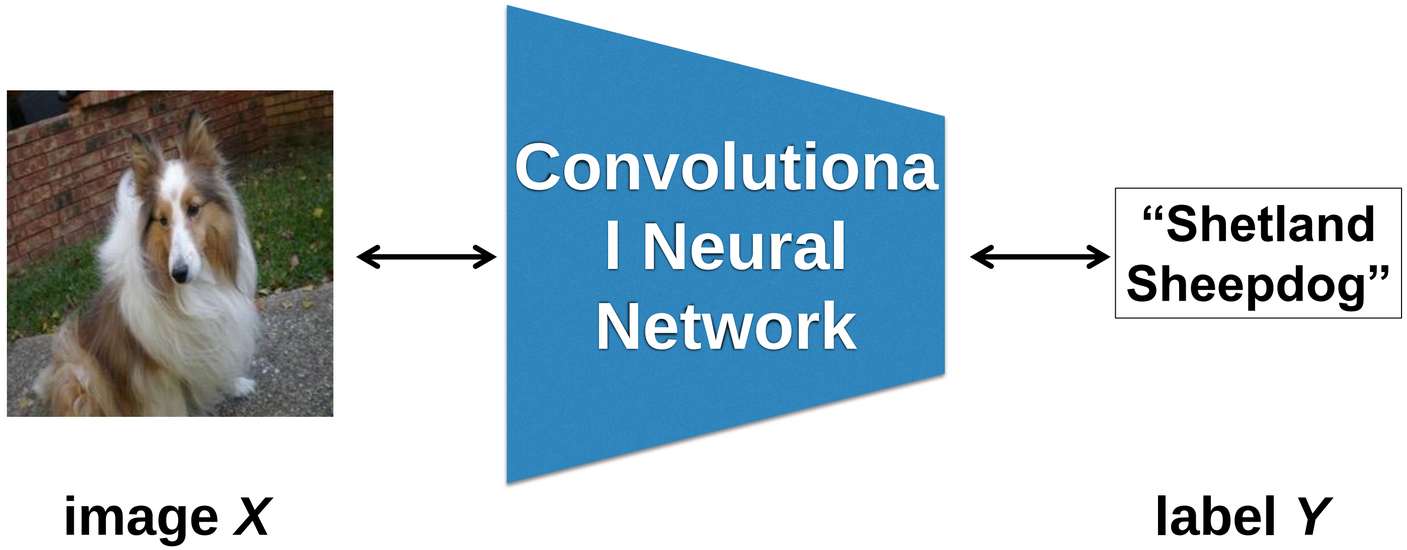







Test Julesz’ Conjecture



ImageNet Recognition is just Texture Recognition



ImageNet Recognition is just Texture Recognition

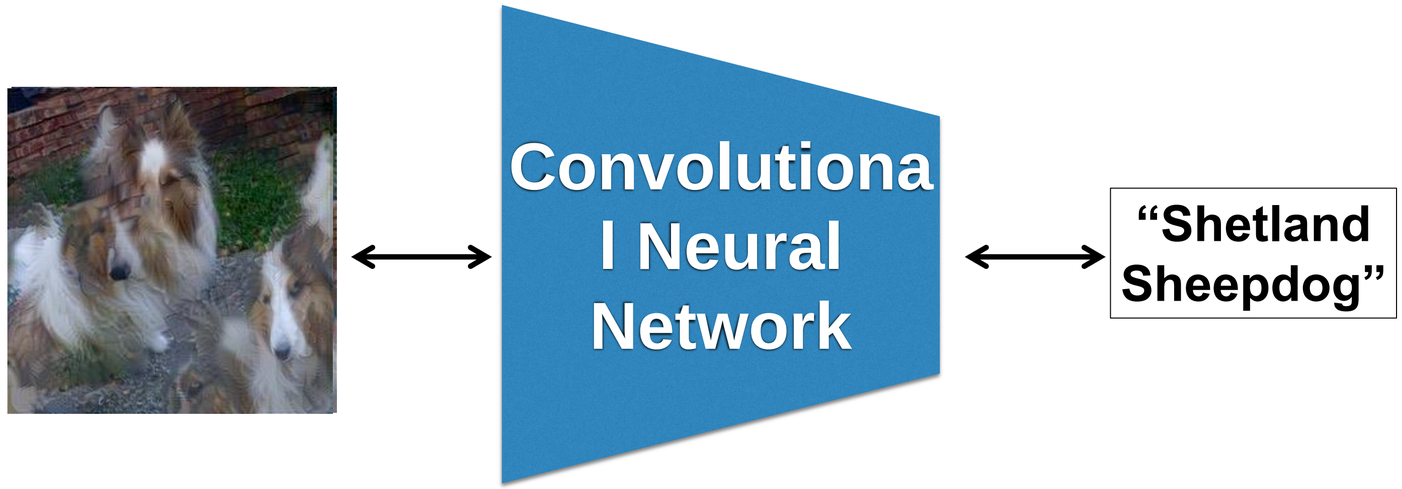
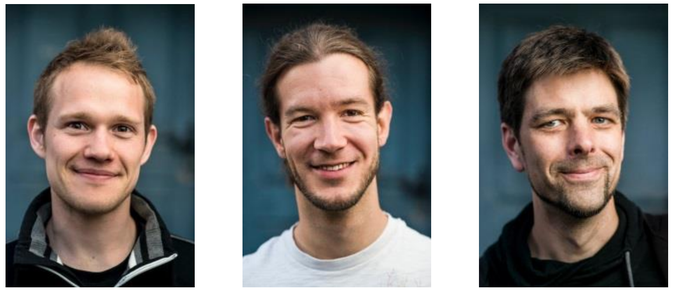


image *X*

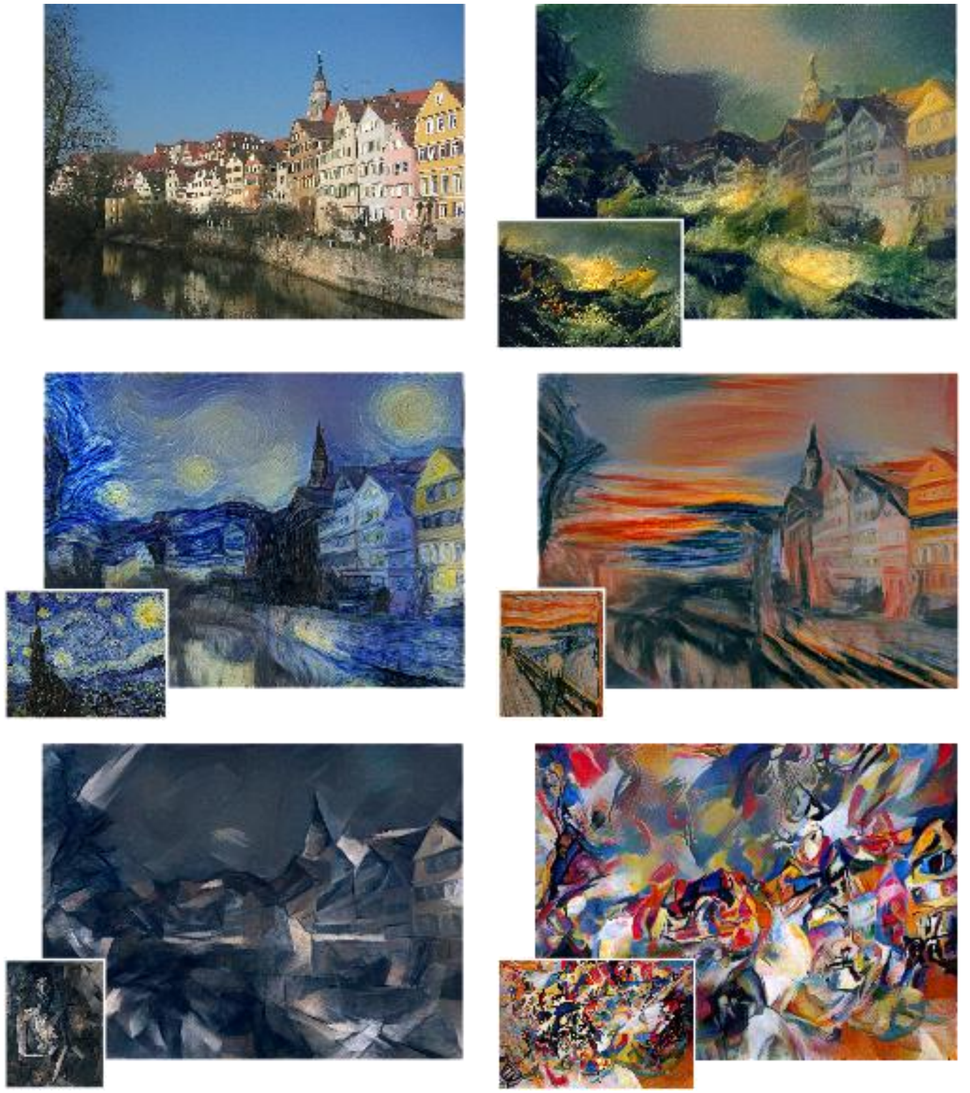
label *Y*

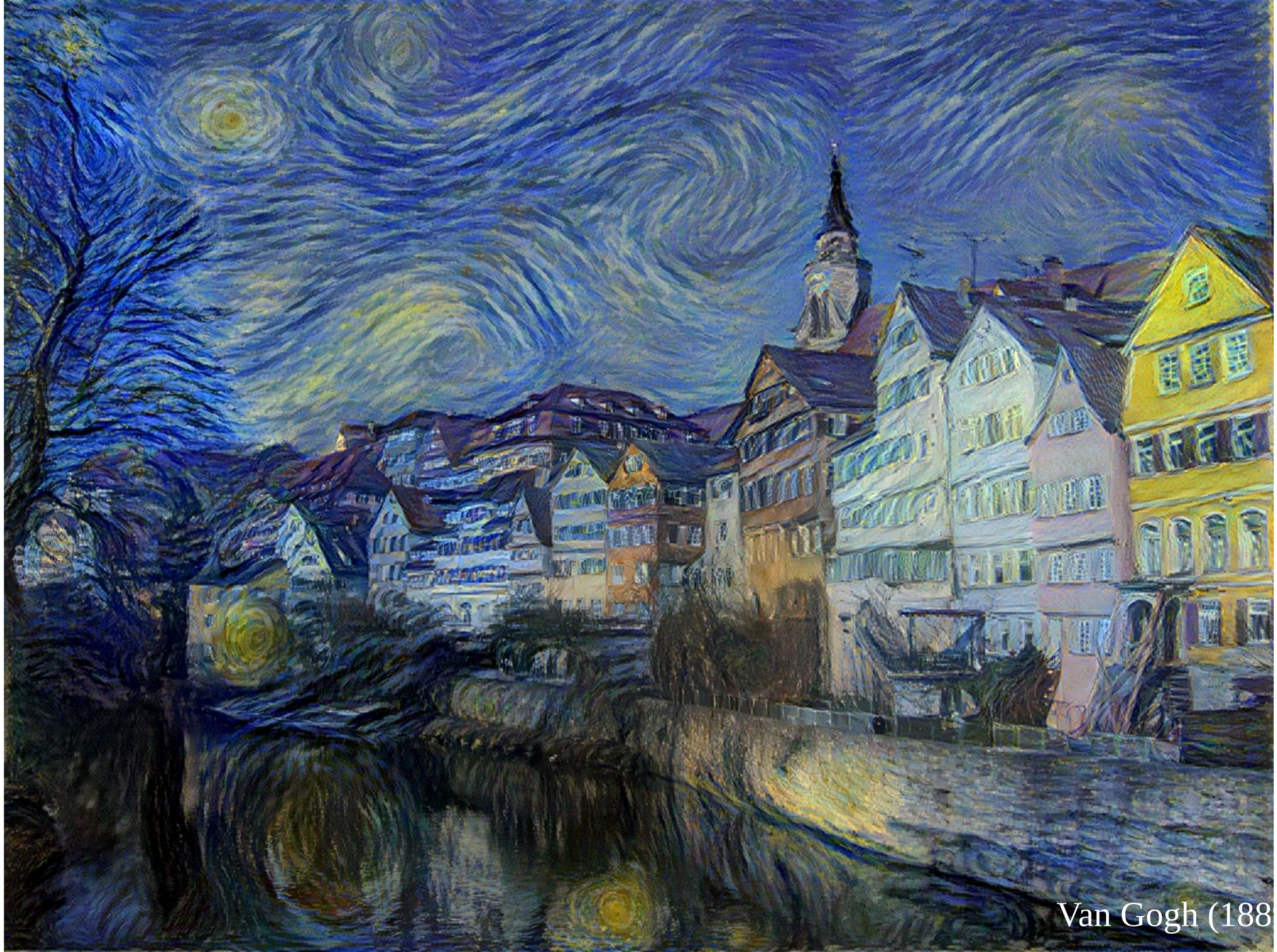
Gatys et al, 2017

A Neural Algorithm of Artistic Style



Gatys, Ecker, Bethge (arXiv 2015)




Van Gogh (188

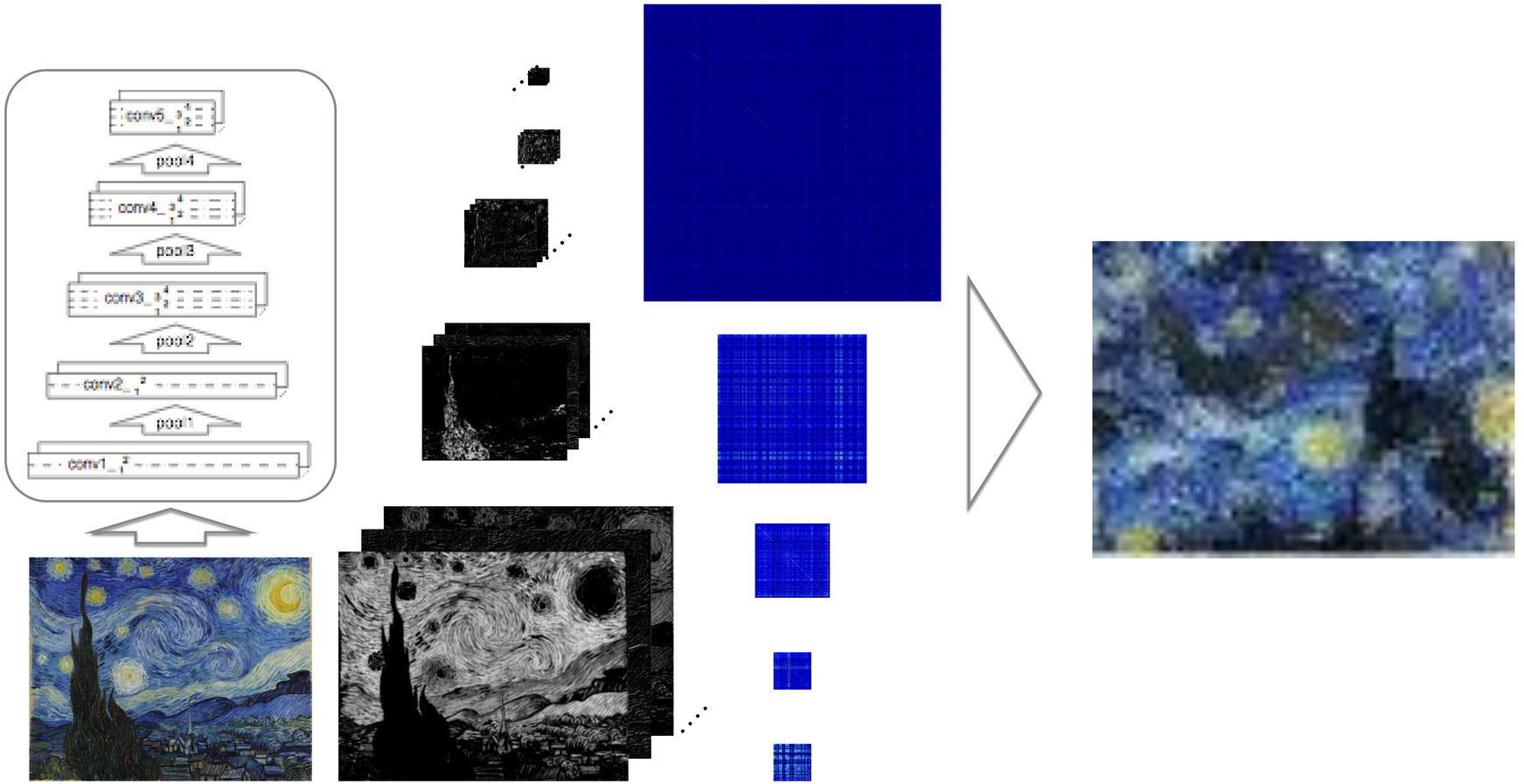
Picasso (1910)

Munch (1893)

Turner (1805)


Kandinsky (191

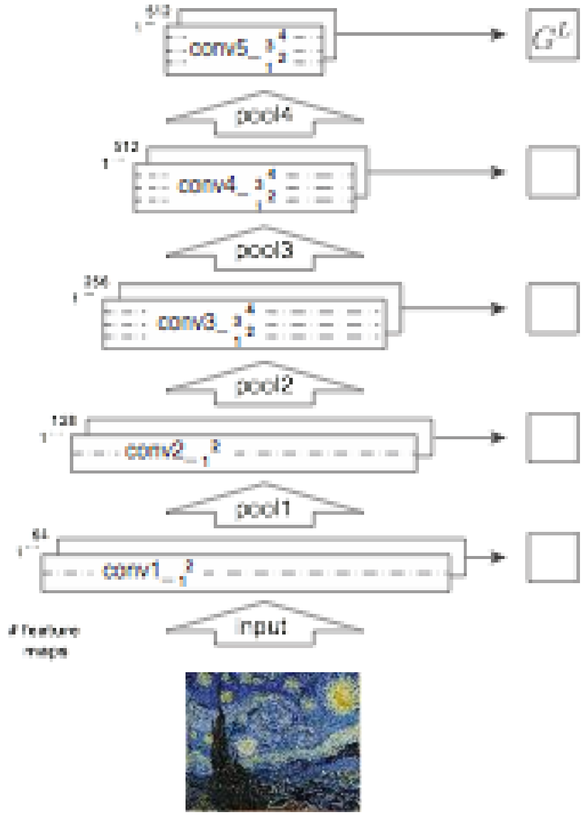
CNN - Texture Synthesis



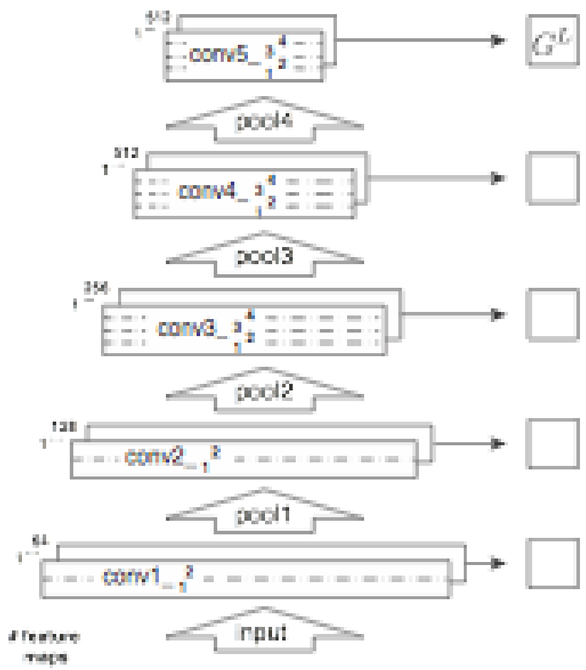
Gatys et al. (NIPS 2015)

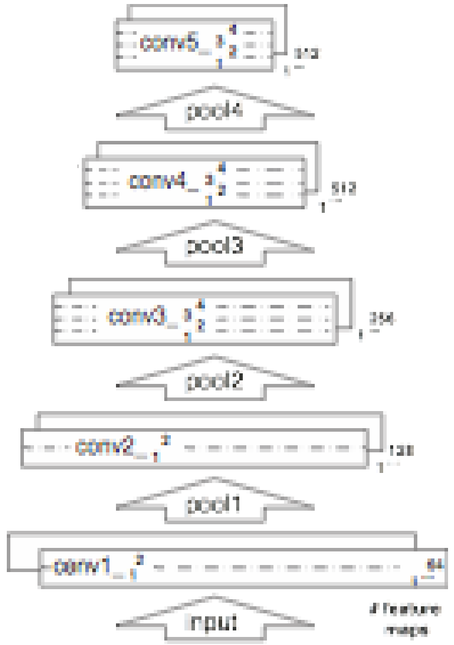
Artistic Style Transfer

Artistic Style Transfer

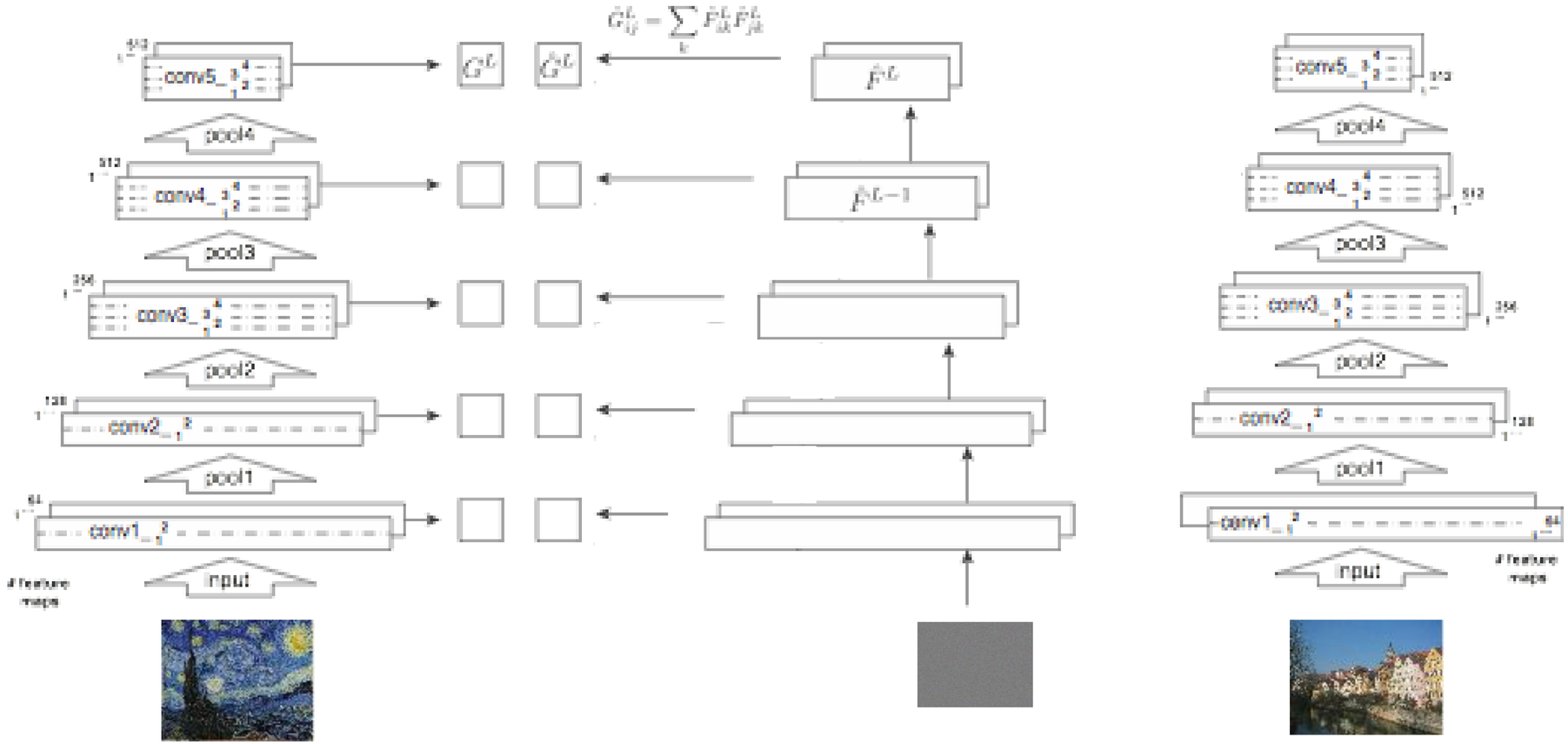


Artistic Style Transfer

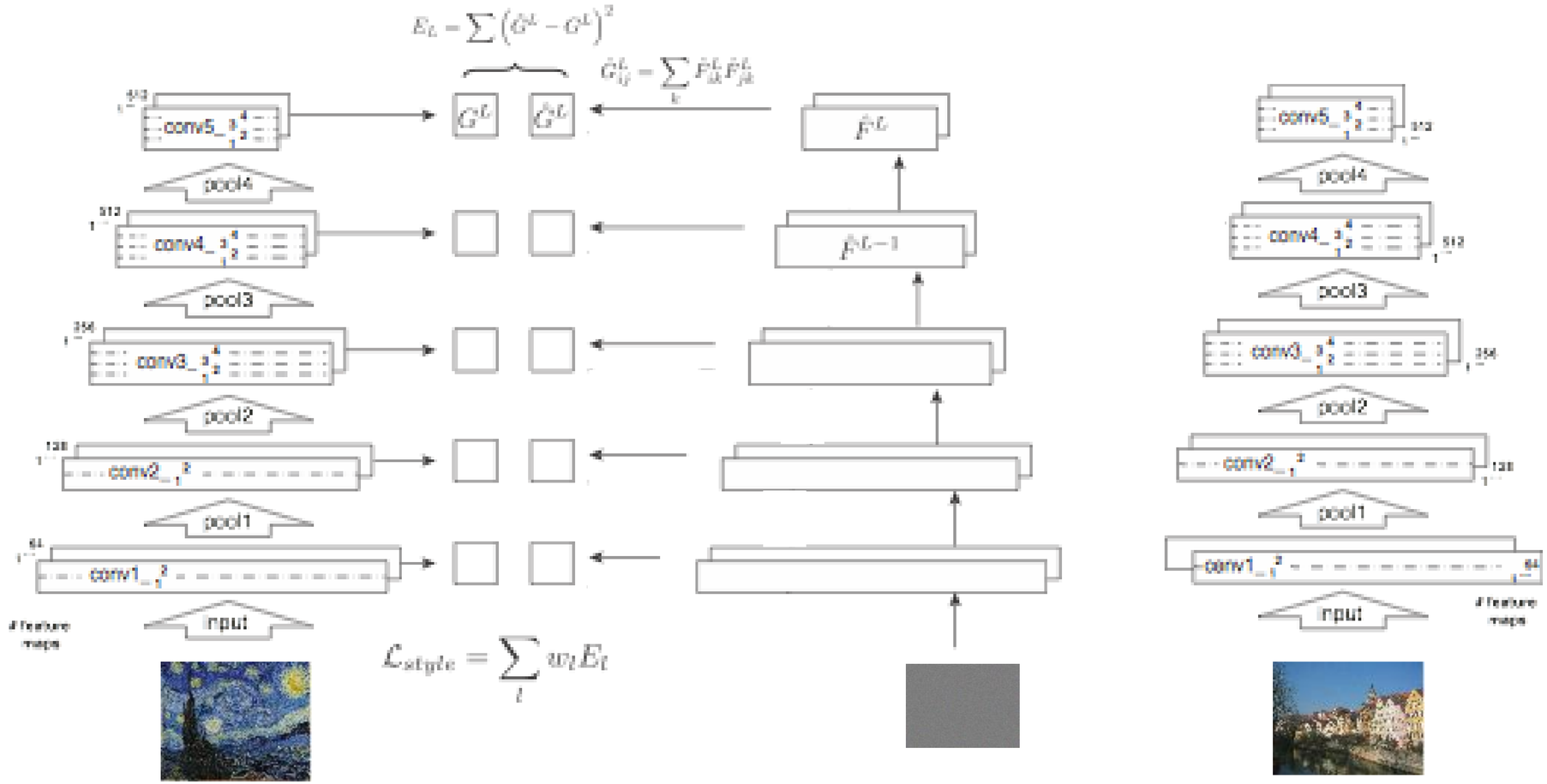




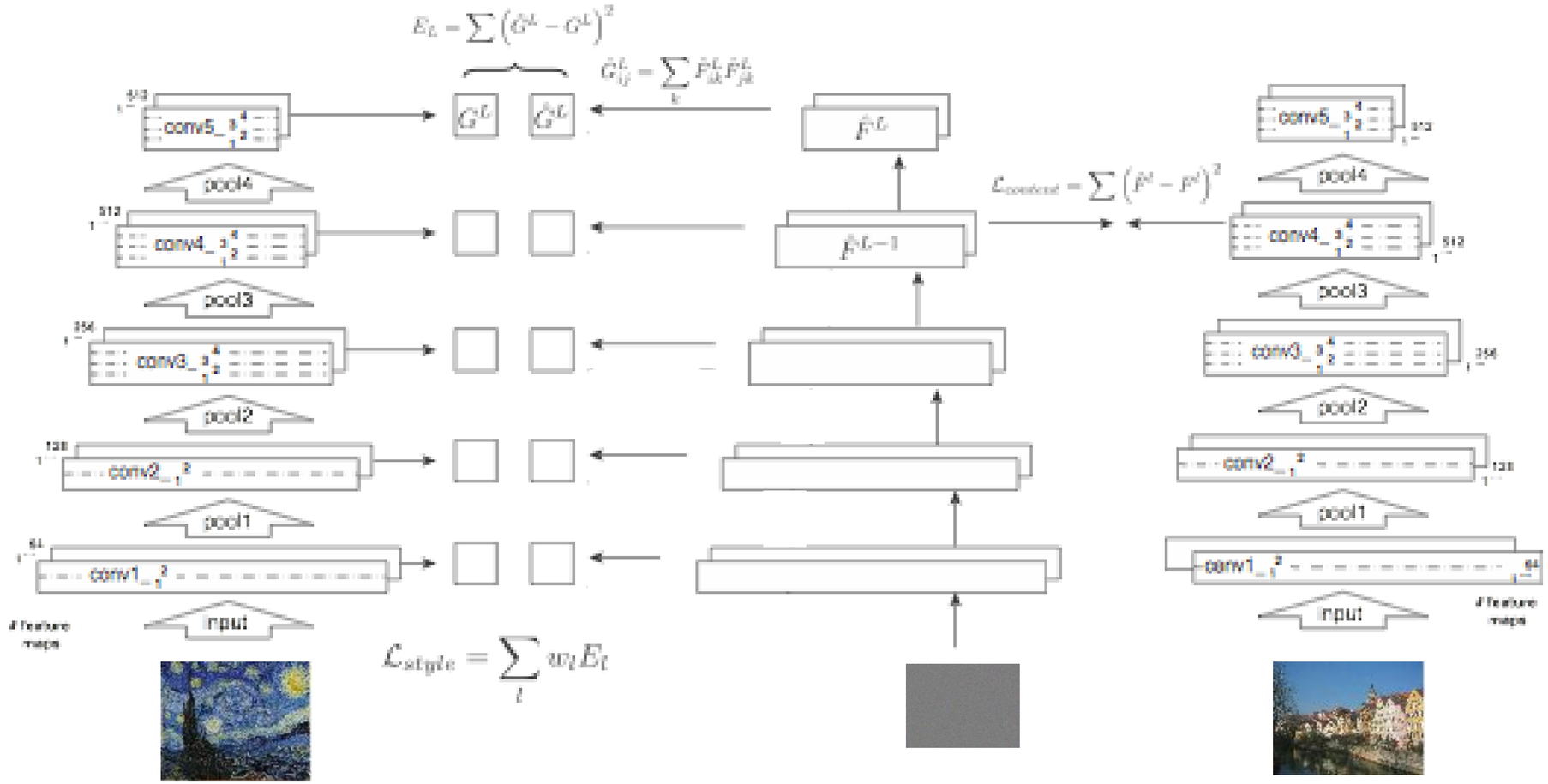
Artistic Style Transfer



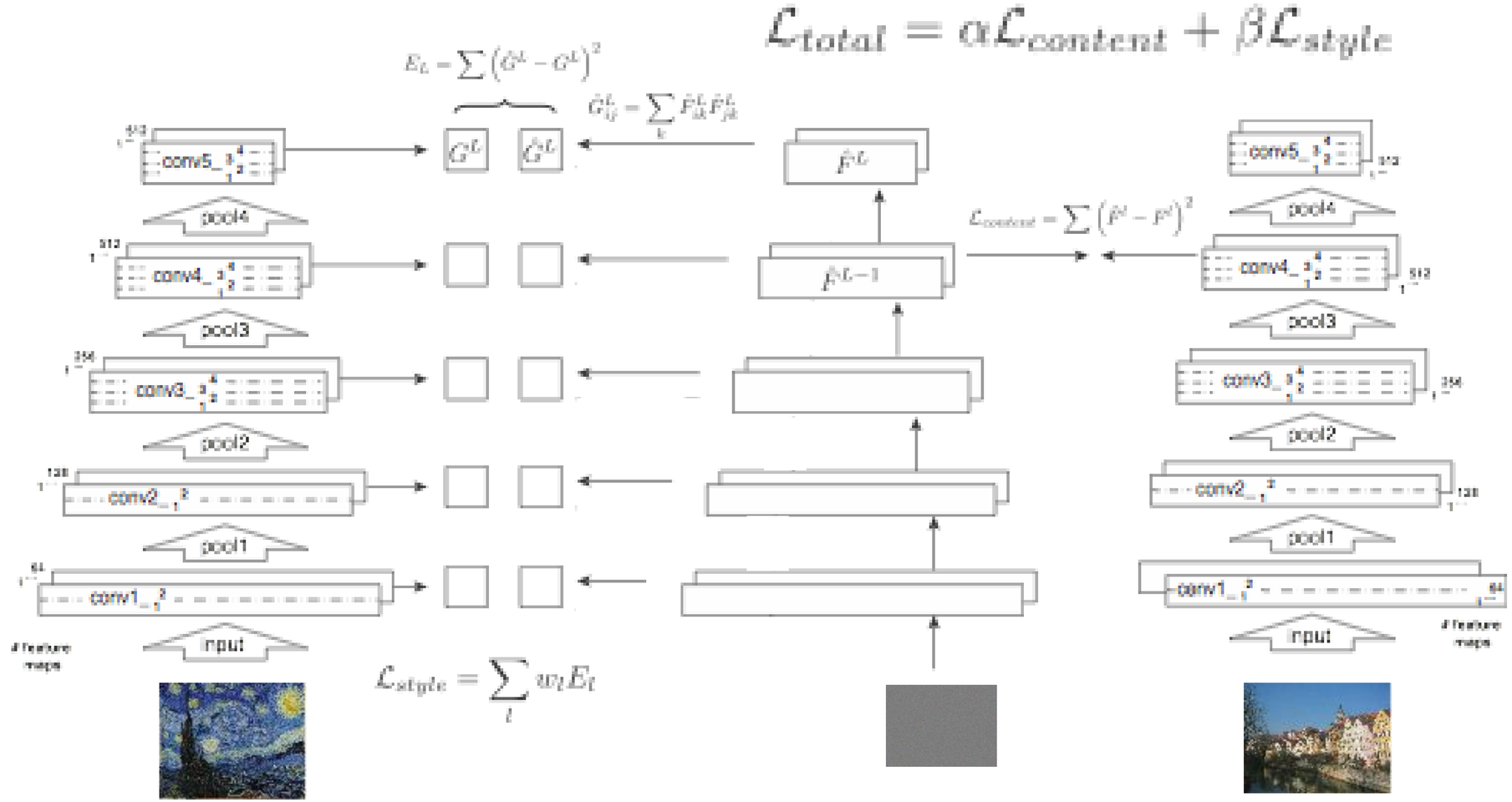
Artistic Style Transfer



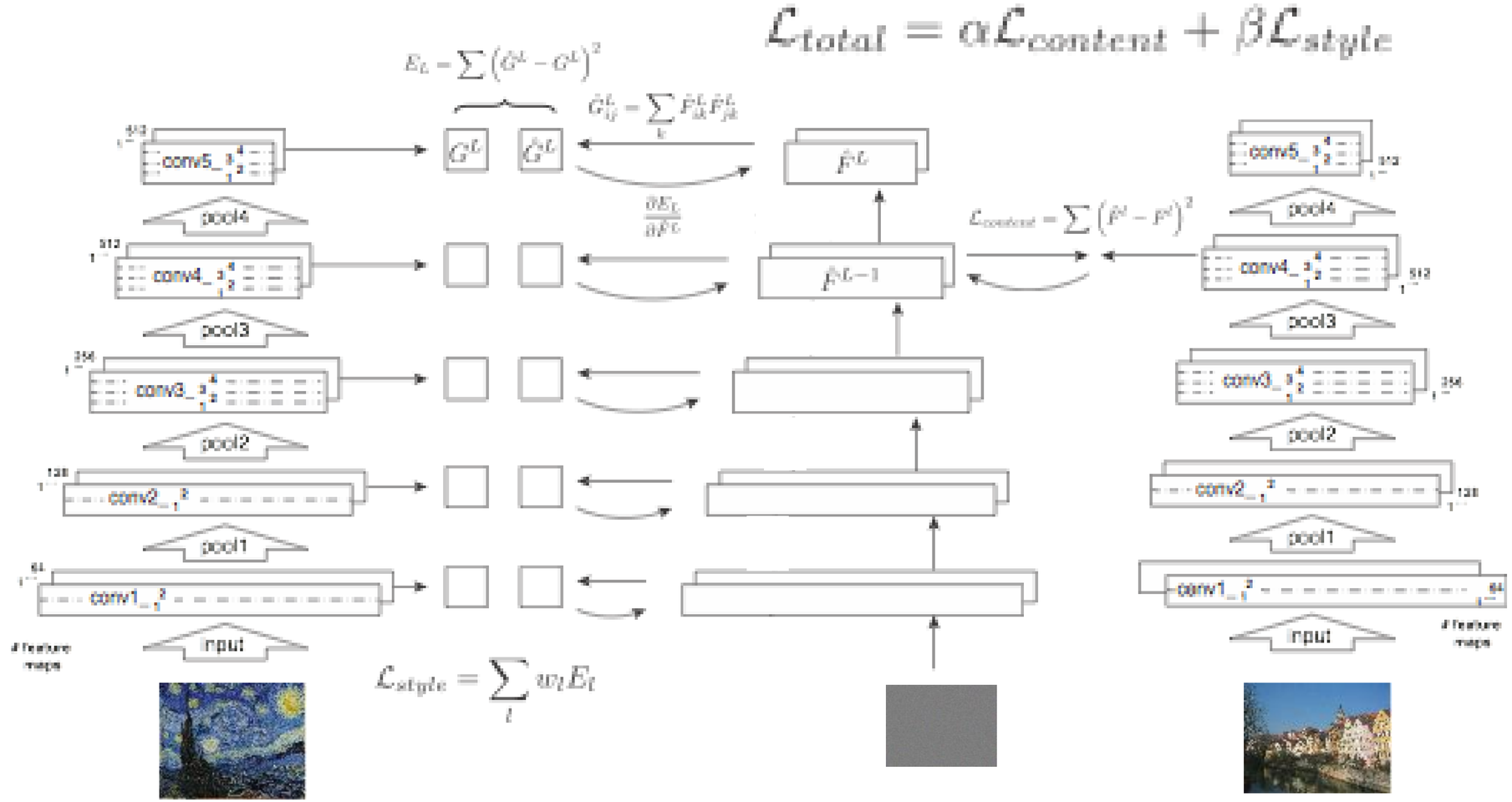
Artistic Style Transfer



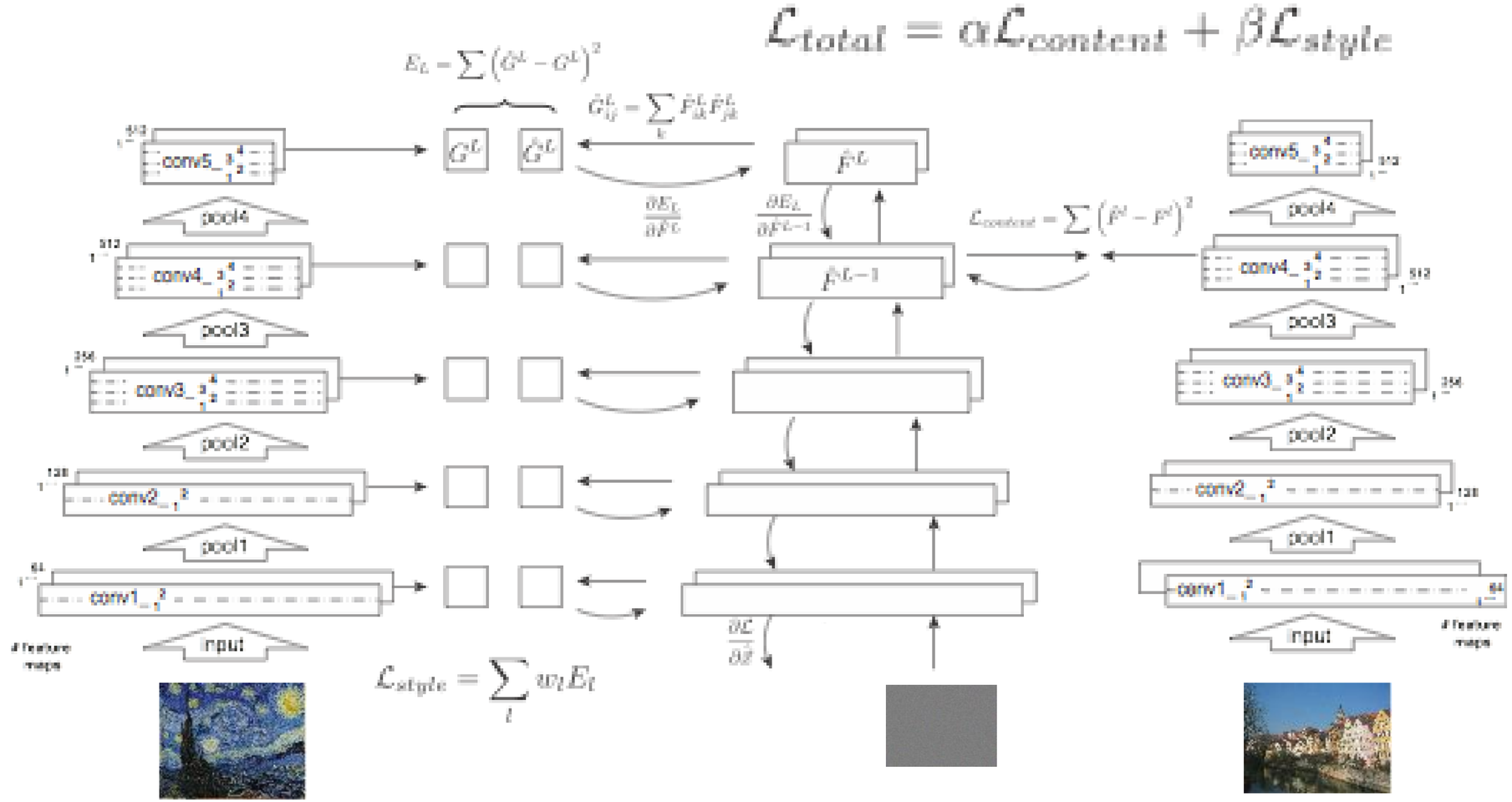
Artistic Style Transfer



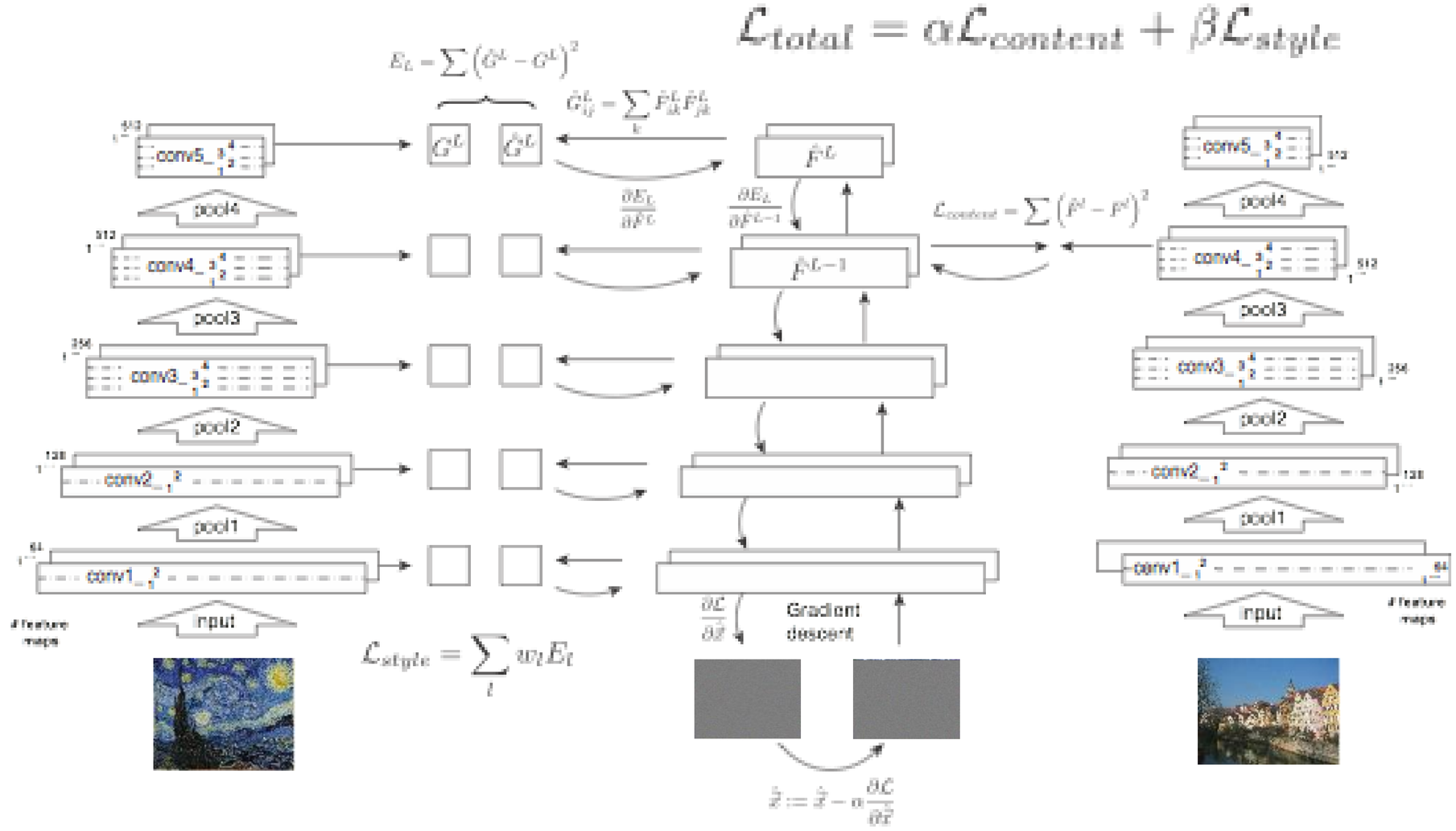
Artistic Style Transfer



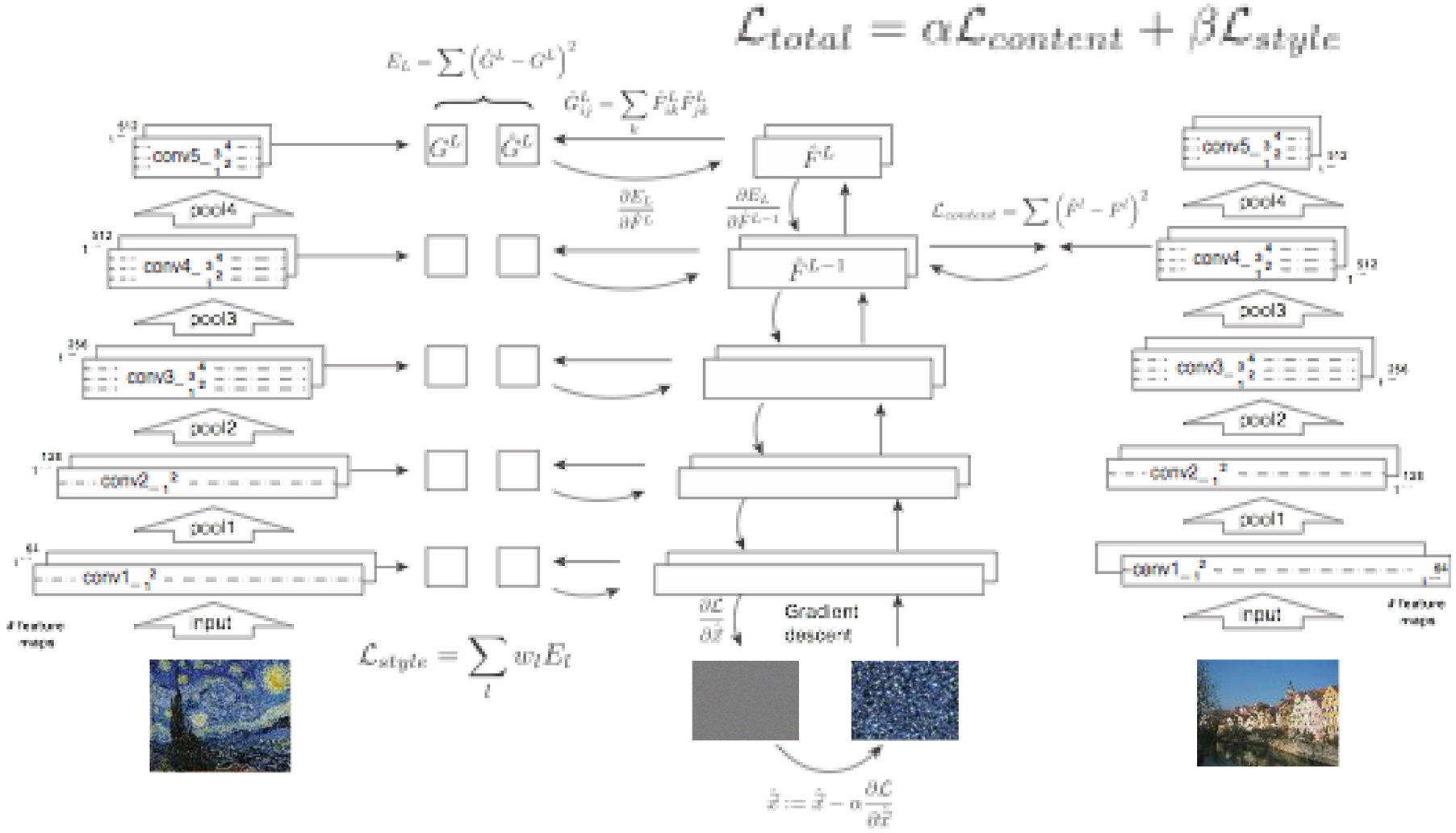
Artistic Style Transfer



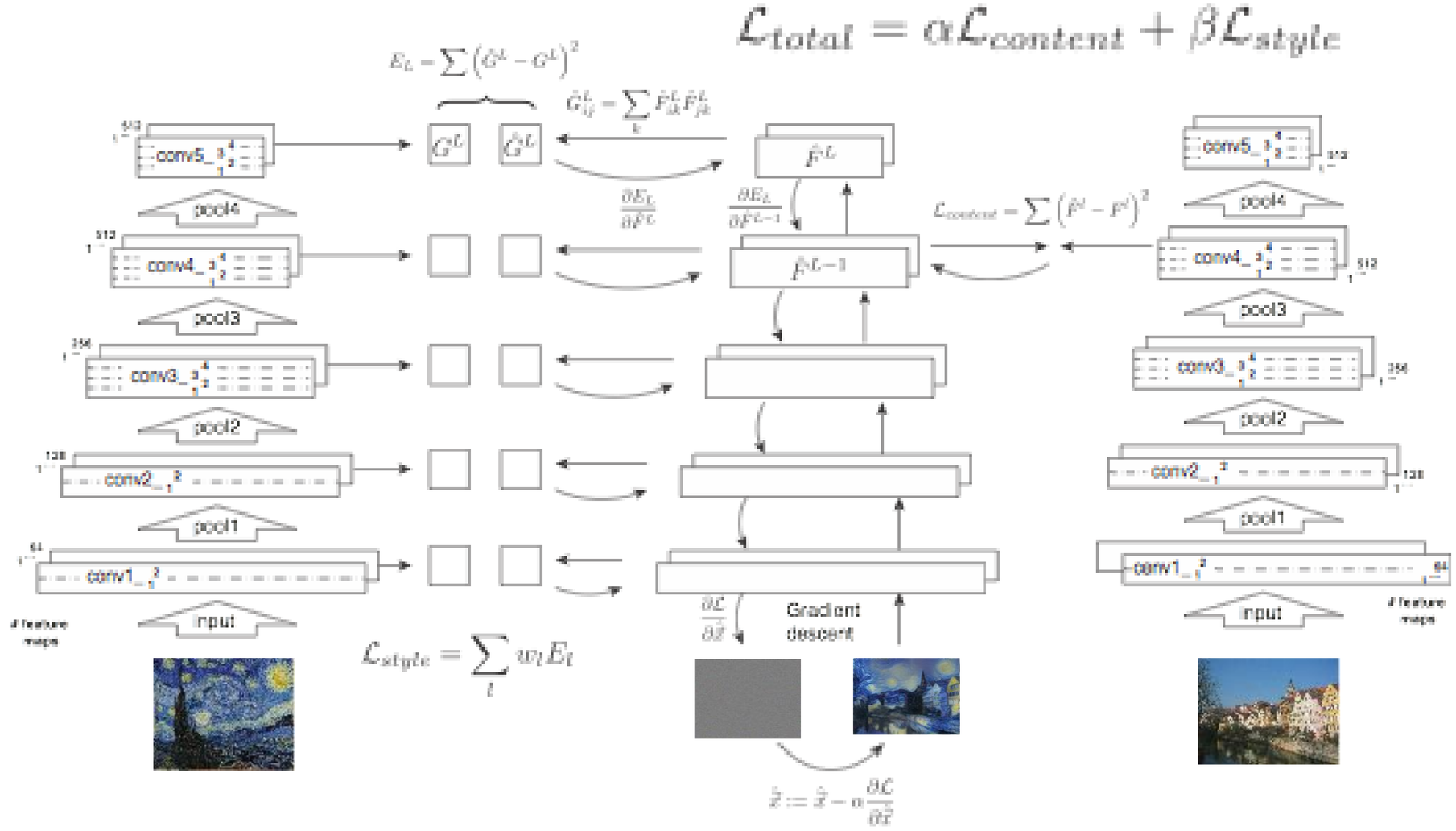
Artistic Style Transfer



Artistic Style Transfer



Artistic Style Transfer



Relative Weighting of Content and Style

1e-4

1e-3

1e-2

1e-1

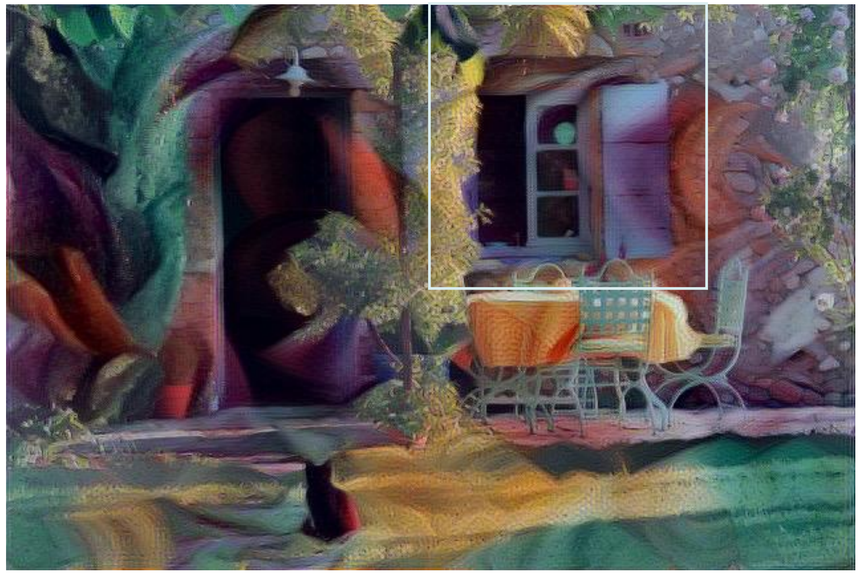
Different Reconstruction Layers

Conv2_2

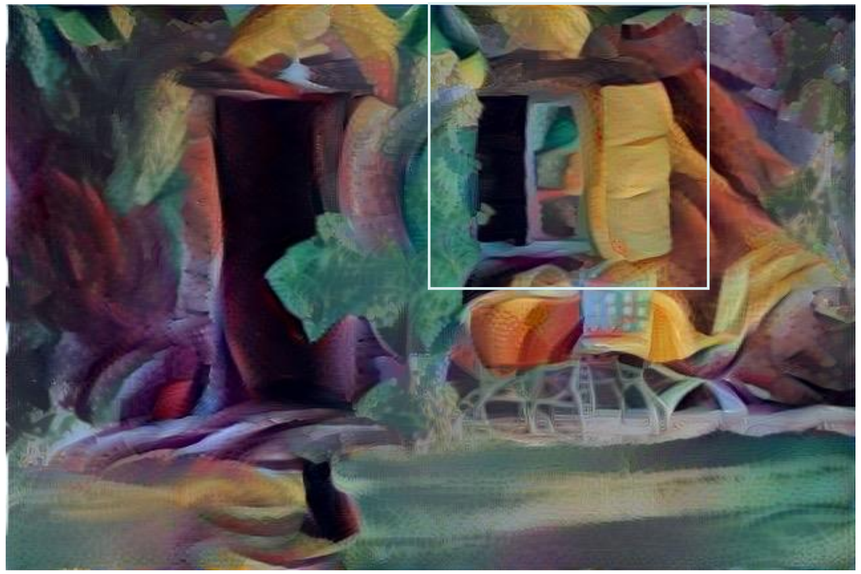
Conv4_2

Different Reconstruction Layers

Conv2_2



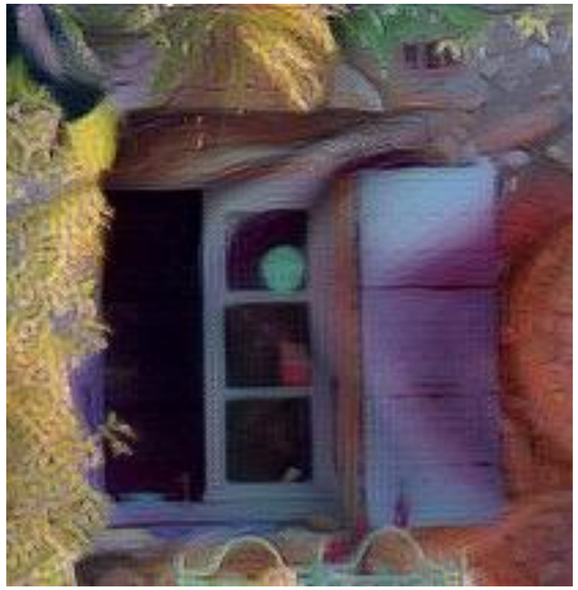
Conv4_2



Different Reconstruction Layers

Original

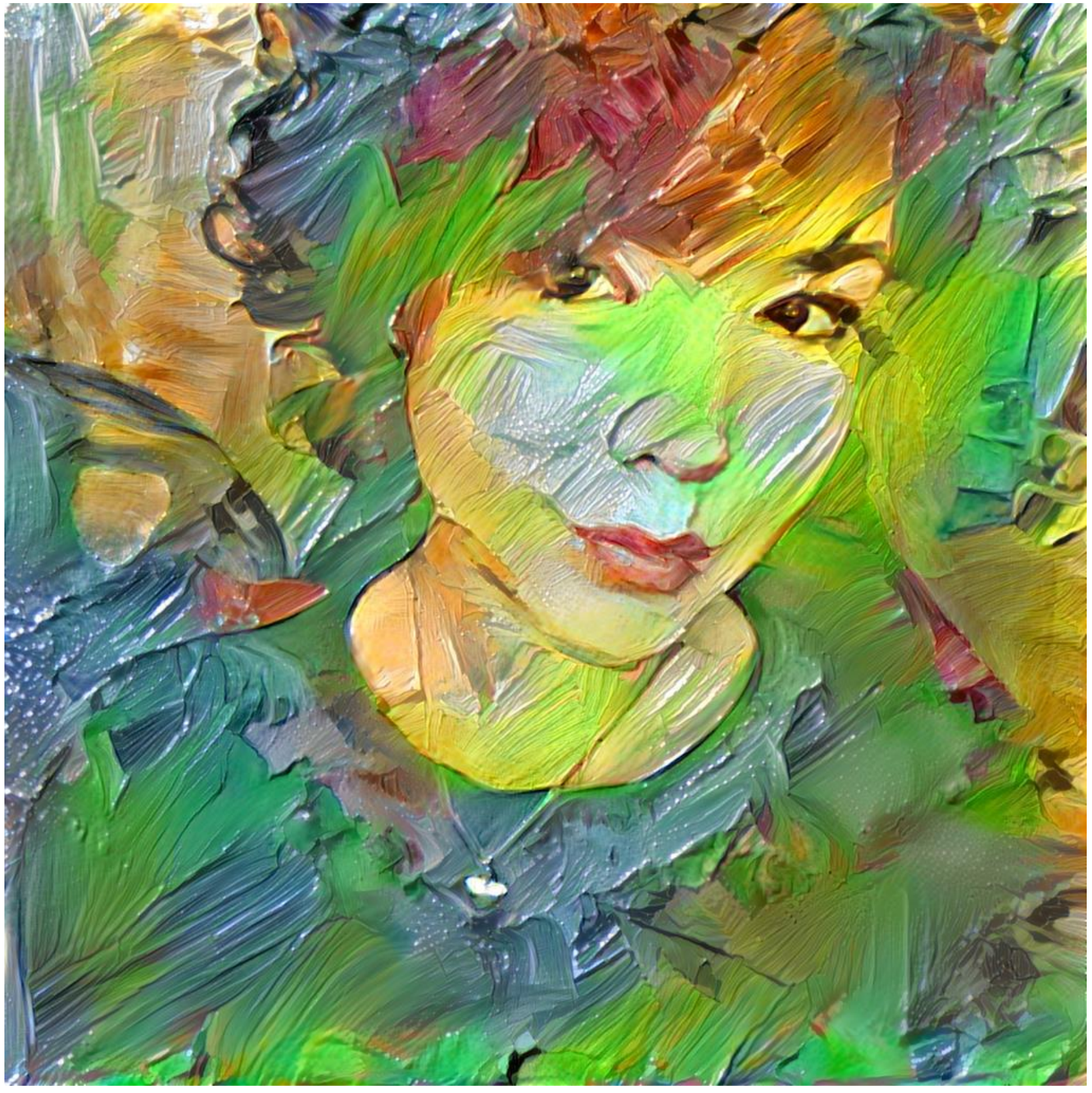
Conv2_2



Conv4_2

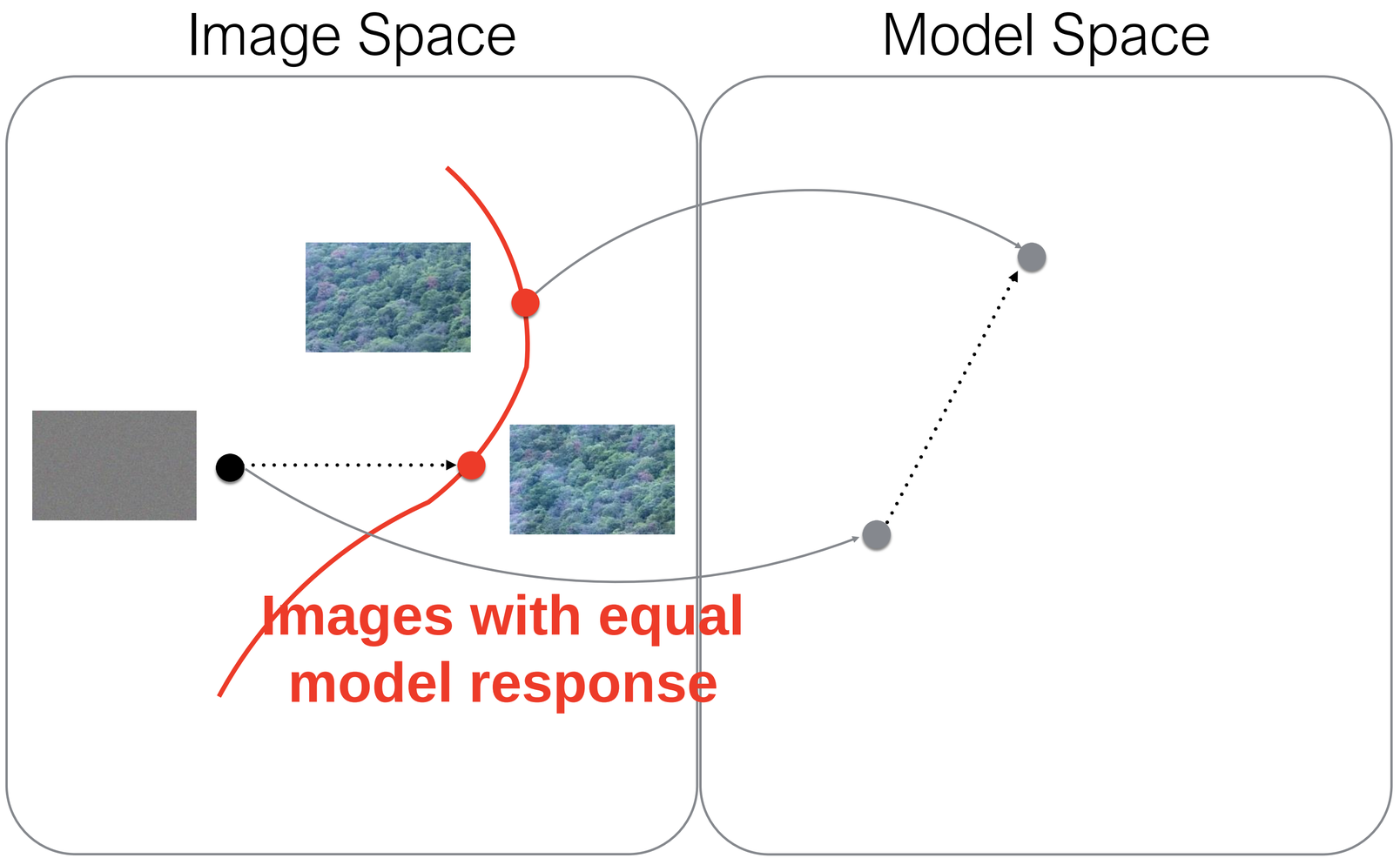
General Style Transfer

General Style Transfer




© Wayne Tilcock

Projecting onto the “Image Manifold”



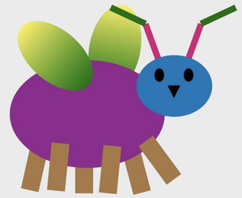
Portilla & Simoncelli (2000)

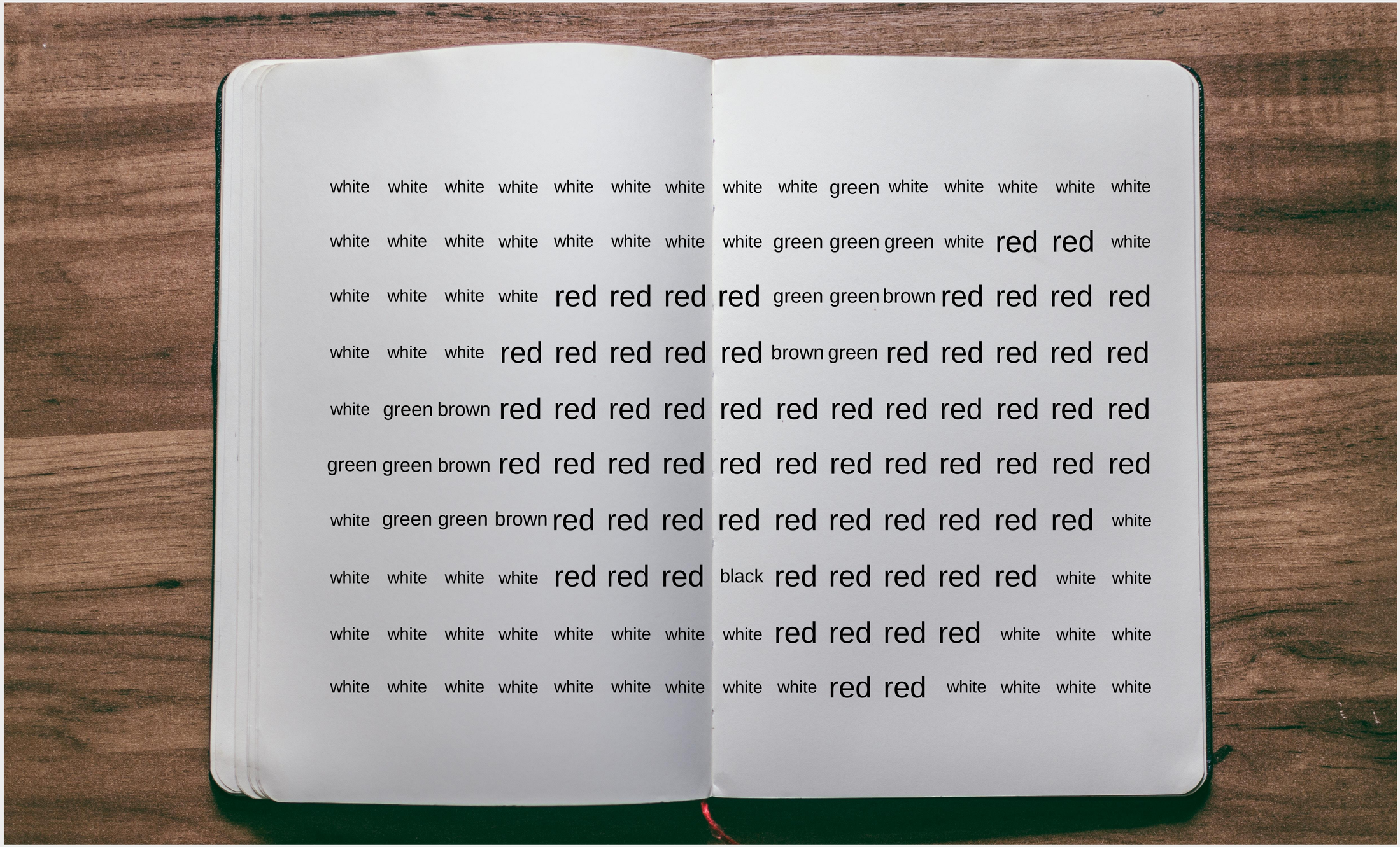
Imagen

DALL-E 2

diffusion

By Steve Seitz




white white white white white white white white white green white white white white white
white white white white white white white white green green green white red red white
white white white white red red red red green green brown red red red red
white white white red red red red red brown green red red red red red
white green brown red red red red red red red red red red red red
green green brown red red red red red red red red red red red red
white green green brown red red red red red red red red red red white
white white white white red red red black red red red red red white white
white white white white white white white white red red red red white white white
white white white white white white white white white red red white white white white

Language Generator

(+ pixels)

Parti

Image Generator

(+ language)

Imagen

slide from Steve Seitz's video

Generate 100 images

slide from Steve Seitz's video

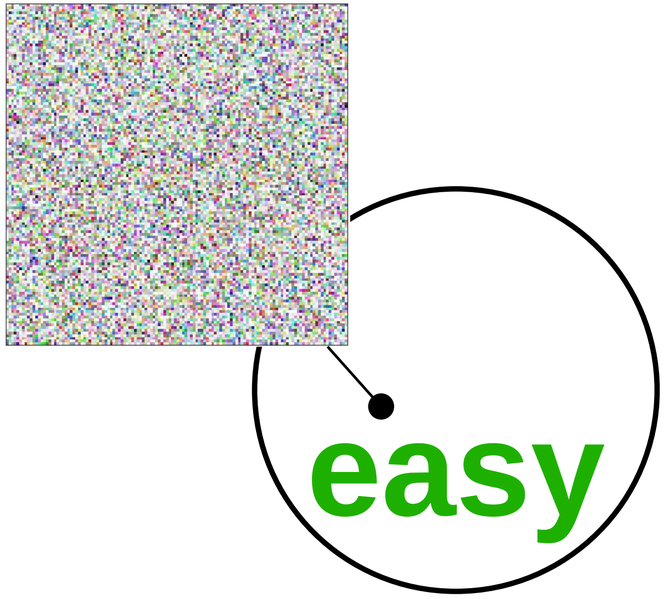
Generate 100 images

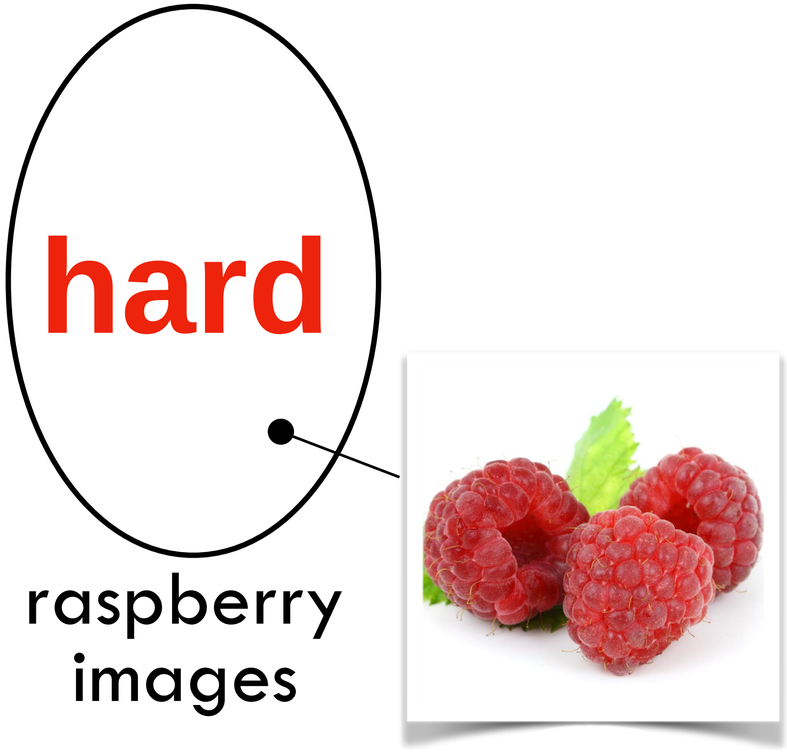
slide from Steve Seitz's video

slide from Steve Seitz’s video

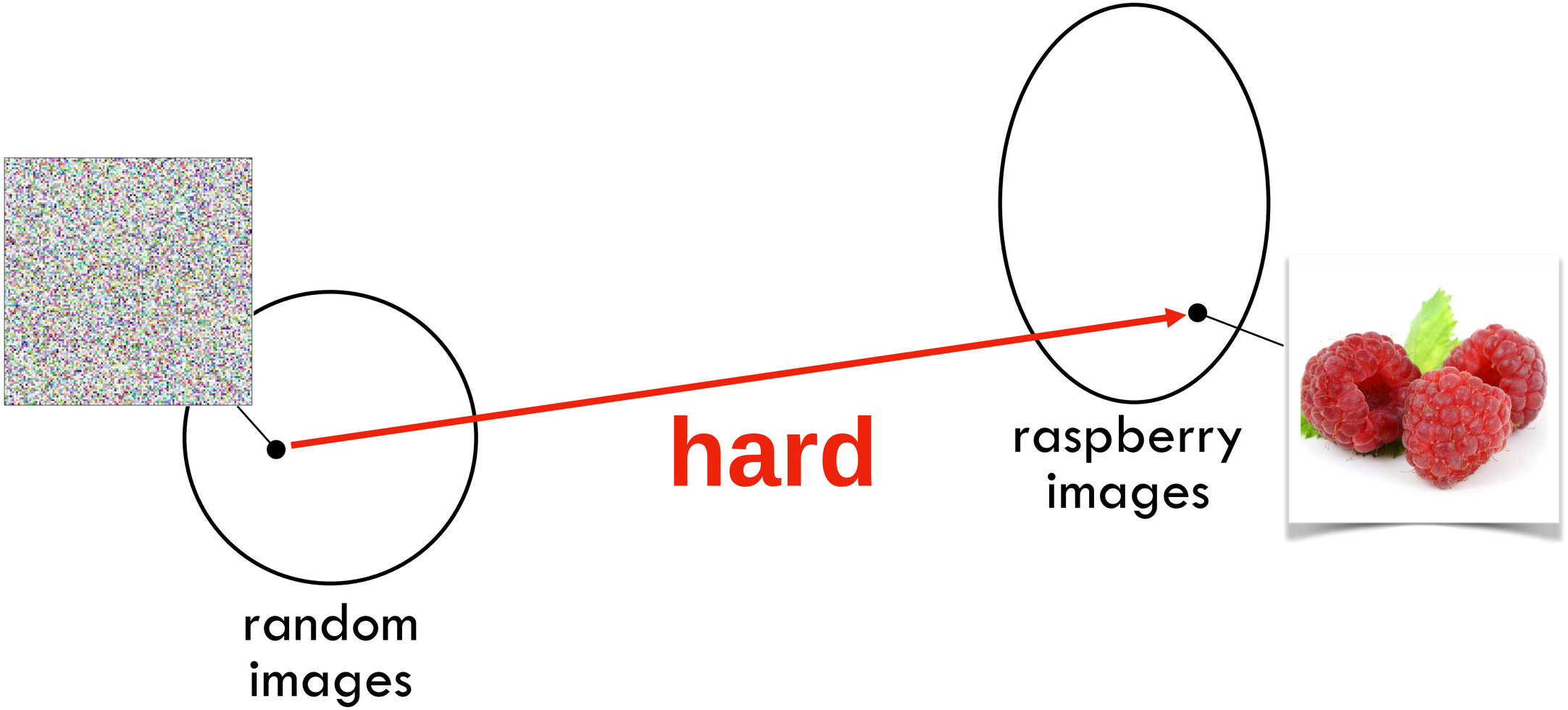
Generate 100 images of raspberries

slide from Steve Seitz's video

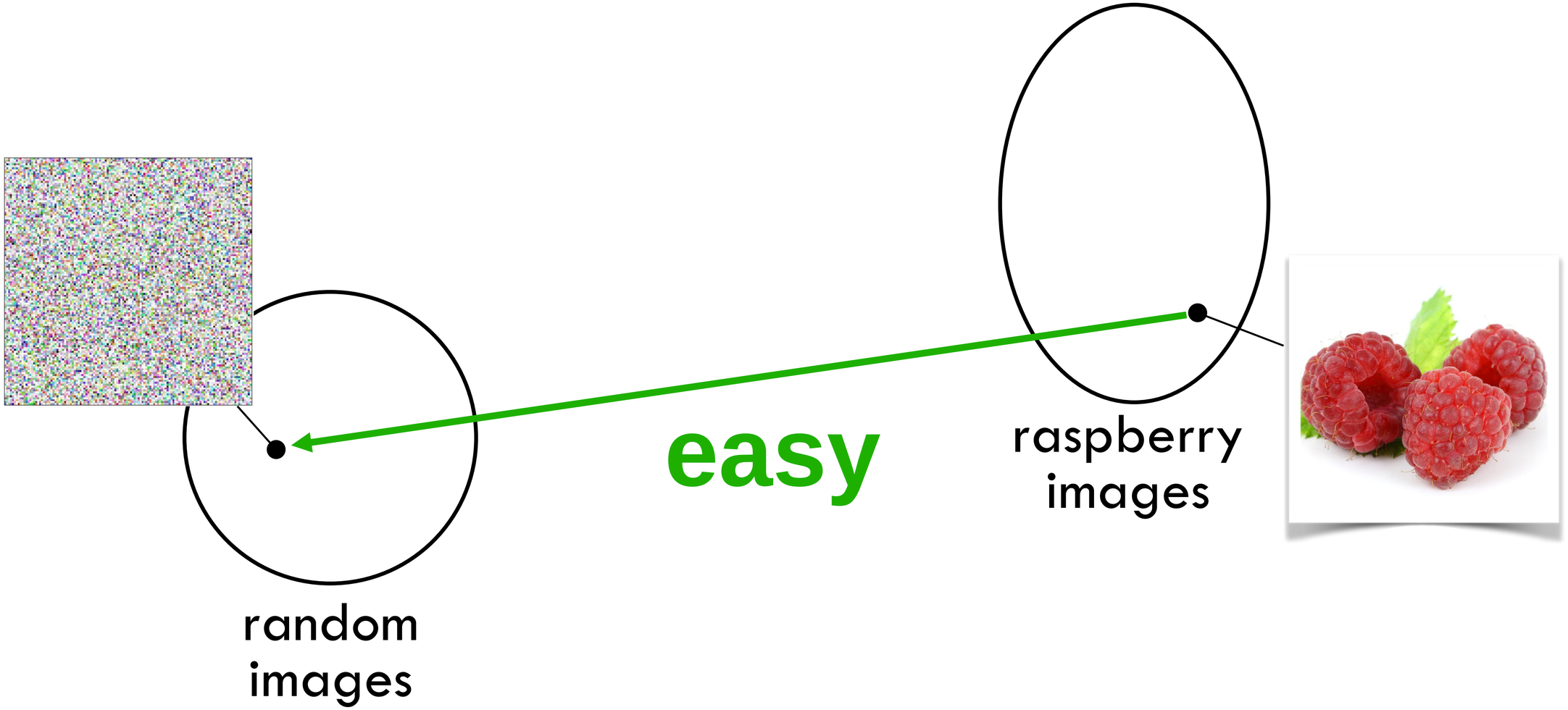




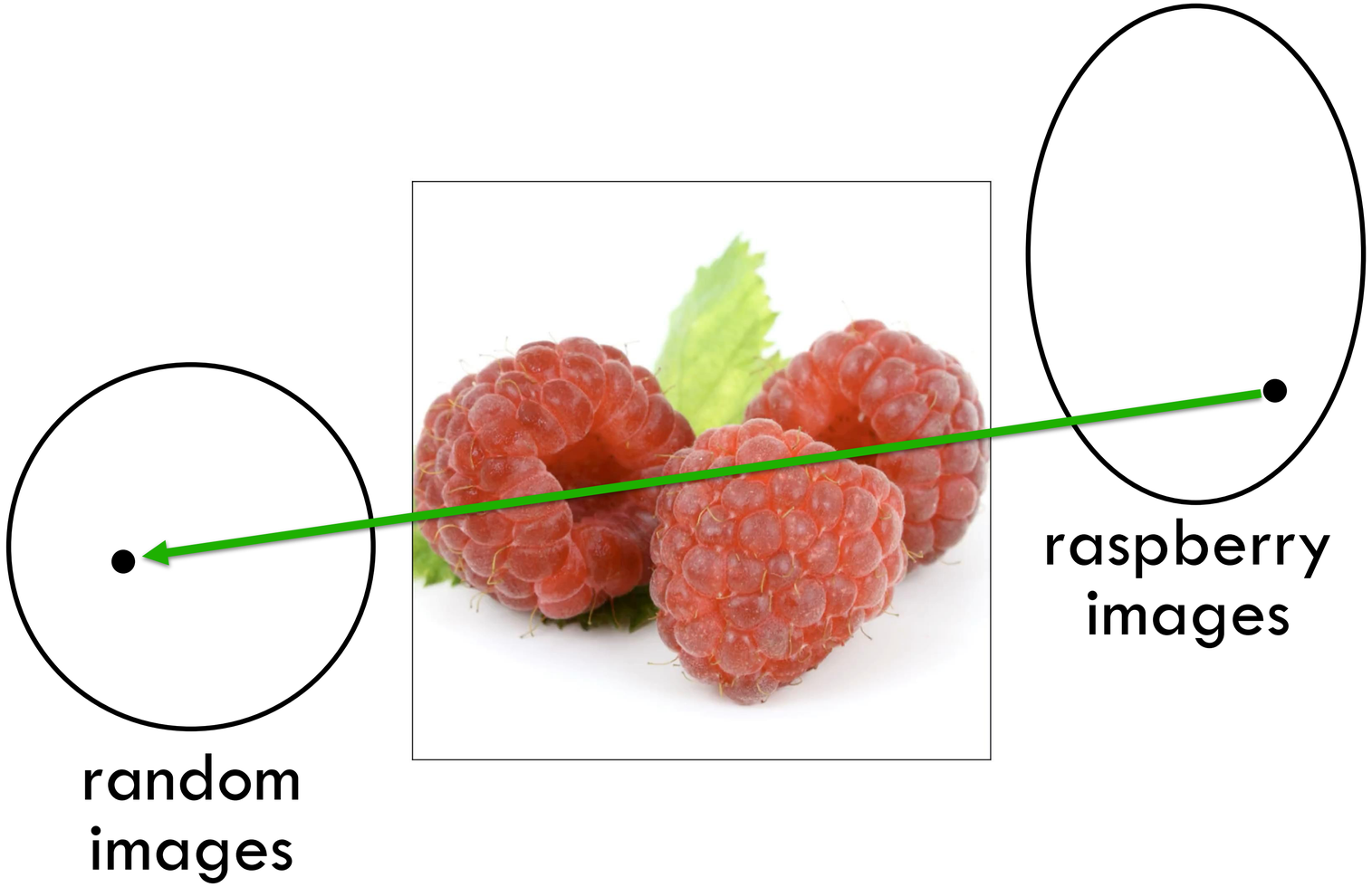
slide from Steve Seitz's video



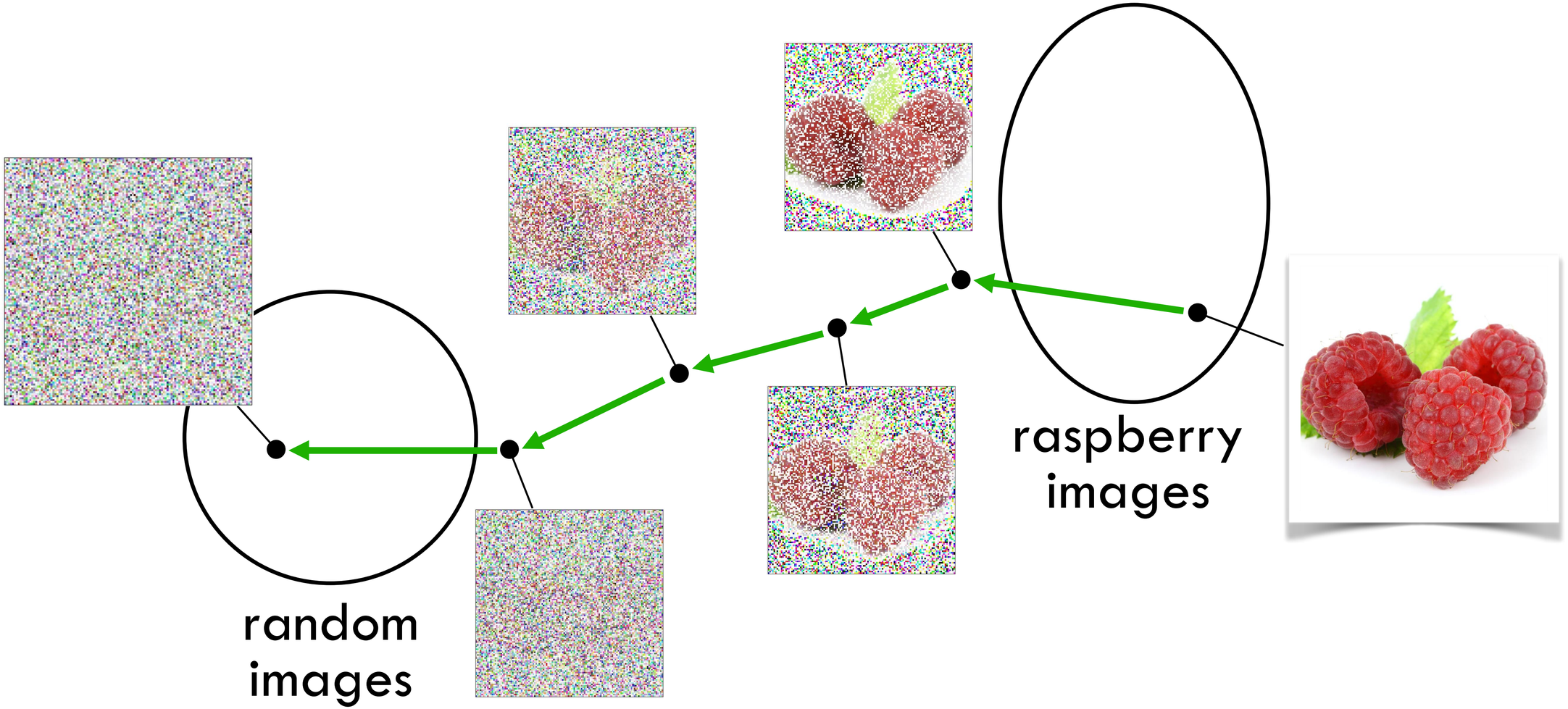
slide from Steve Seitz's video



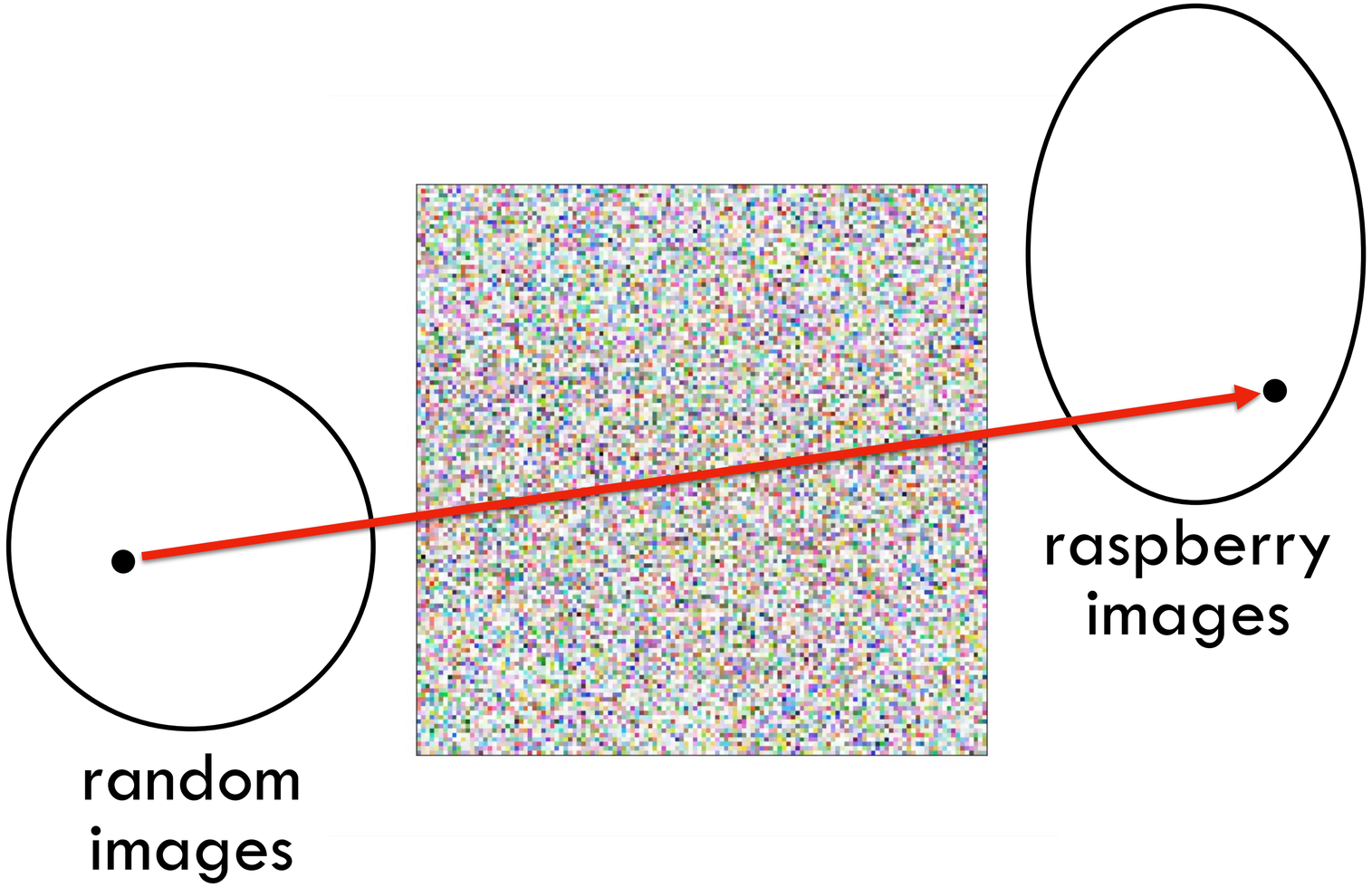
slide from Steve Seitz's video



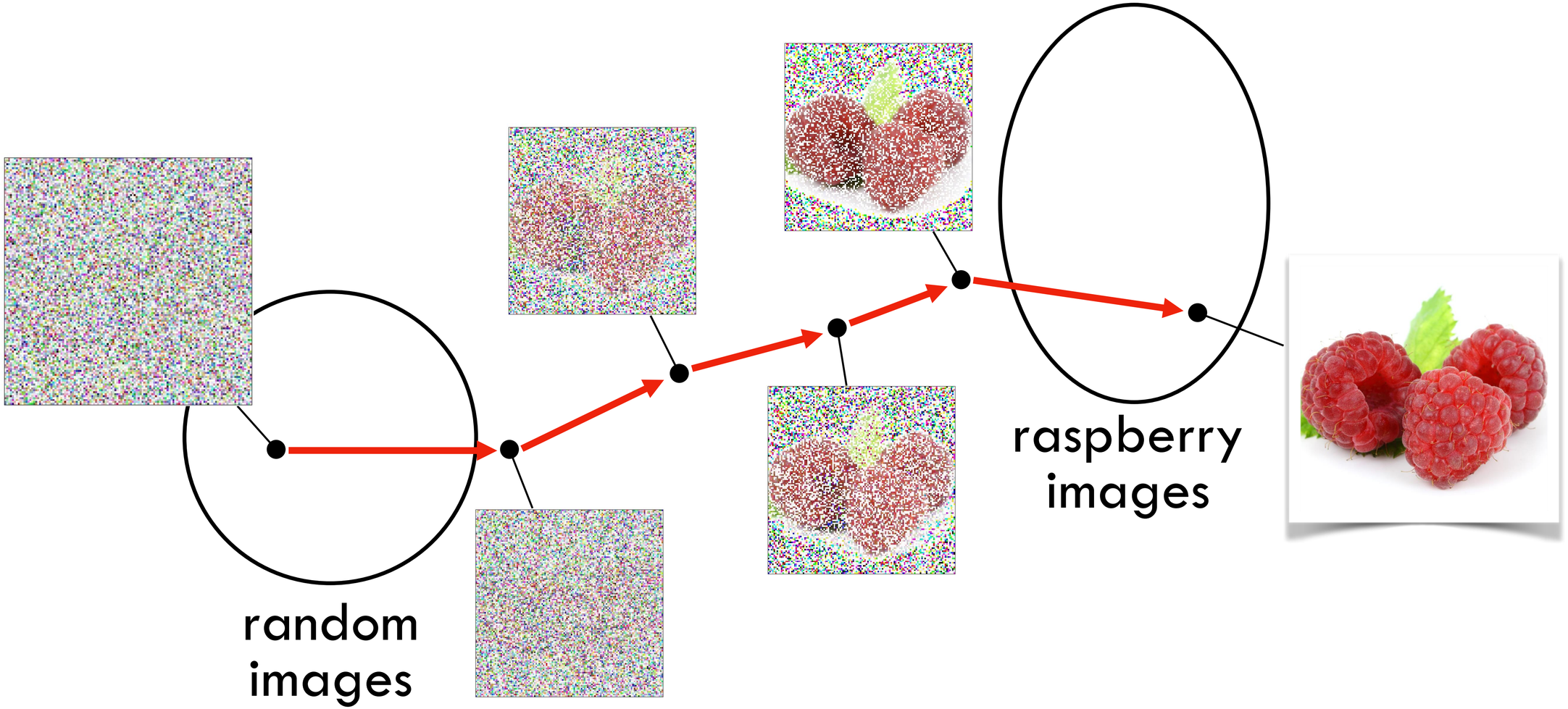
slide from Steve Seitz's video



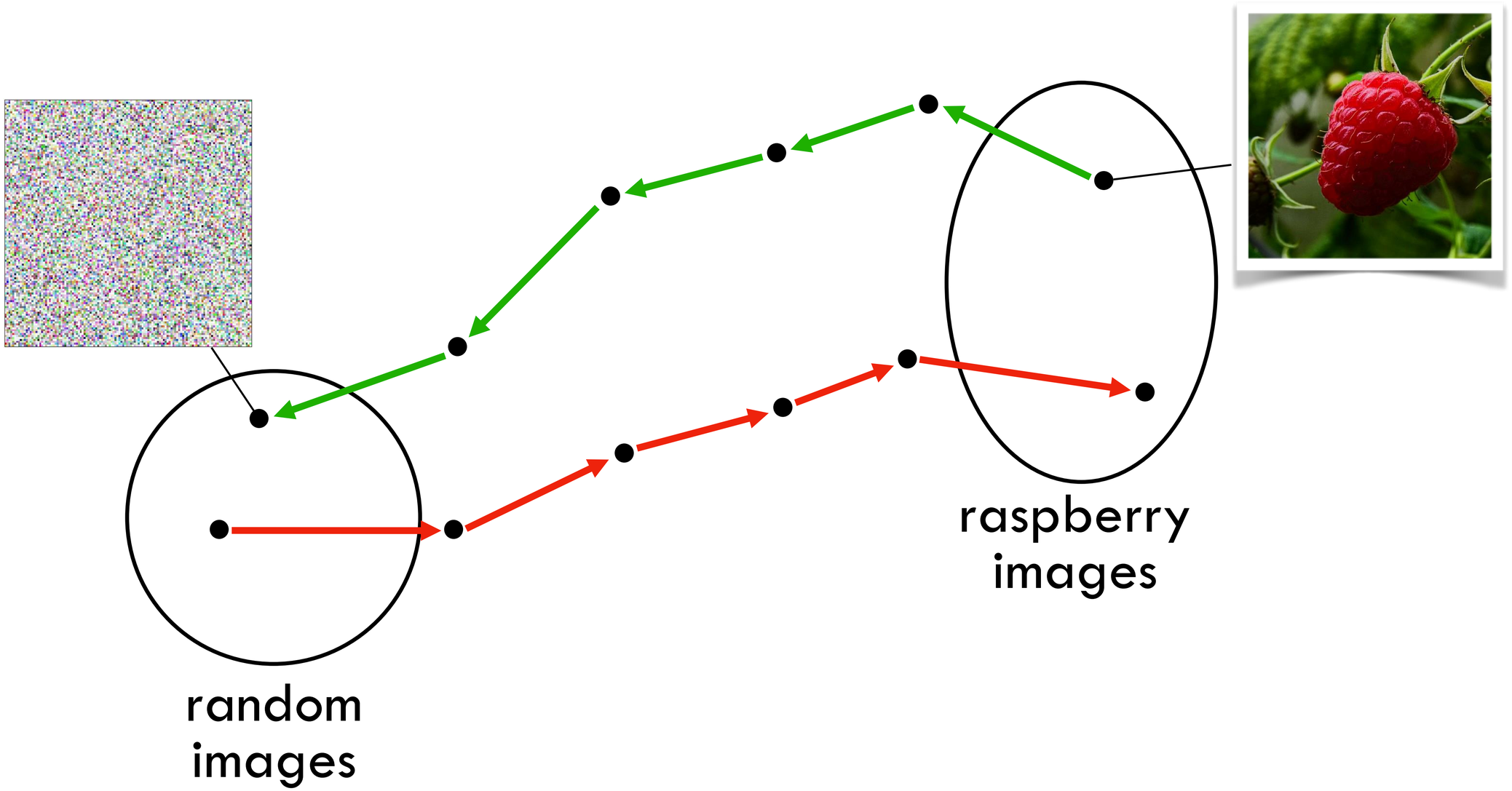
slide from Steve Seitz's video



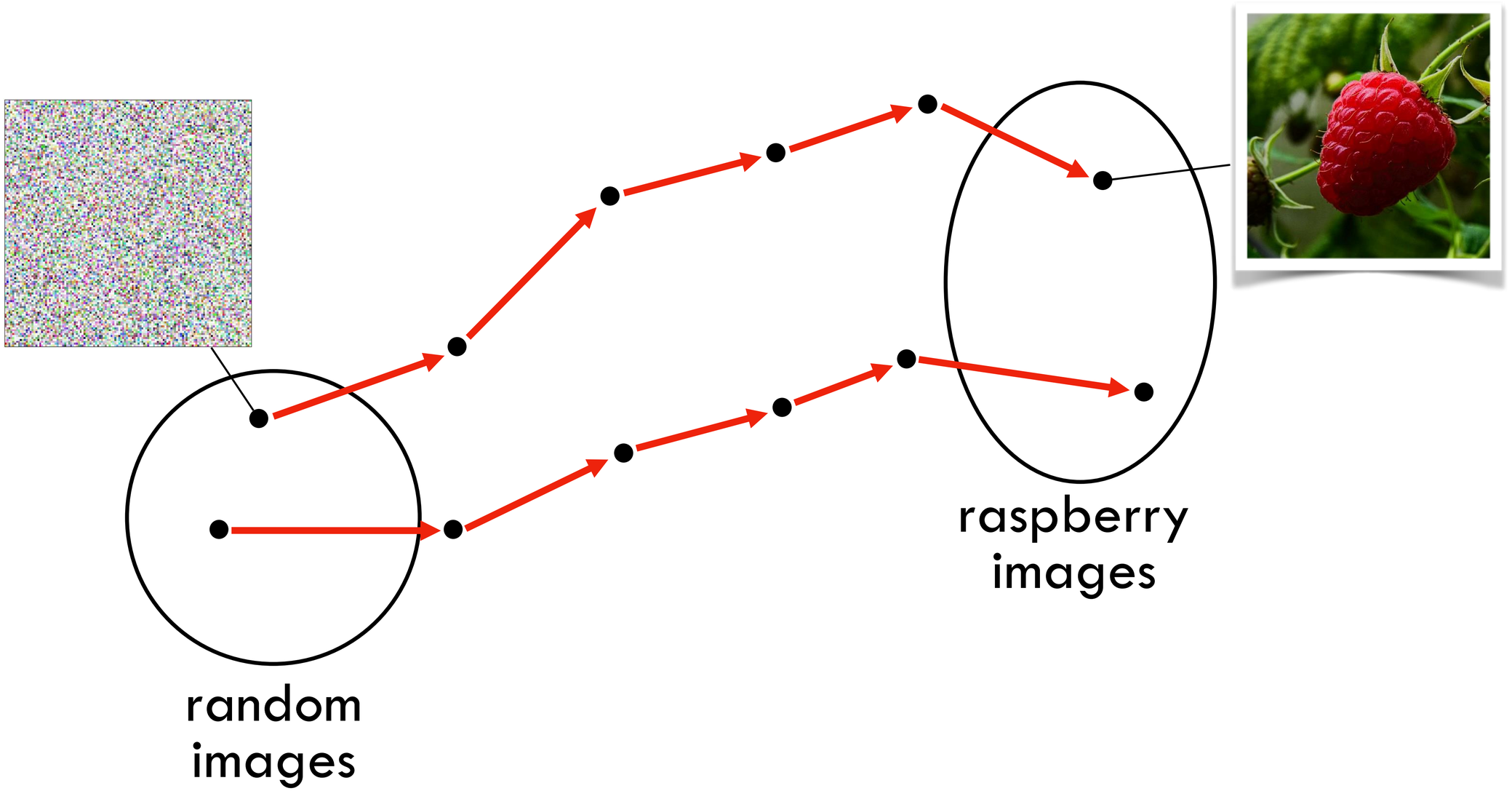
slide from Steve Seitz's video



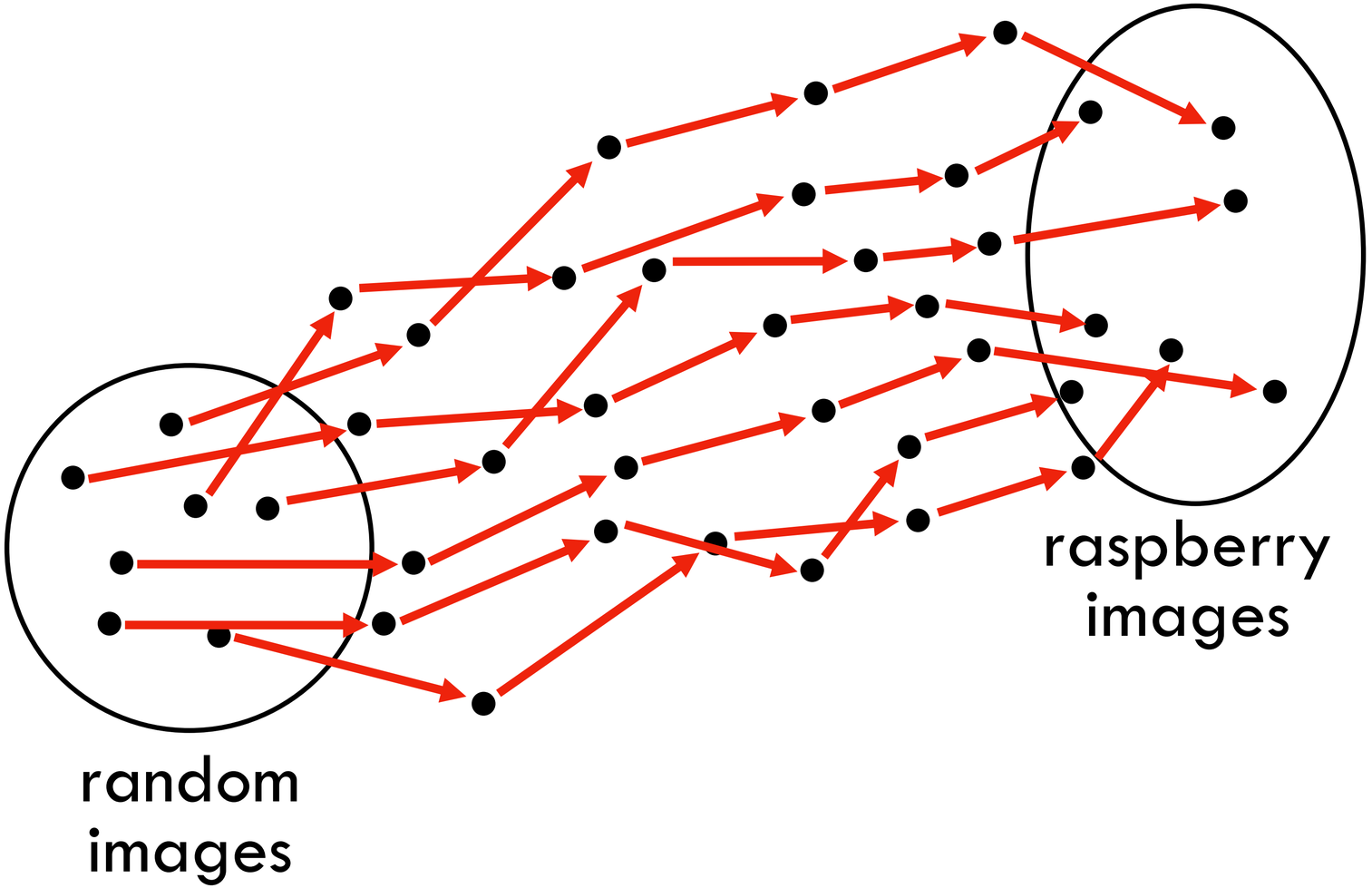
slide from Steve Seitz's video



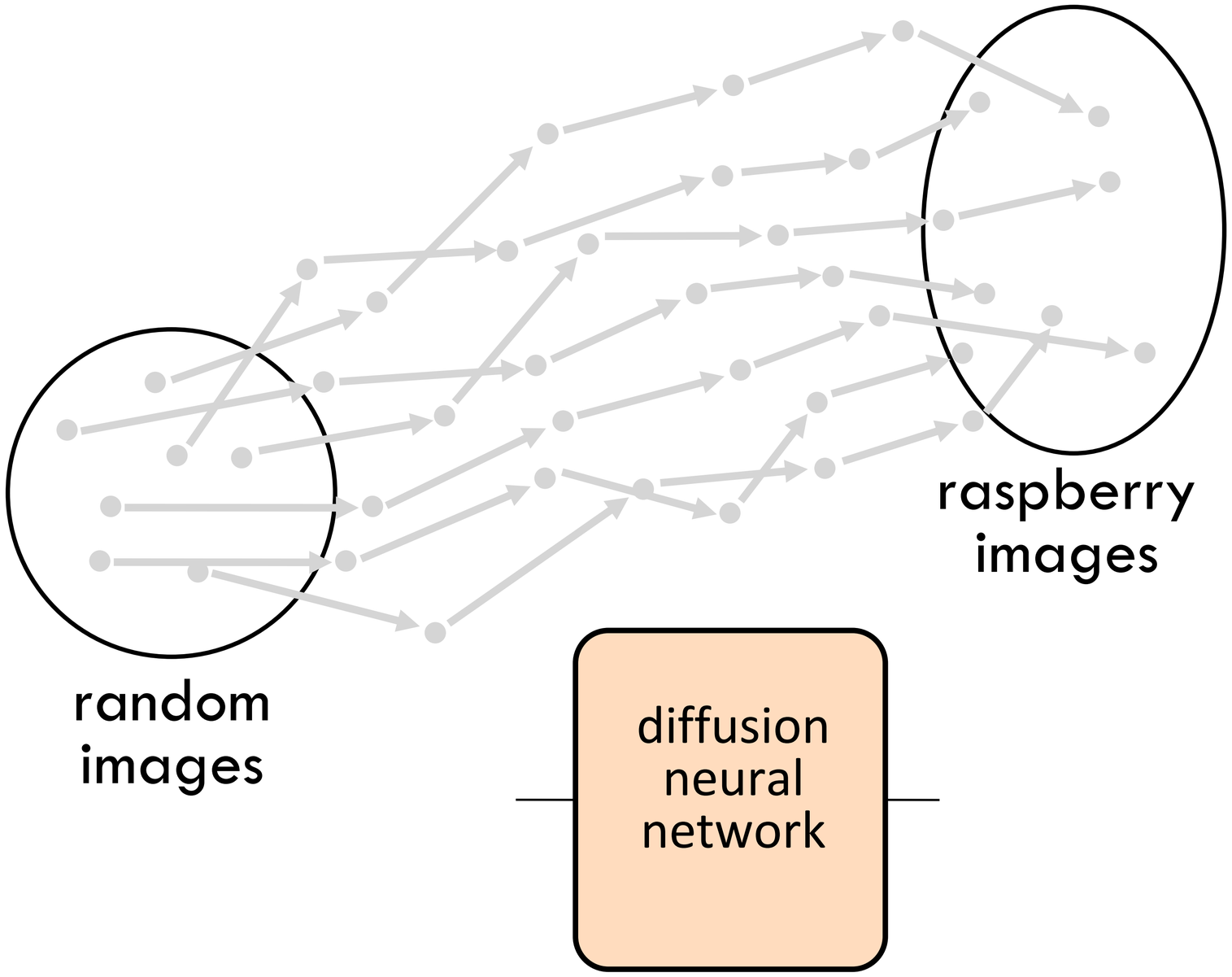
slide from Steve Seitz's video



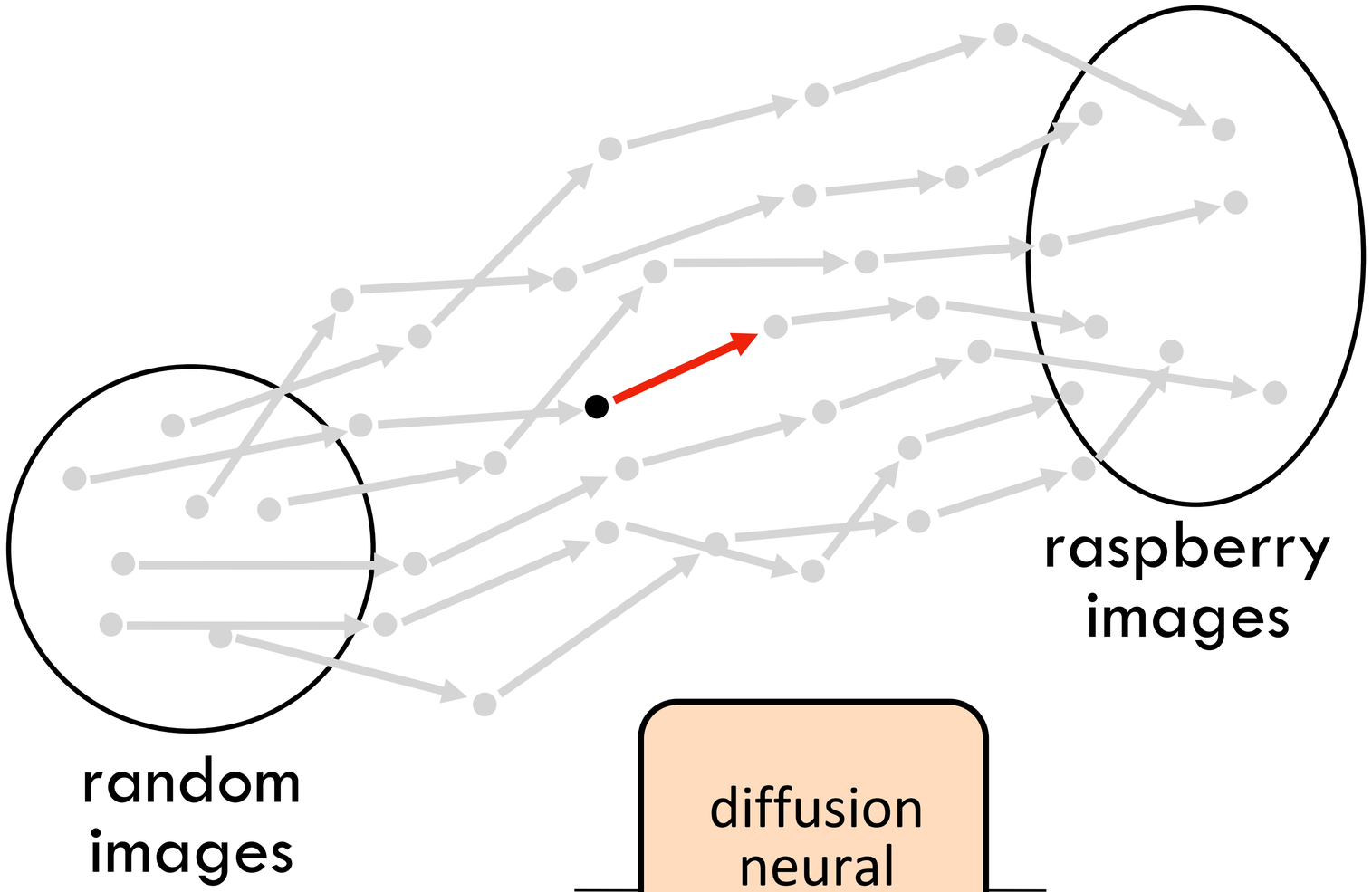
slide from Steve Seitz's video



slide from Steve Seitz's video

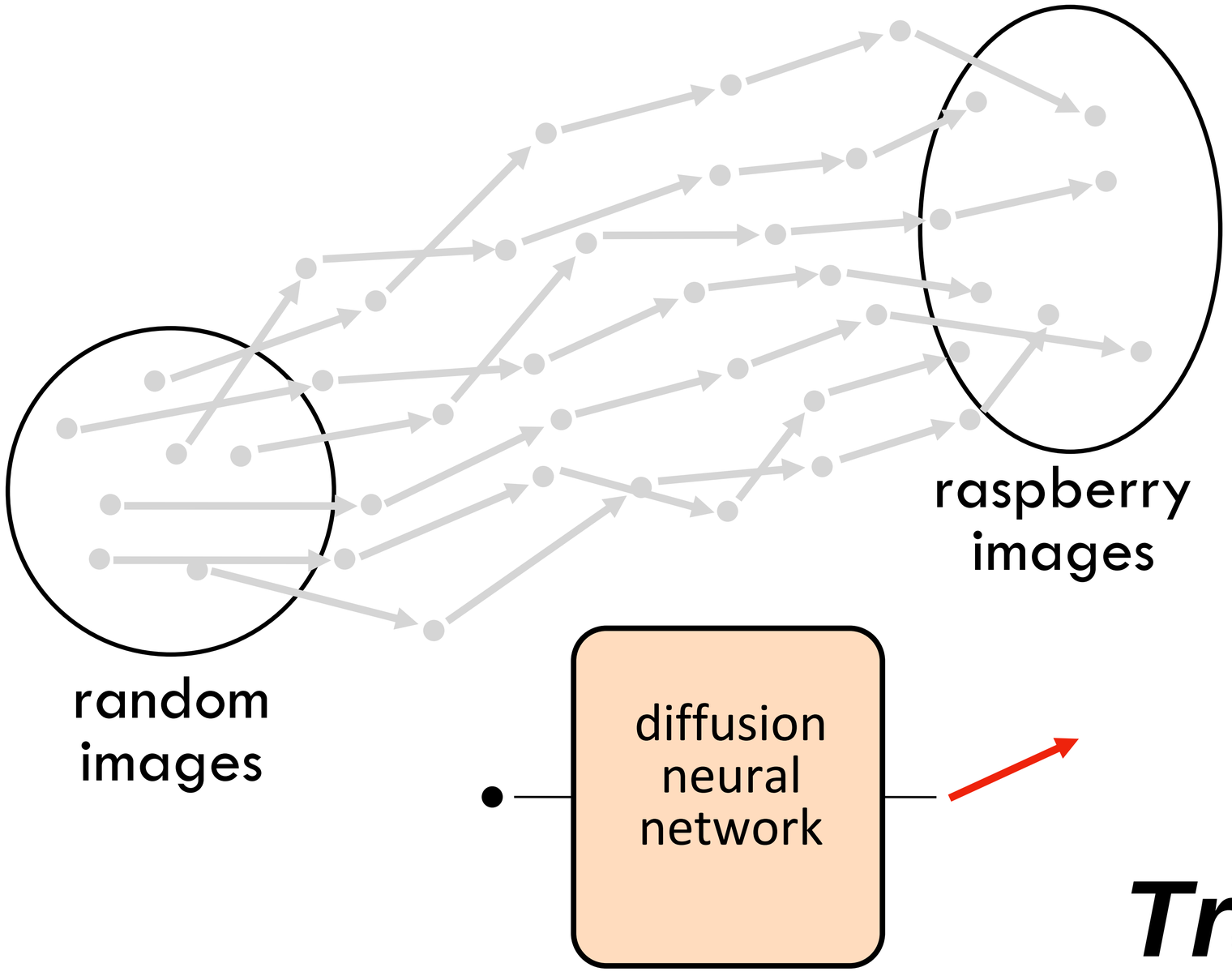


slide from Steve Seitz's video



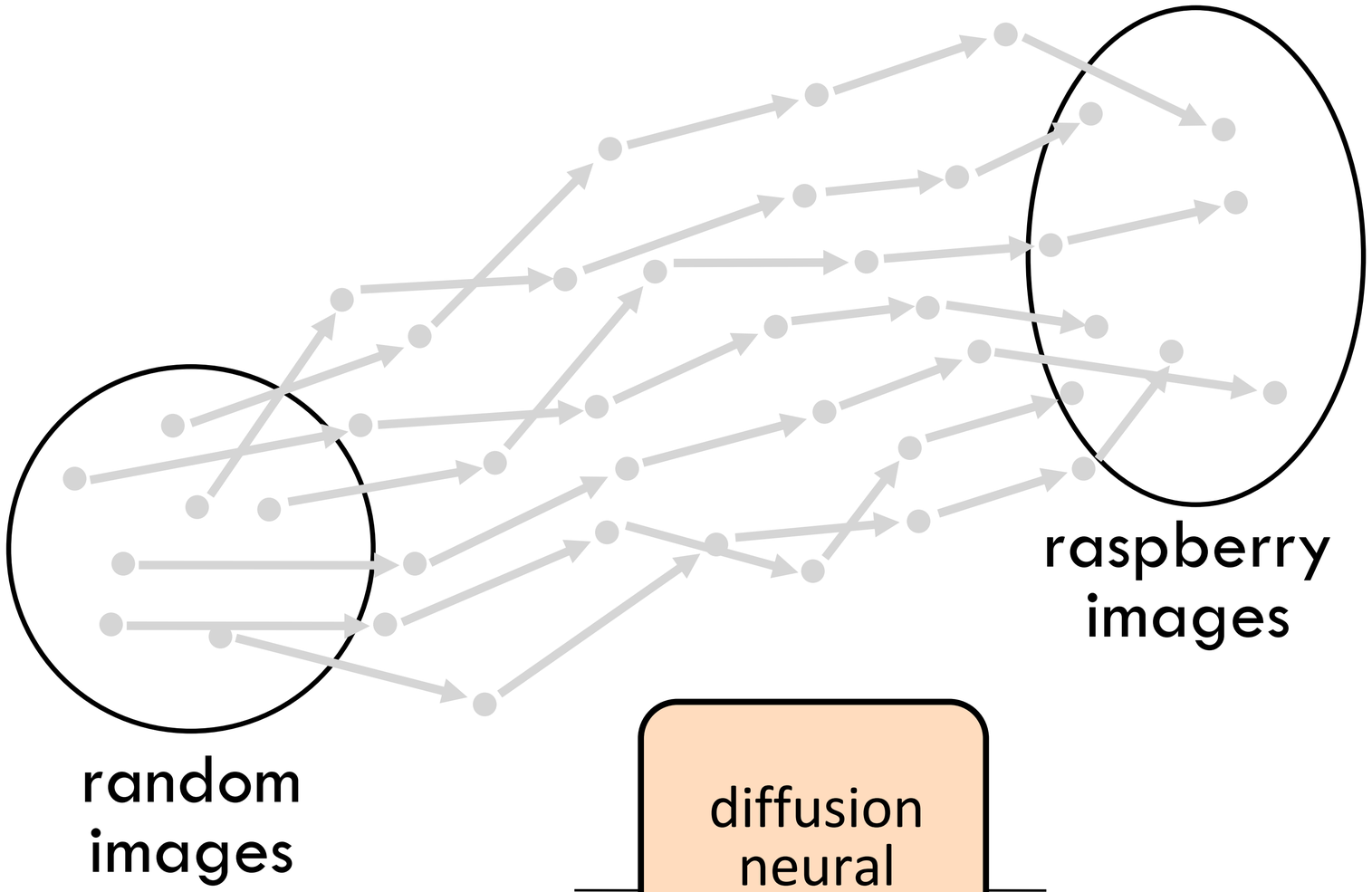
Training

slide from Steve Seitz's video



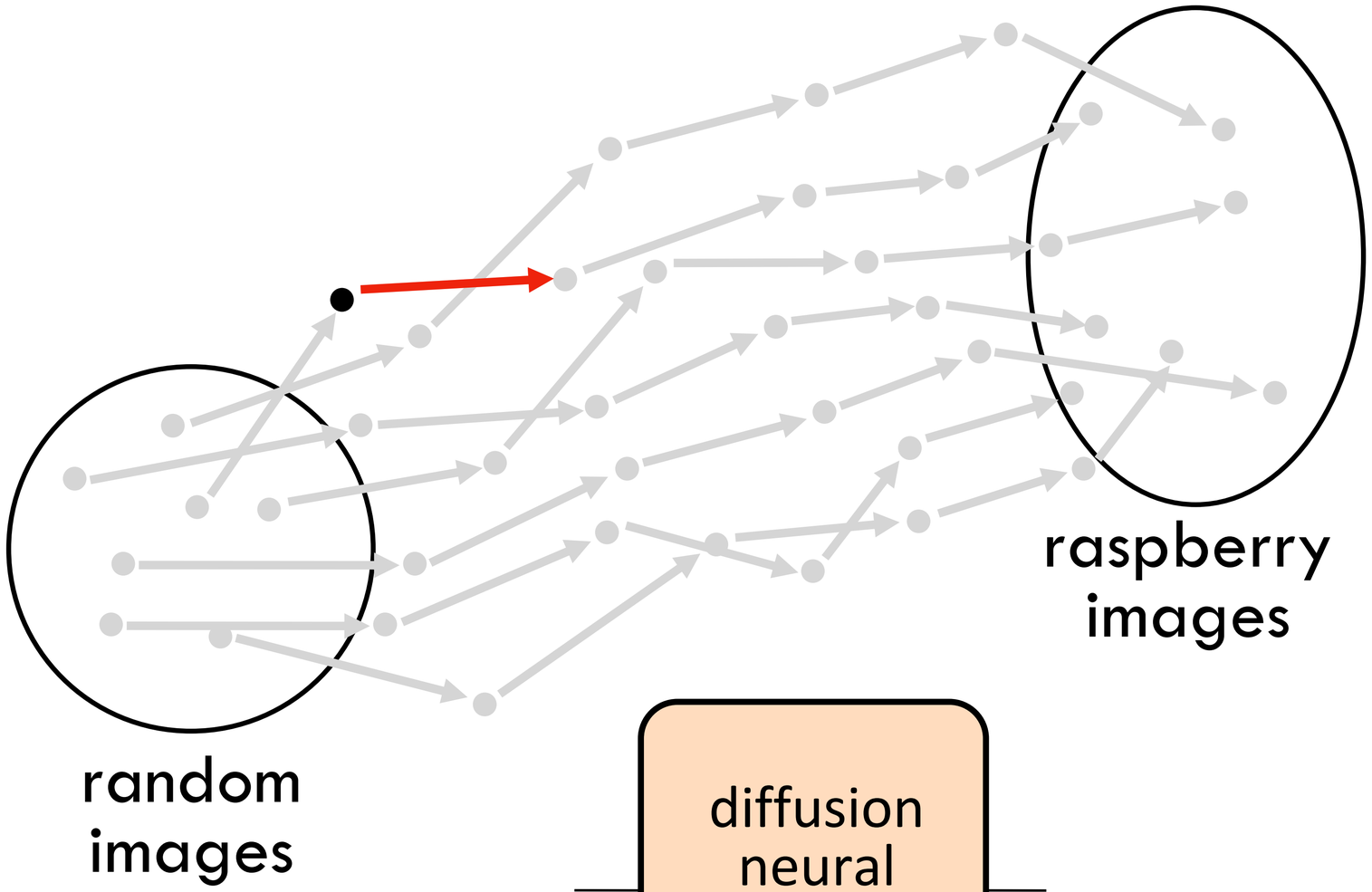
Training

slide from Steve Seitz's video



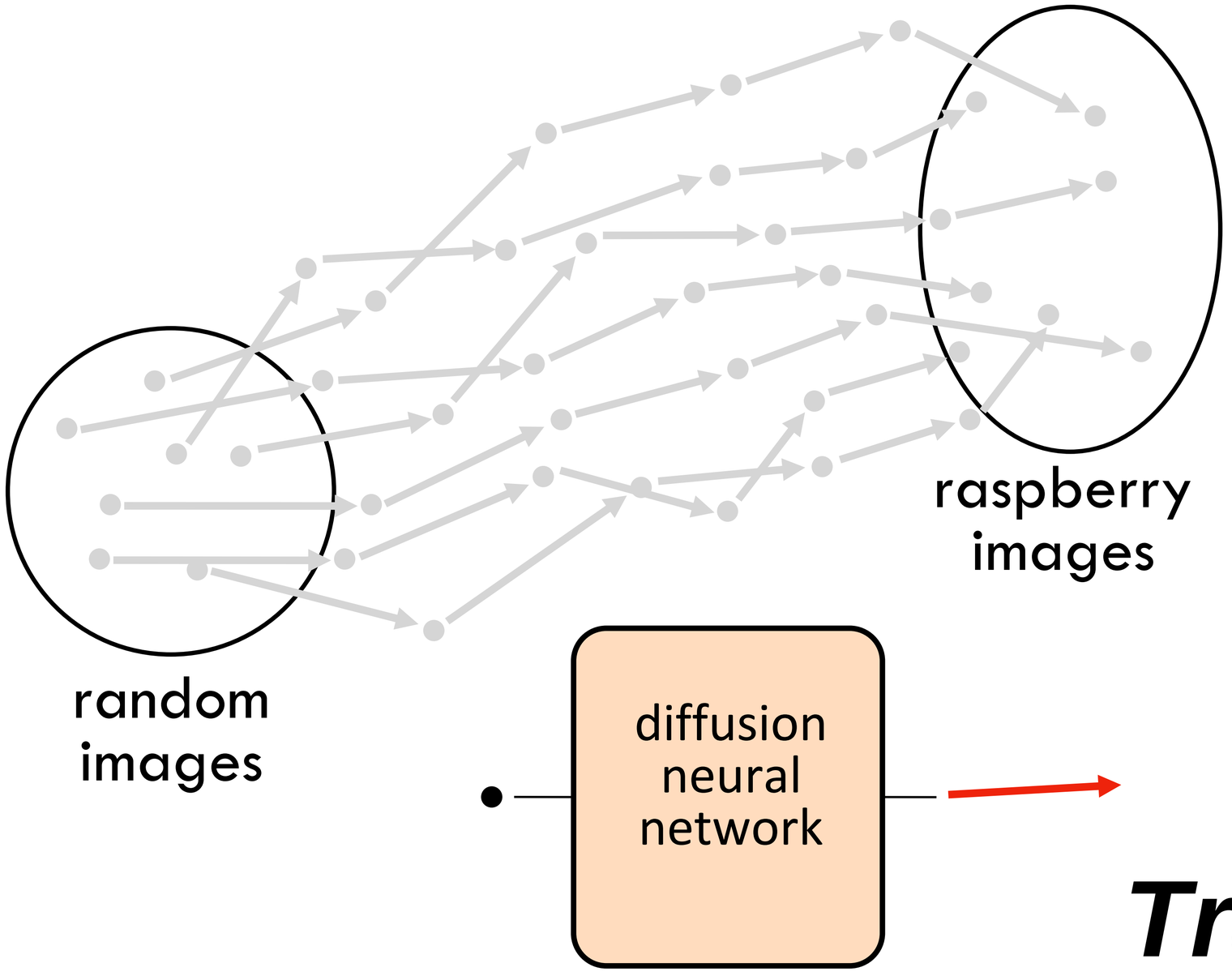
Training

slide from Steve Seitz's video



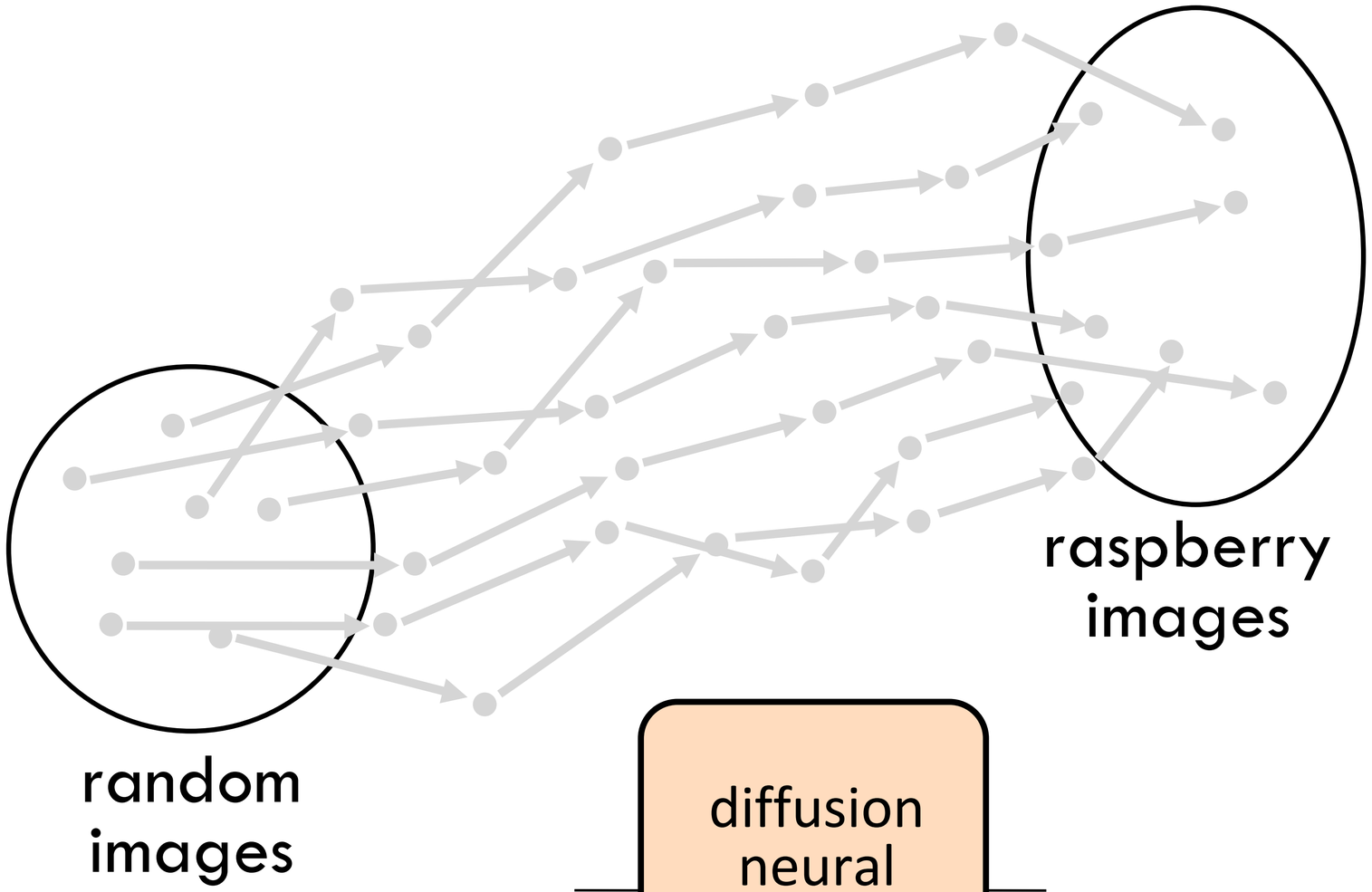
Training

slide from Steve Seitz's video



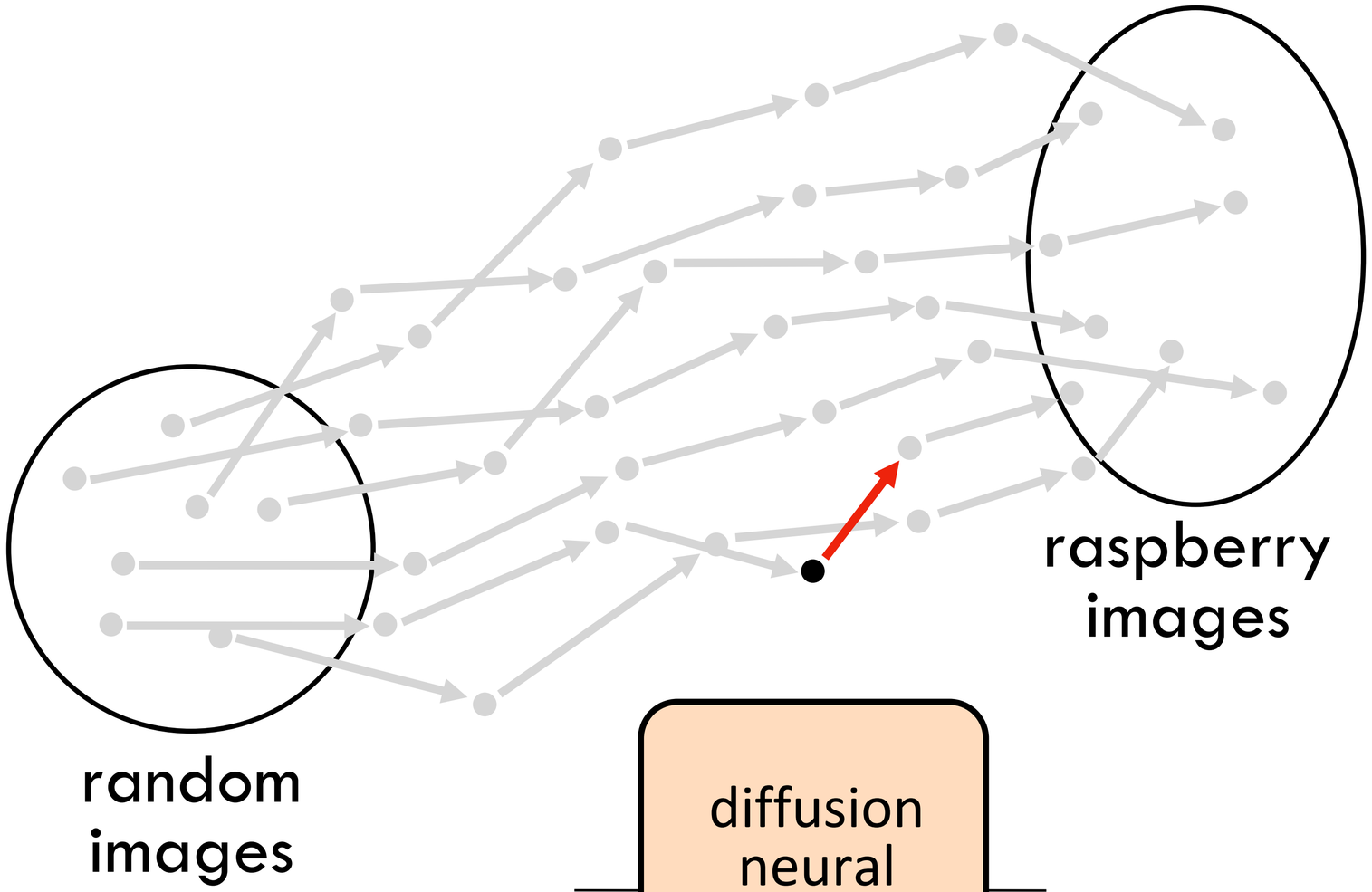
Training

slide from Steve Seitz's video



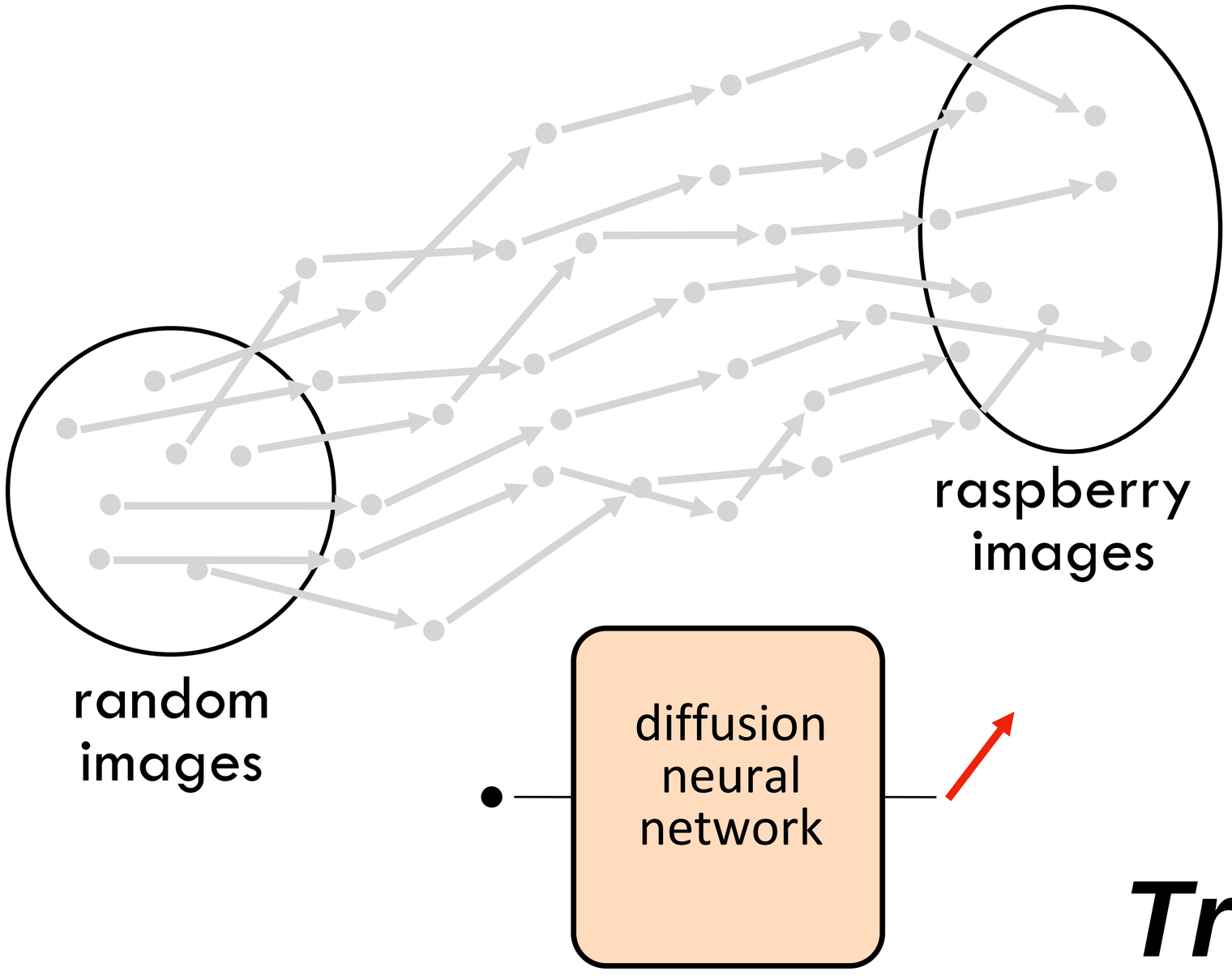
Training

slide from Steve Seitz's video



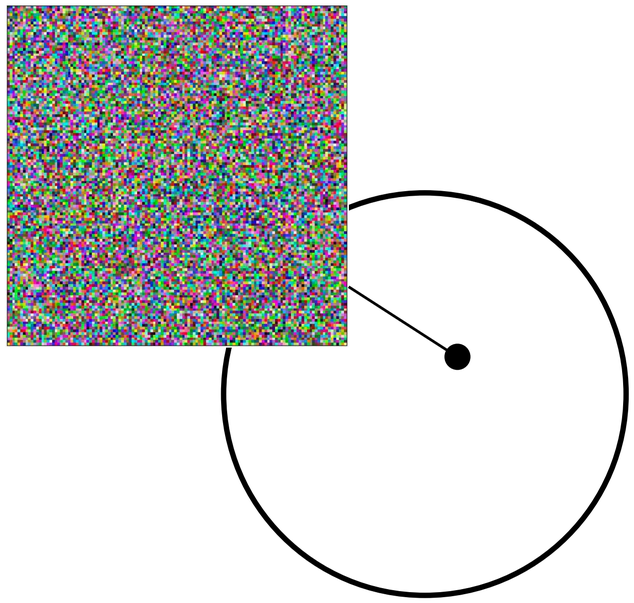
Training

slide from Steve Seitz's video



Training

slide from Steve Seitz's video

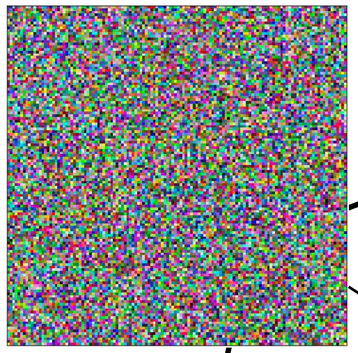


random images

raspberry images

diffusion neural network

slide from Steve Seitz's video

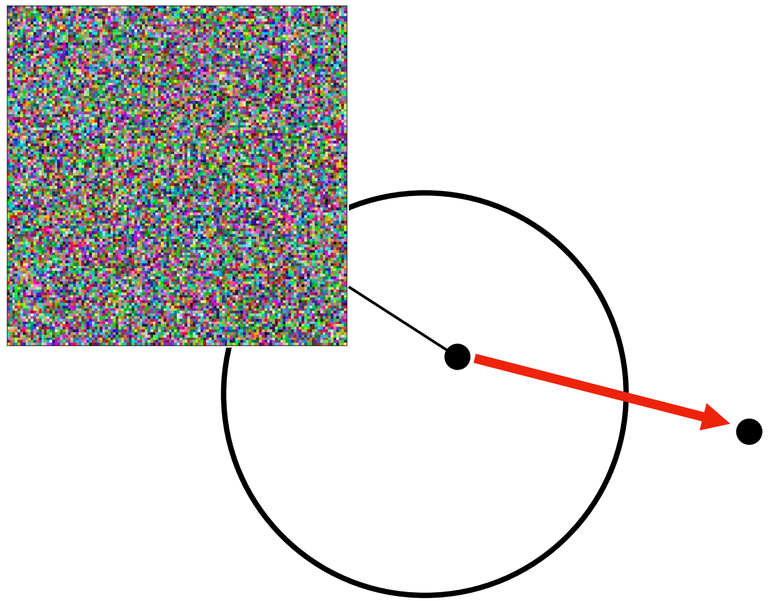


random images

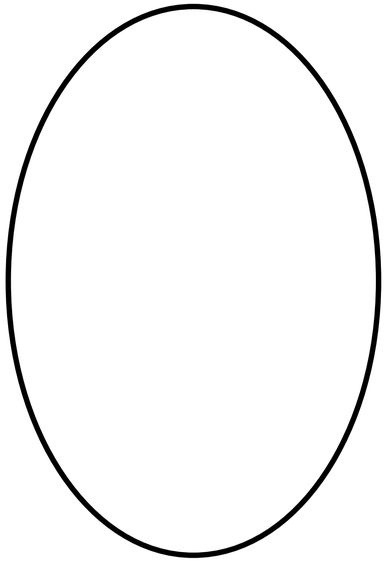
raspberry images

diffusion neural network

slide from Steve Seitz's video



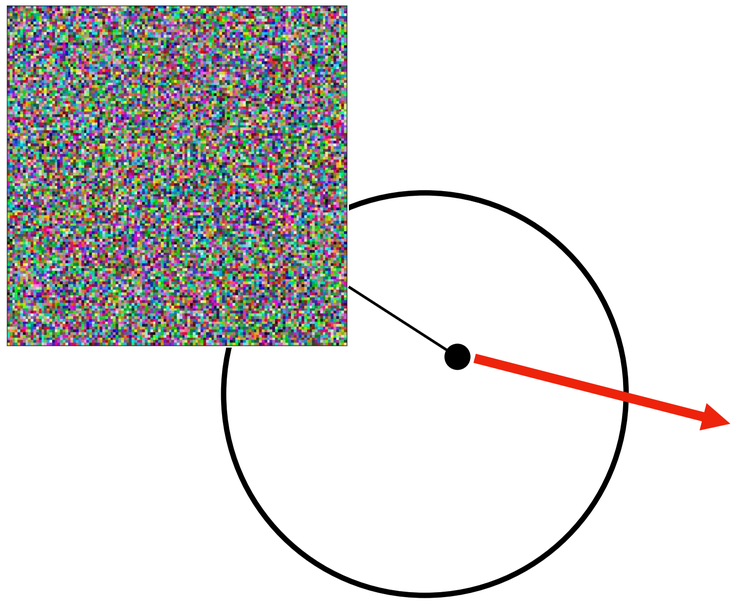
random images



raspberry images

diffusion neural network

slide from Steve Seitz's video

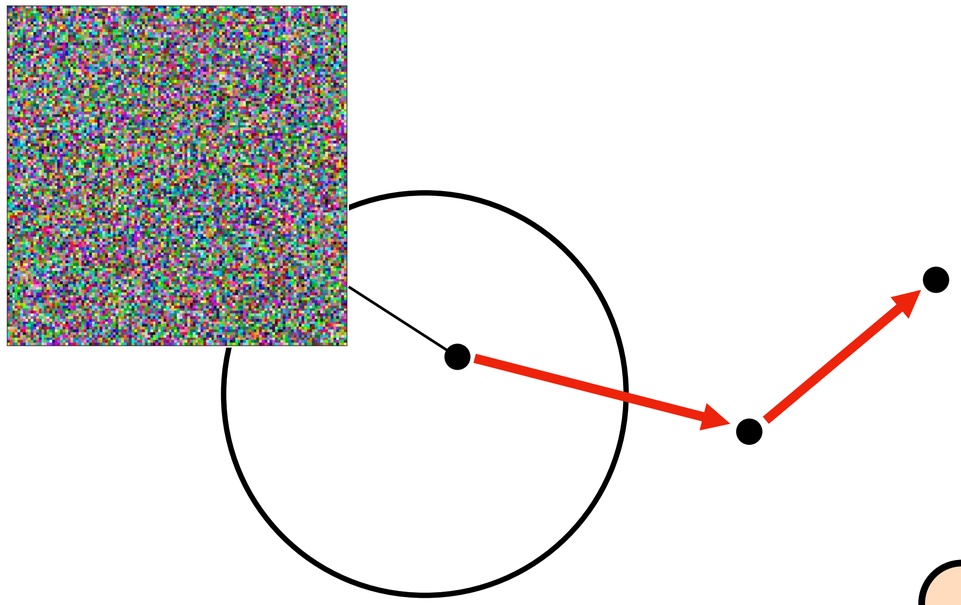


random images

raspberry images

diffusion neural network

slide from Steve Seitz's video

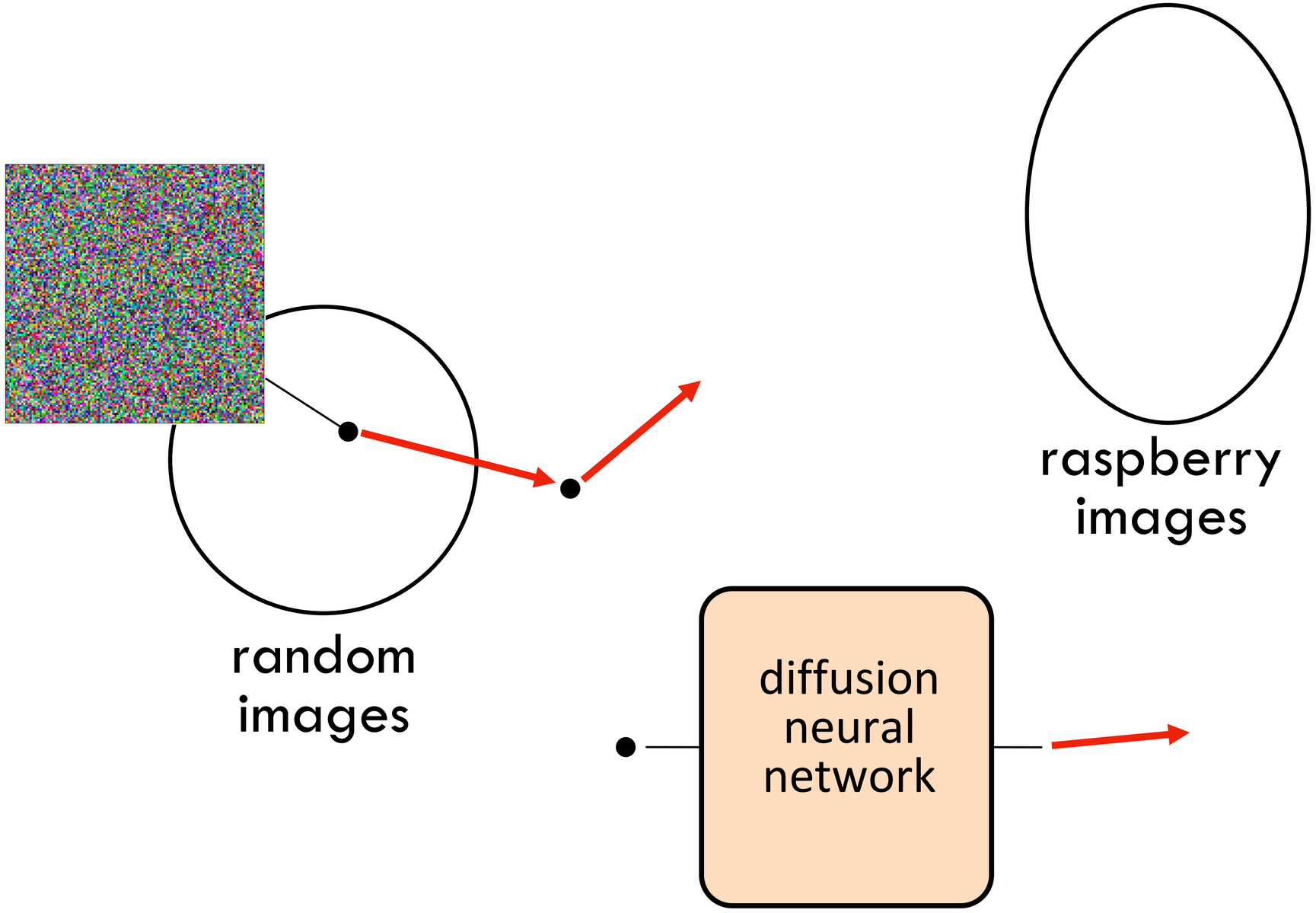


random images

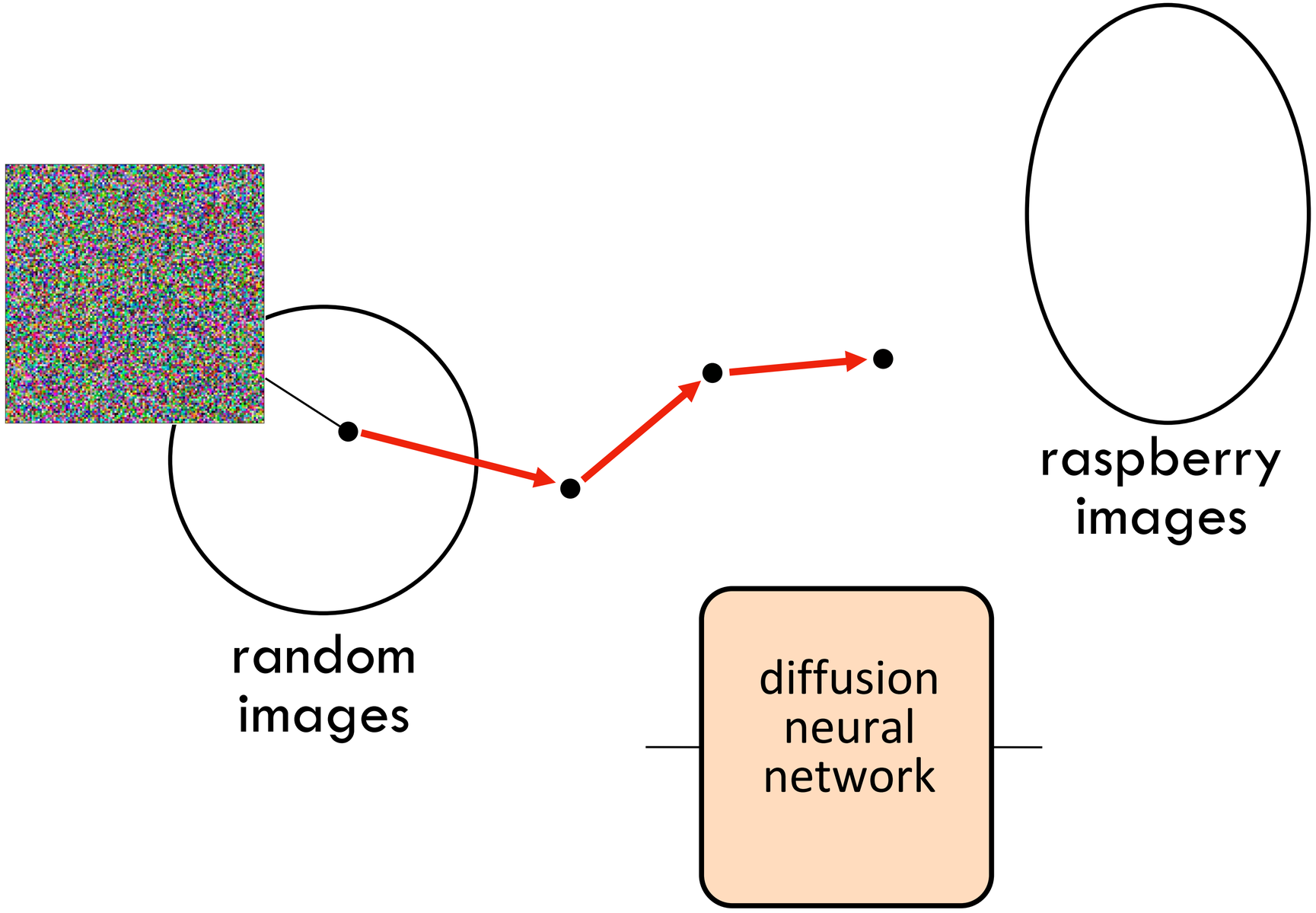
raspberry images

diffusion neural network

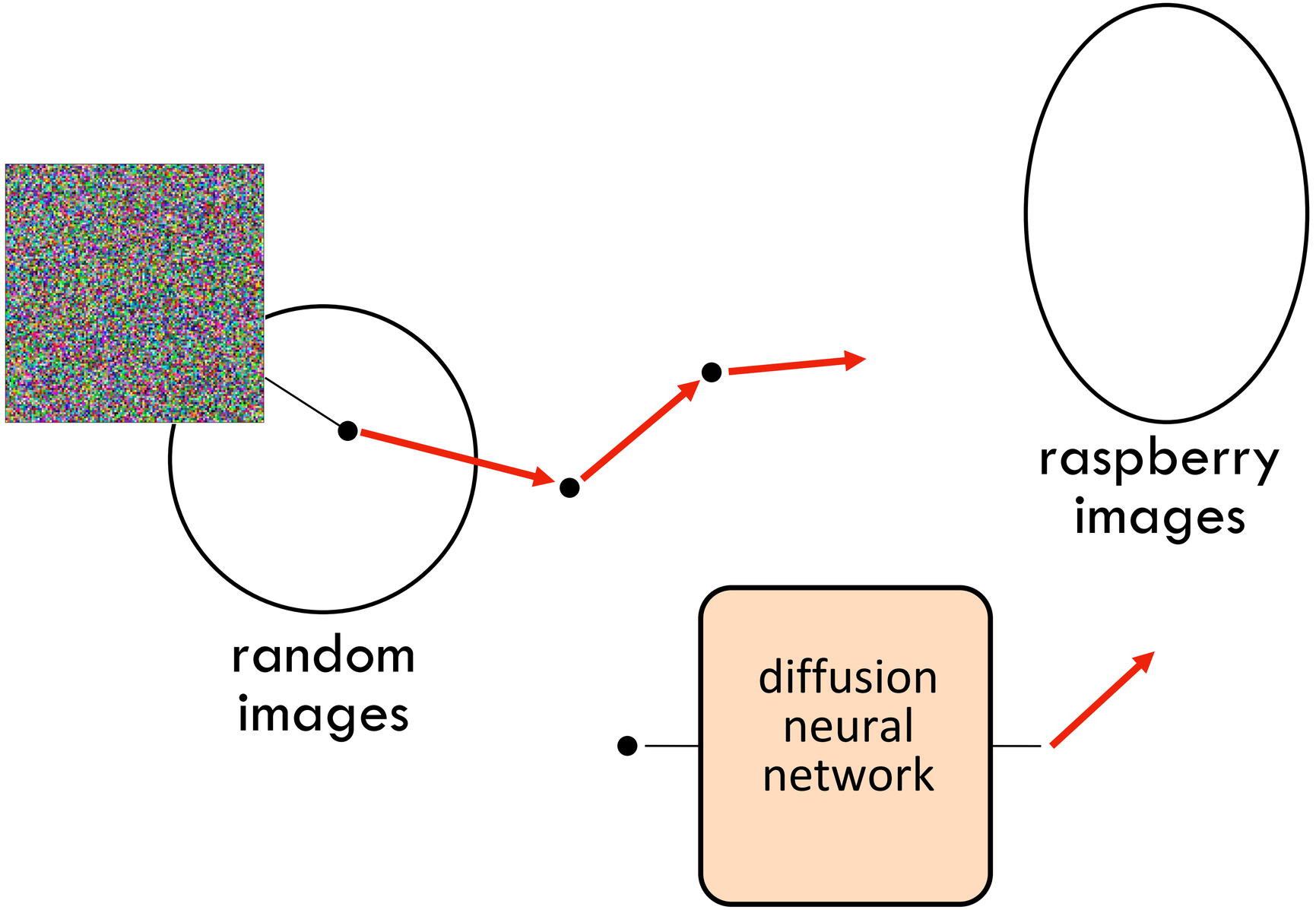
slide from Steve Seitz's video



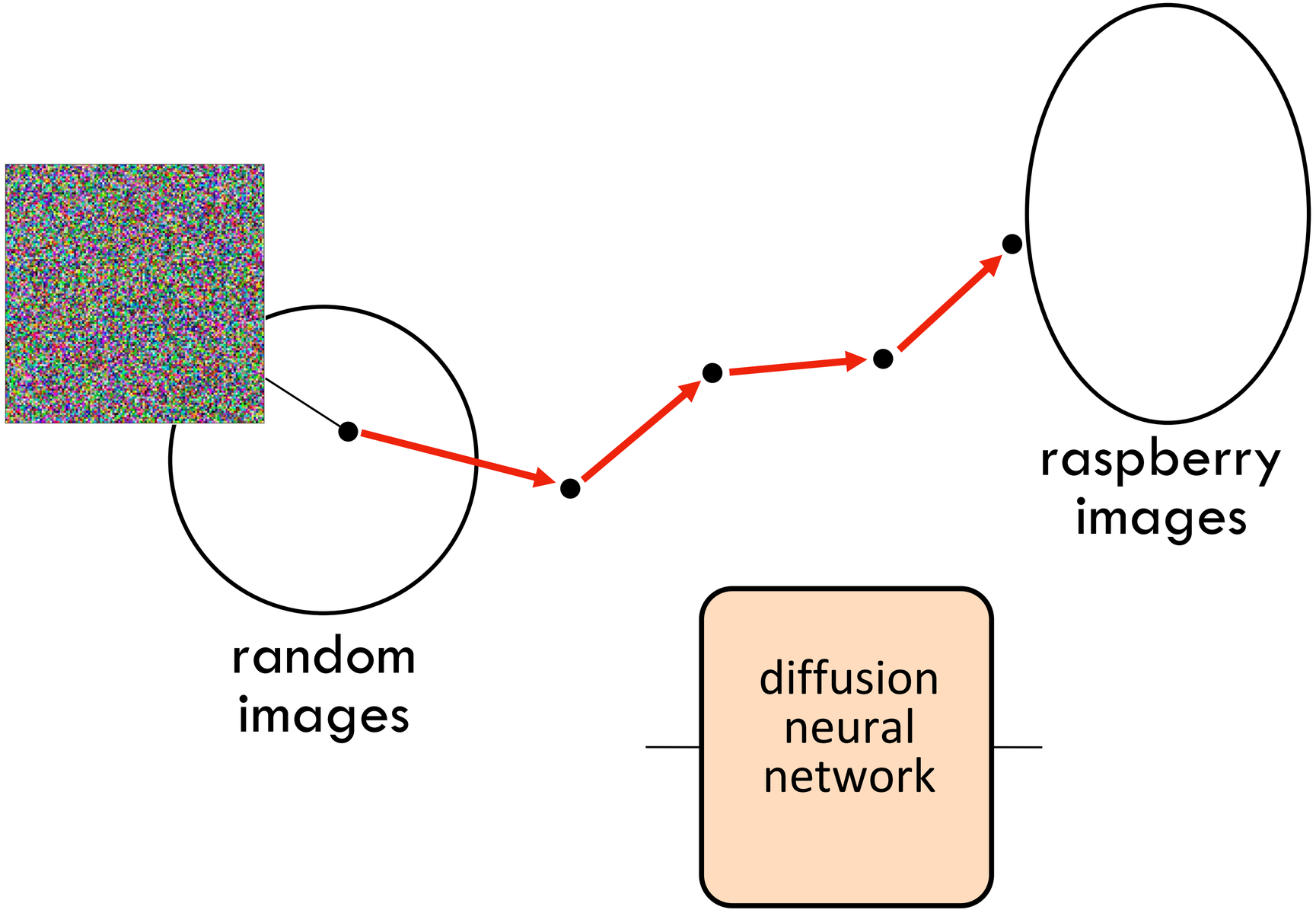
slide from Steve Seitz's video



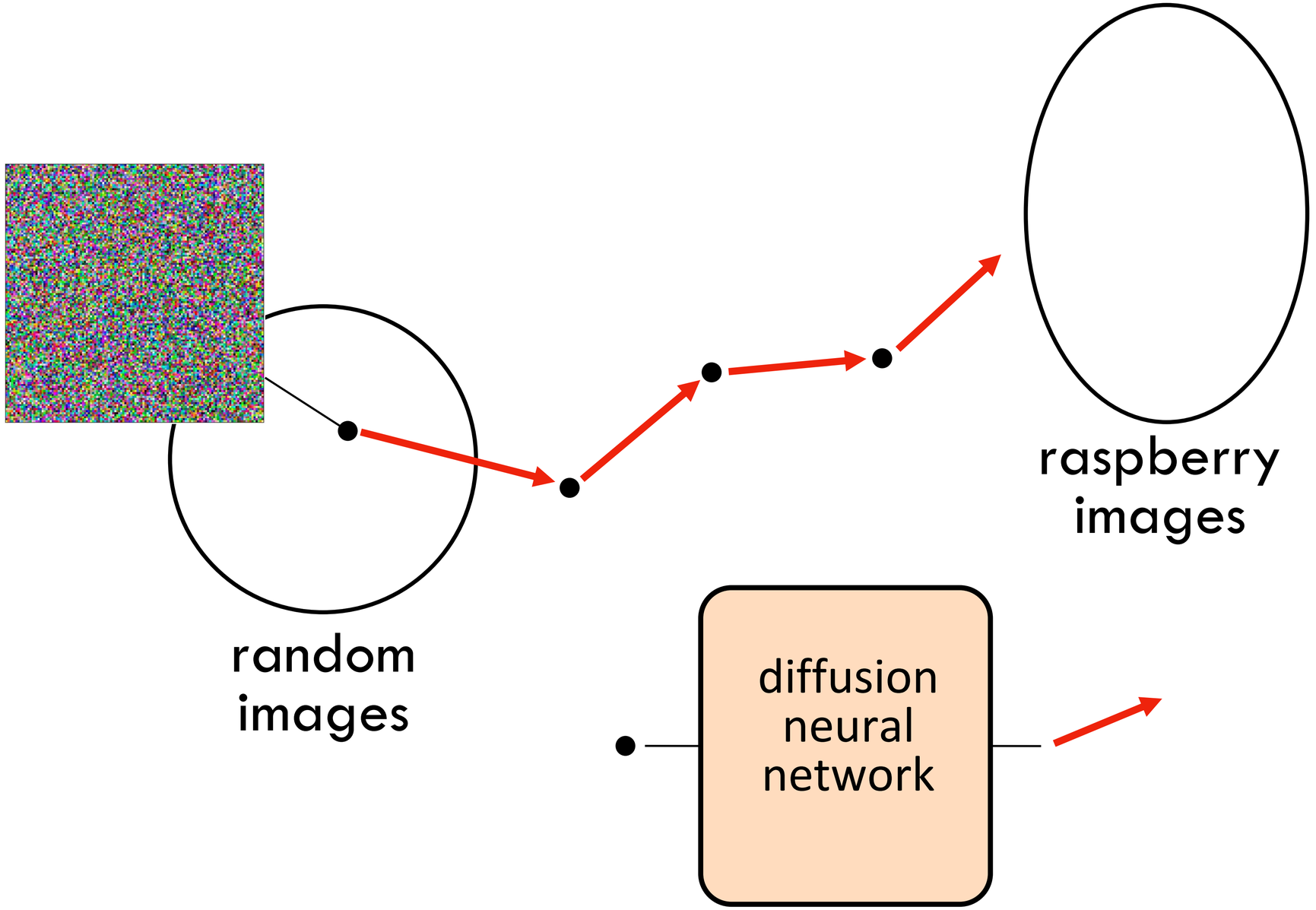
slide from Steve Seitz's video



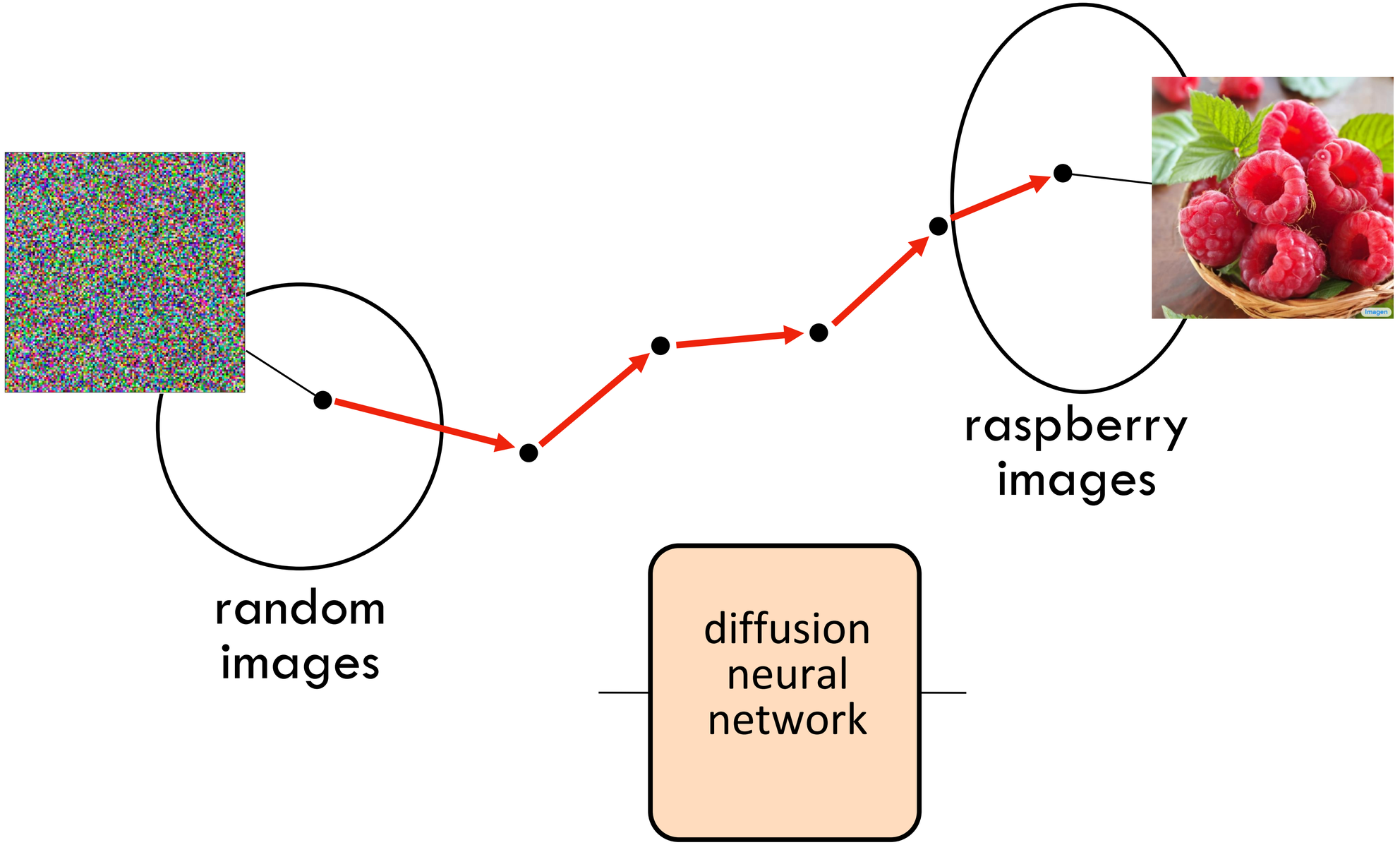
slide from Steve Seitz's video



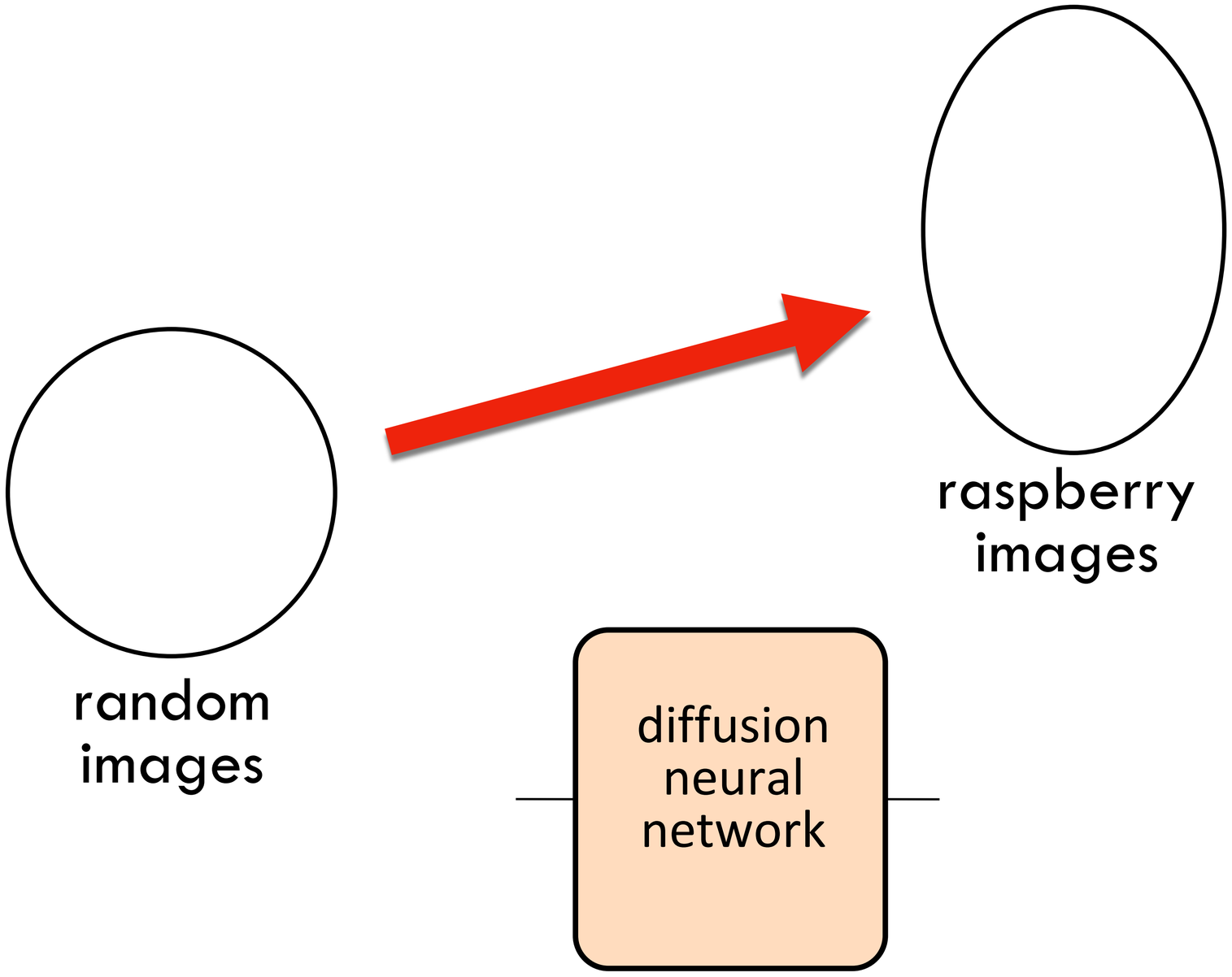
slide from Steve Seitz's video



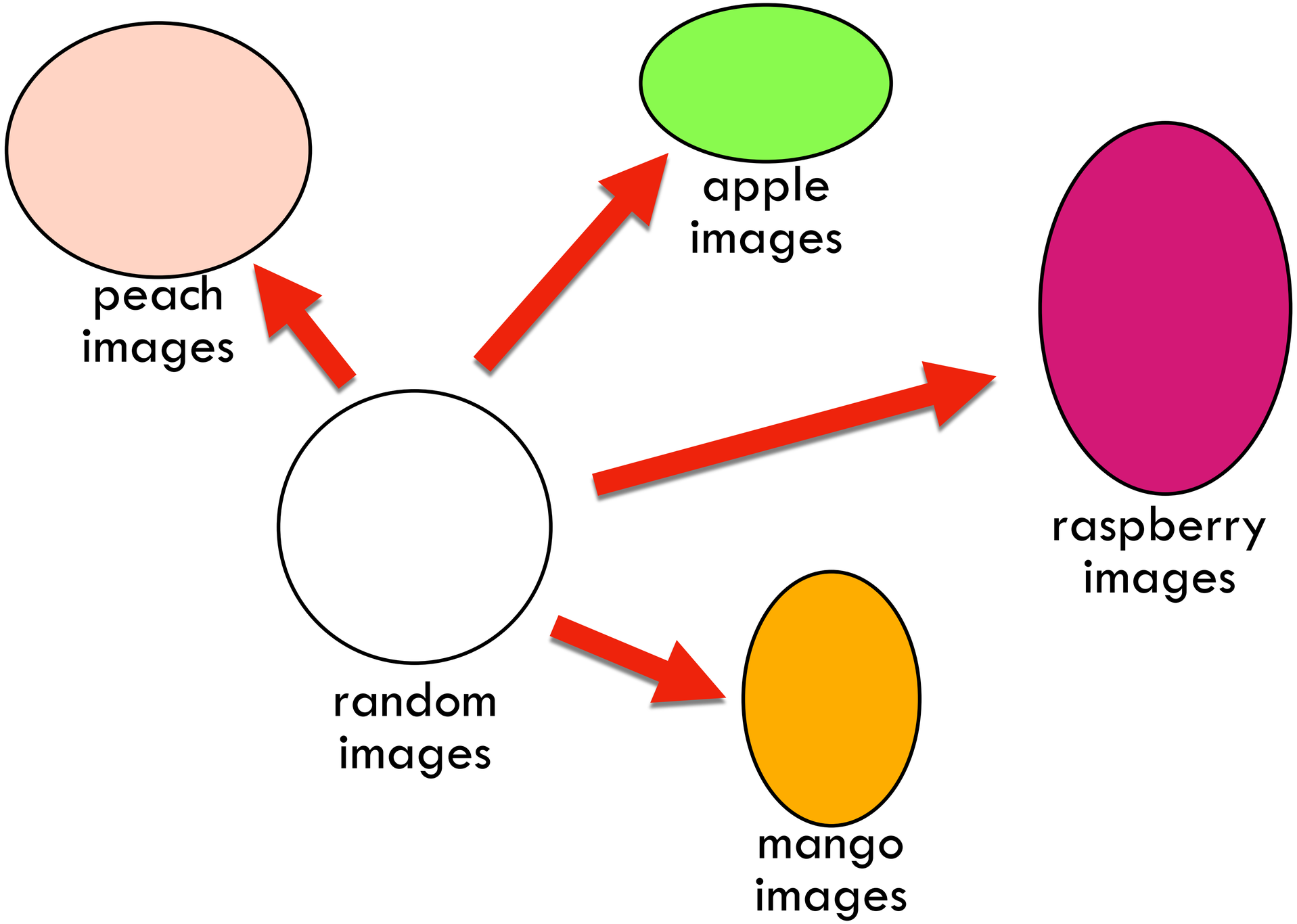
slide from Steve Seitz's video



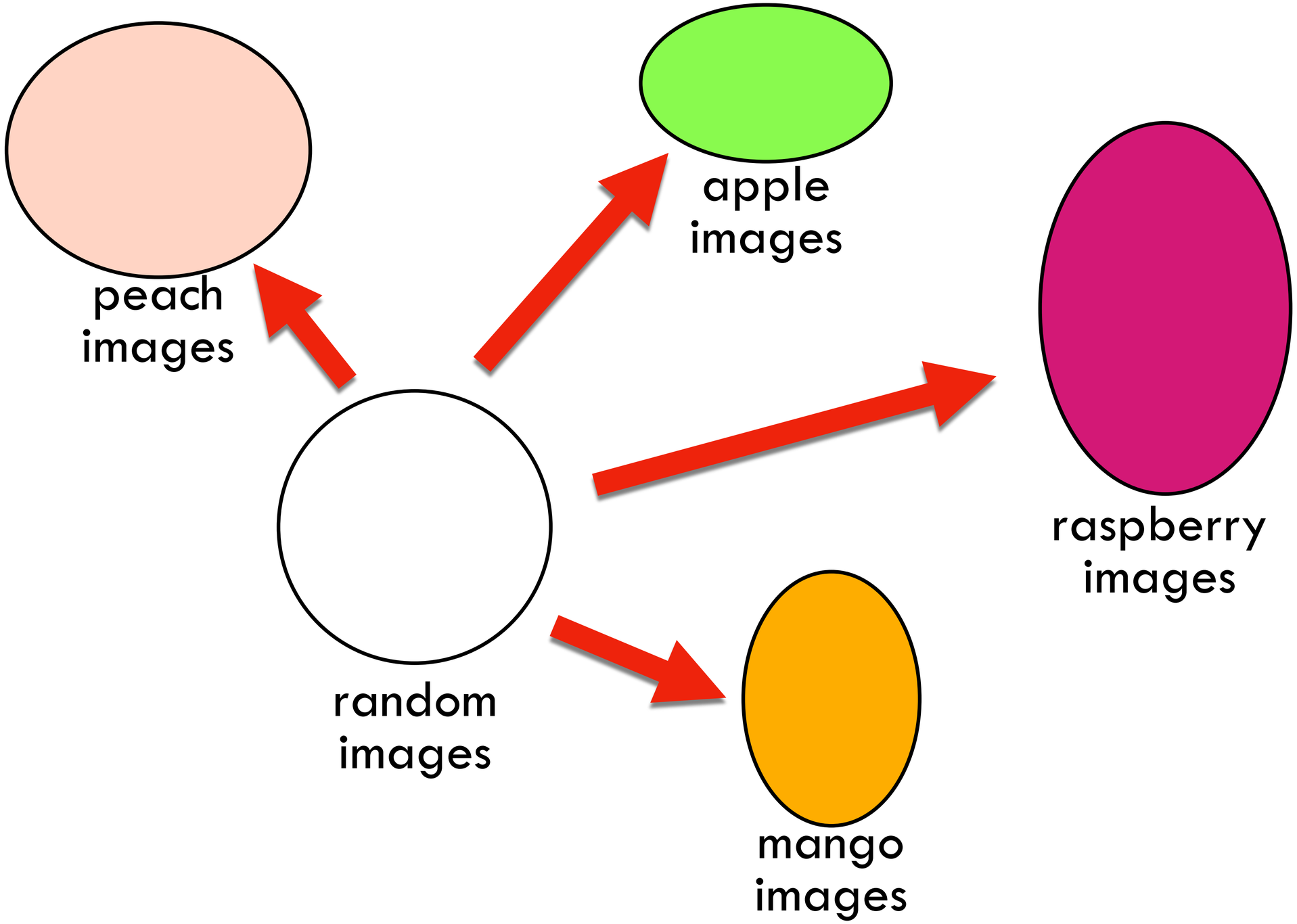
slide from Steve Seitz's video



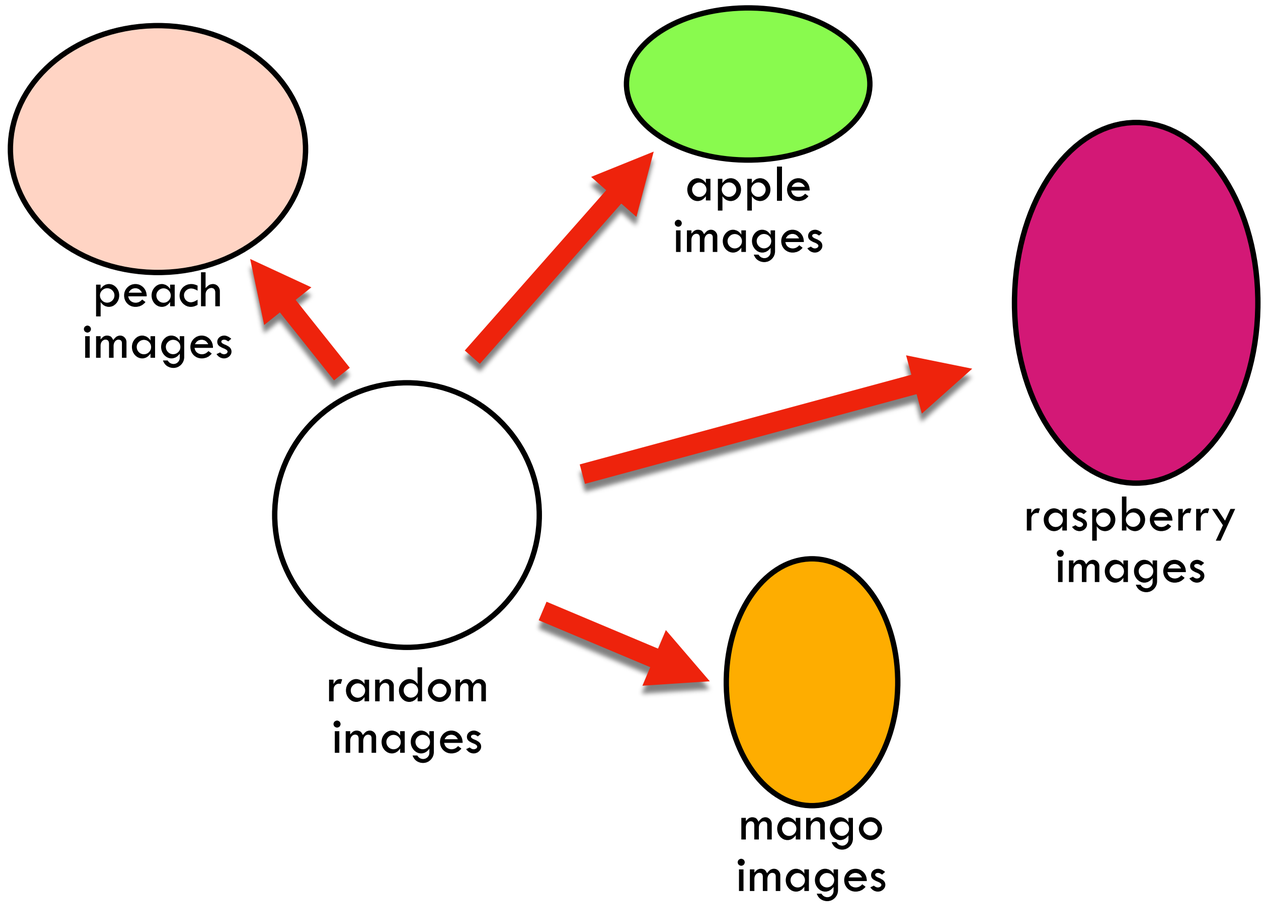
slide from Steve Seitz's video

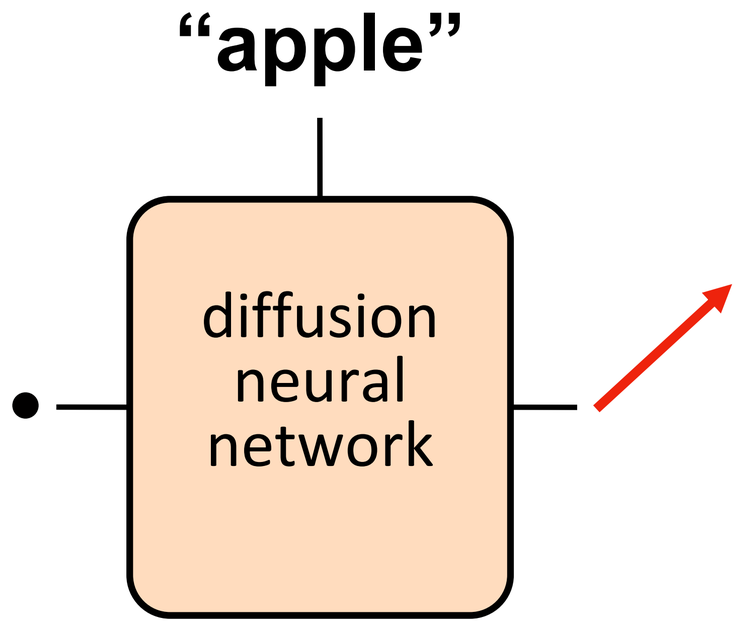


slide from Steve Seitz's video

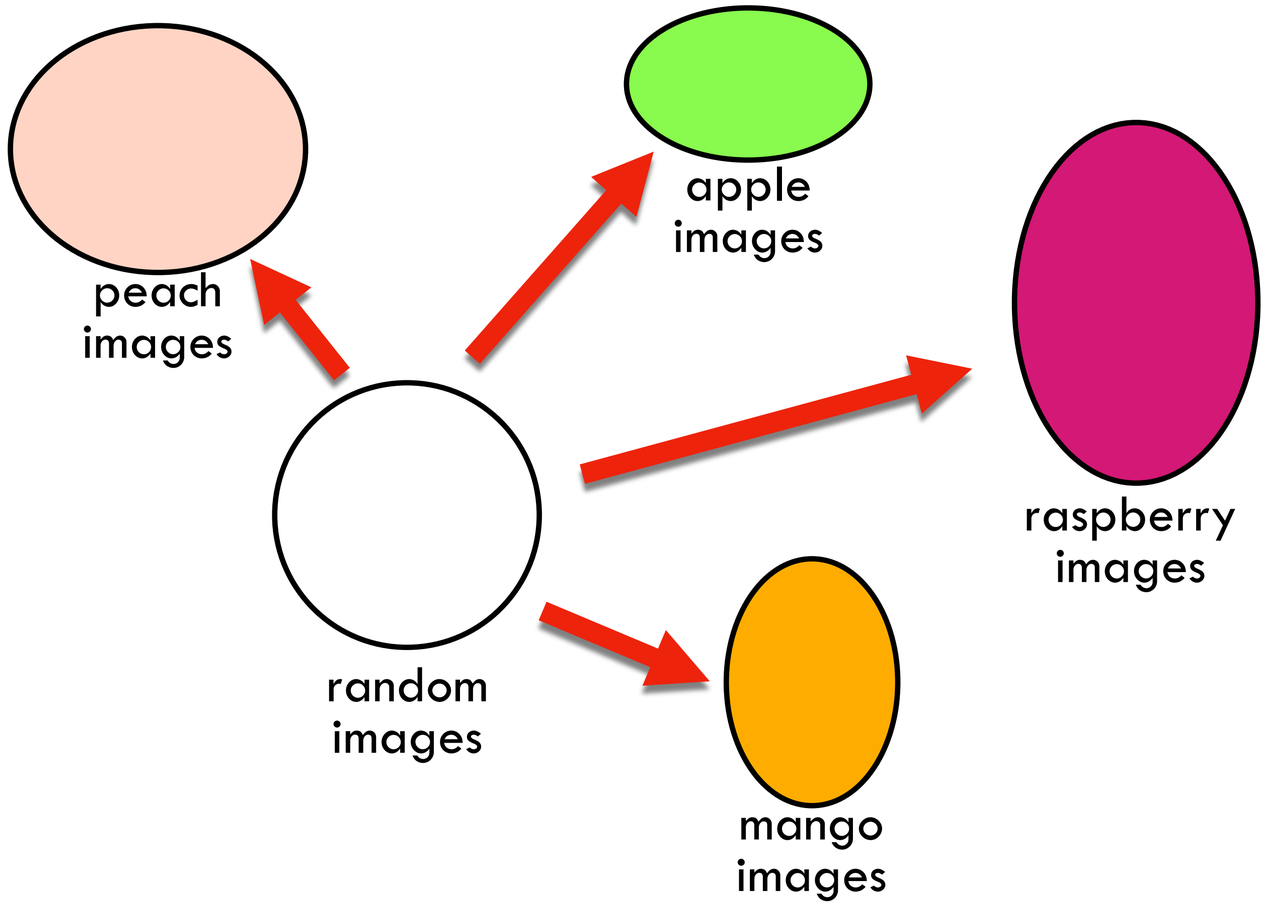


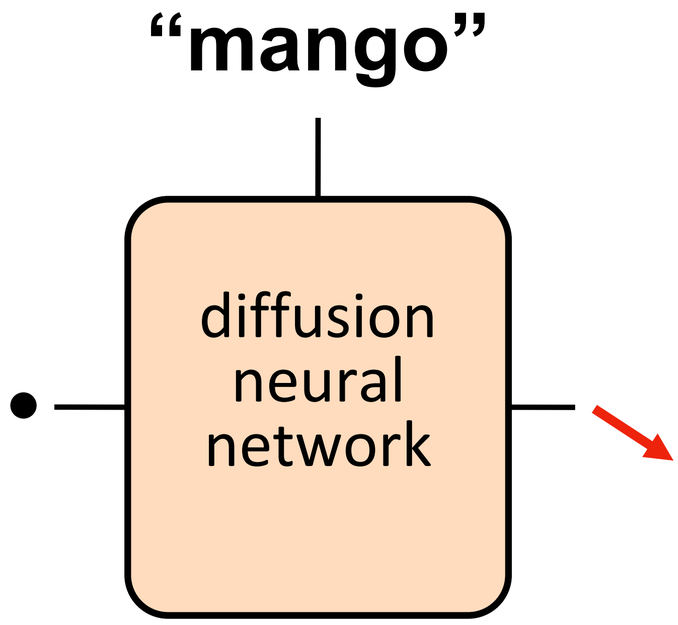
slide from Steve Seitz's video





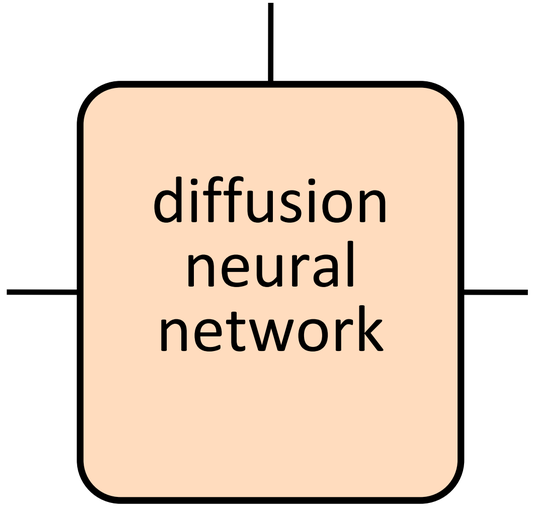
slide from Steve Seitz’s video



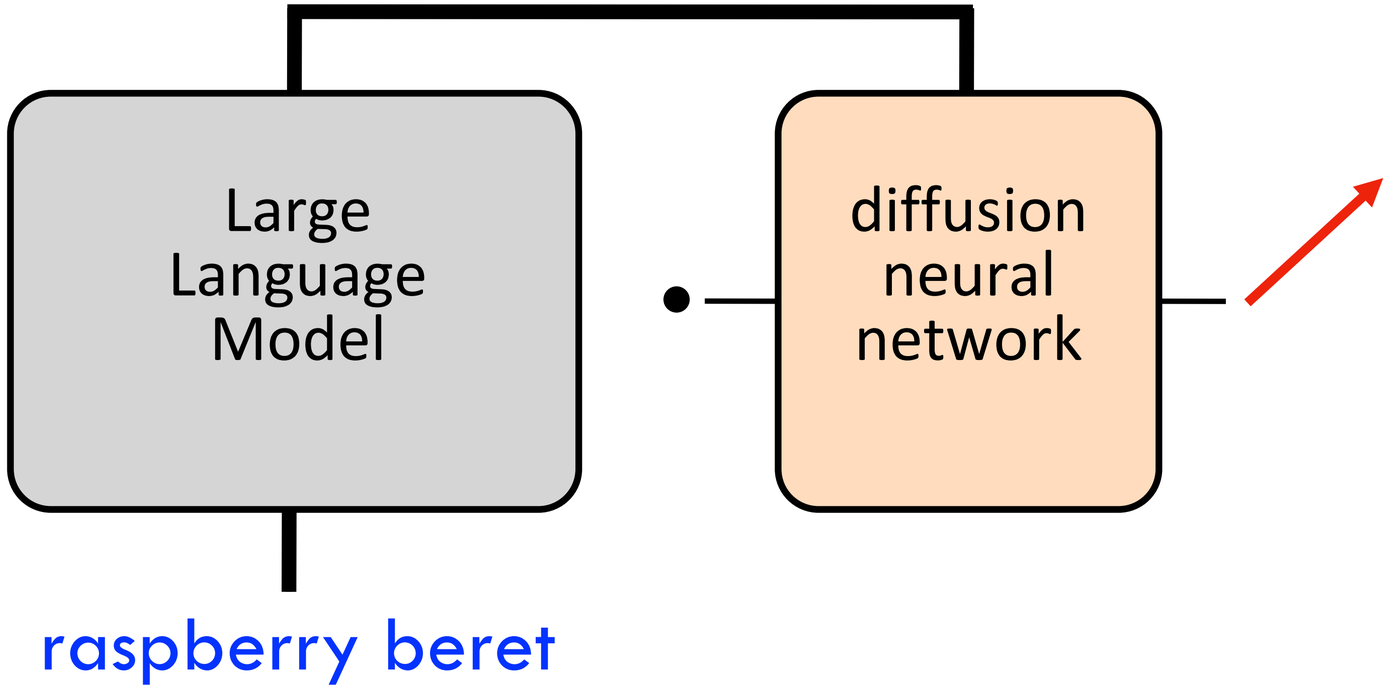


slide from Steve Seitz’s video

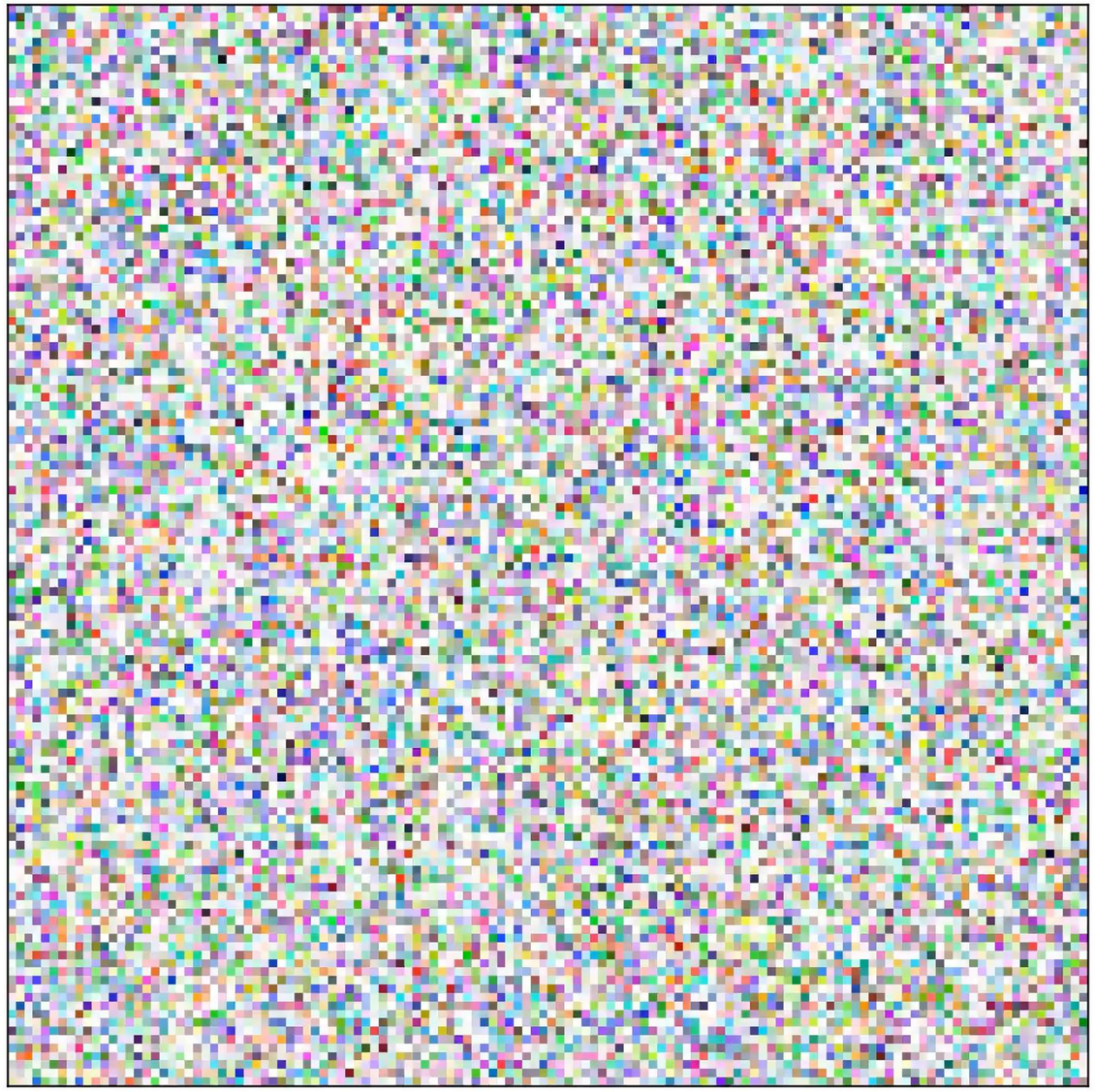
raspberry beret



slide from Steve Seitz's video



slide from Steve Seitz's video



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)

Parti

Diffusion

(+ language)

Imagen

slide from Steve Seitz's video

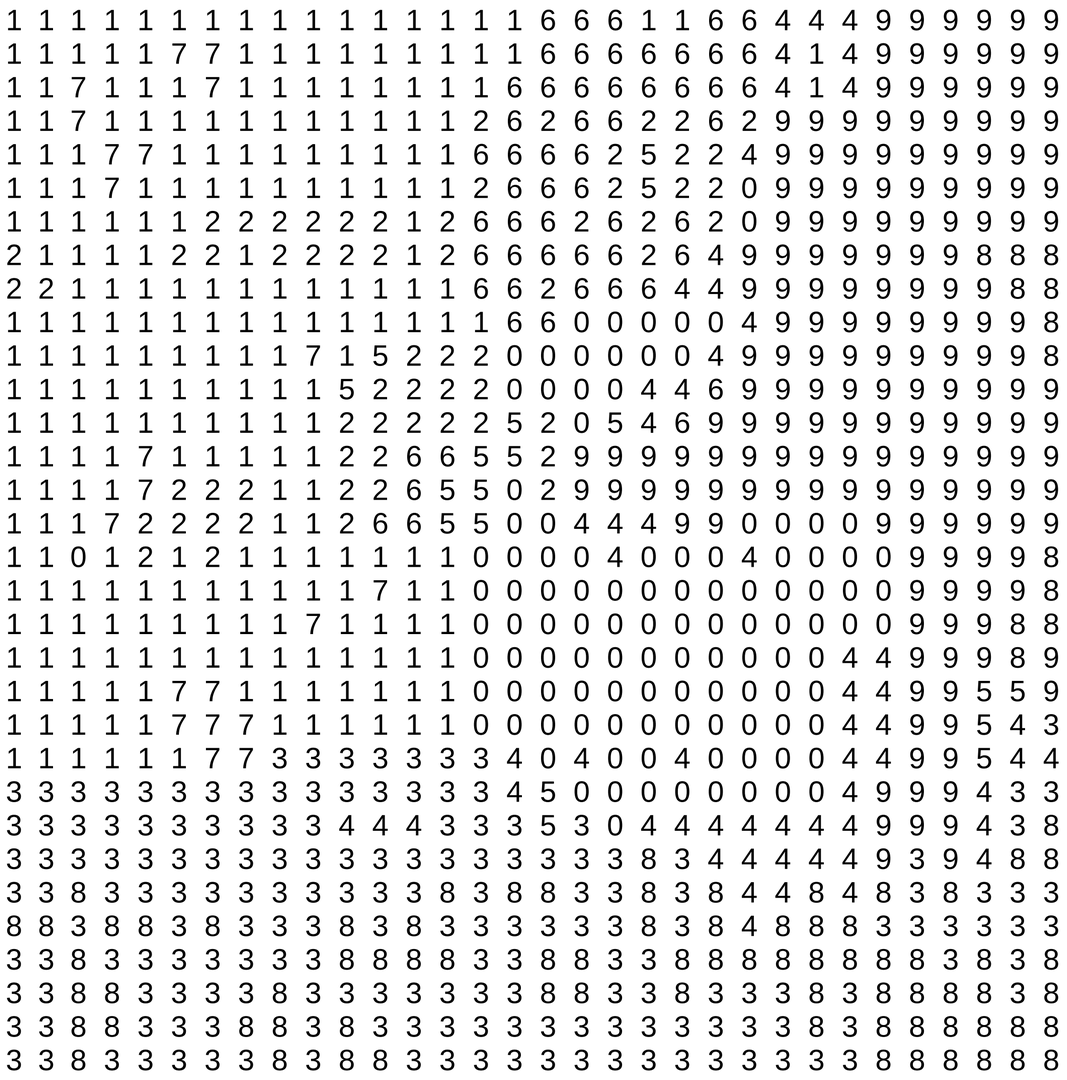
Language Generator

+

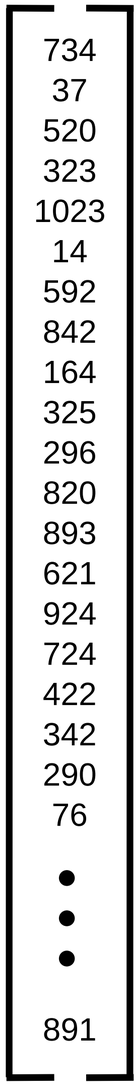
Diffusion

Dall-E 2

slide from Steve Seitz's video

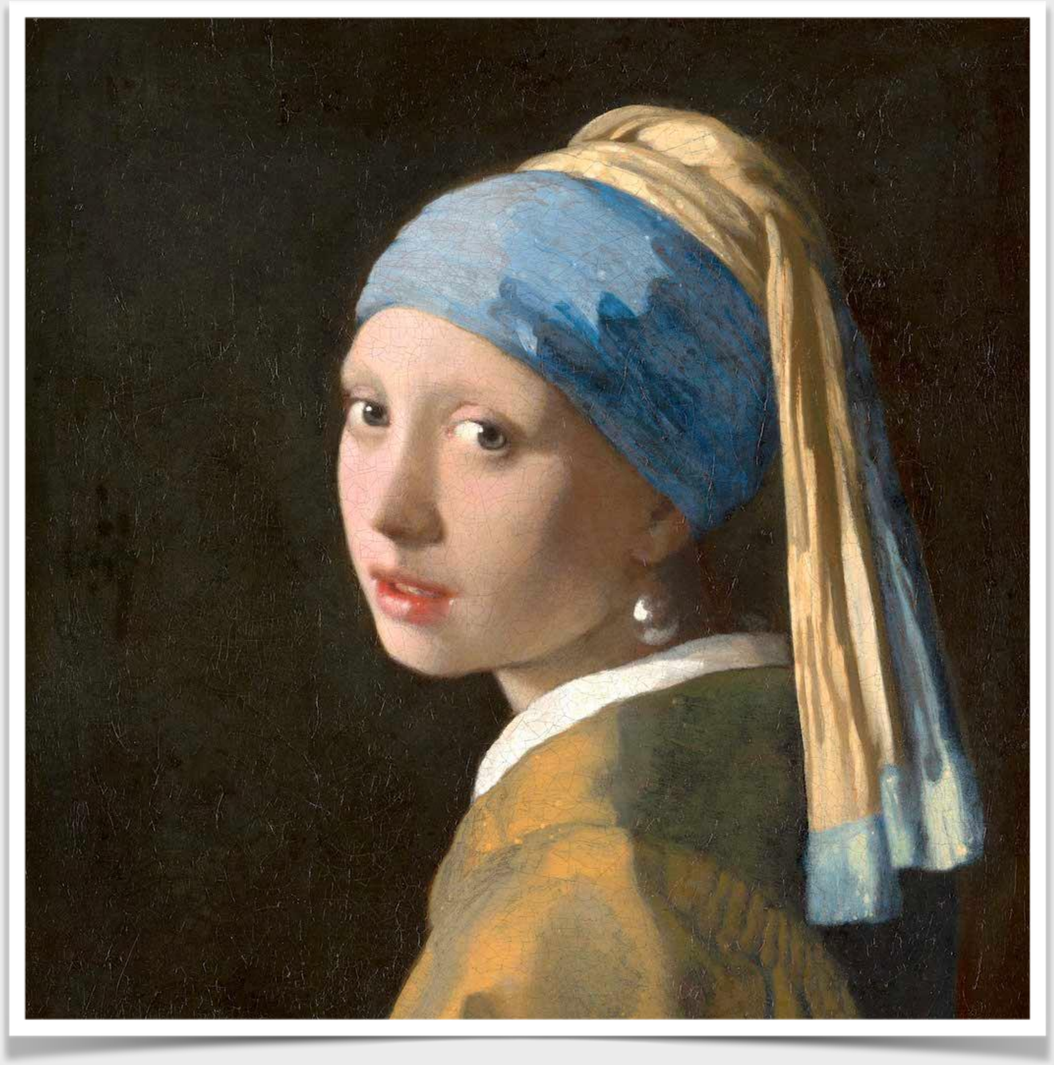


Parti

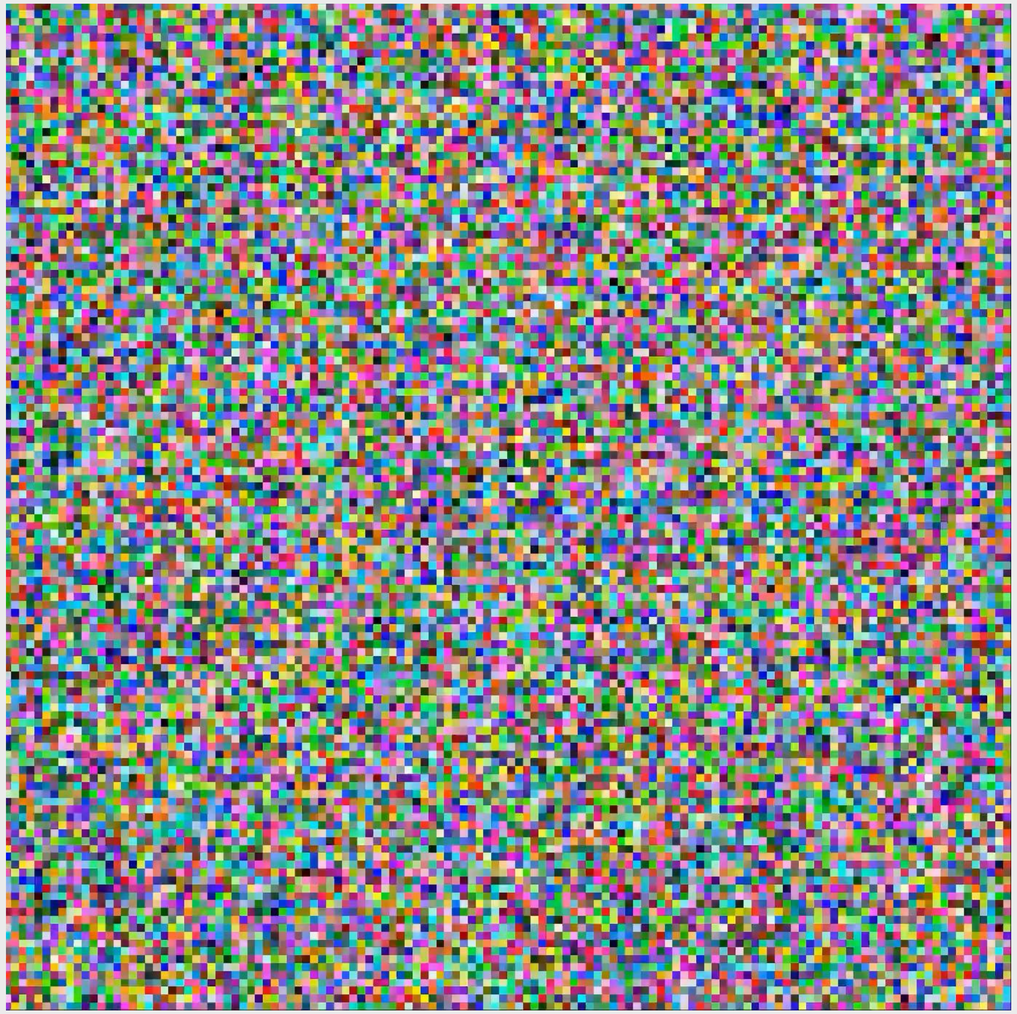


Dall-E 2

slide from Steve Seitz's video

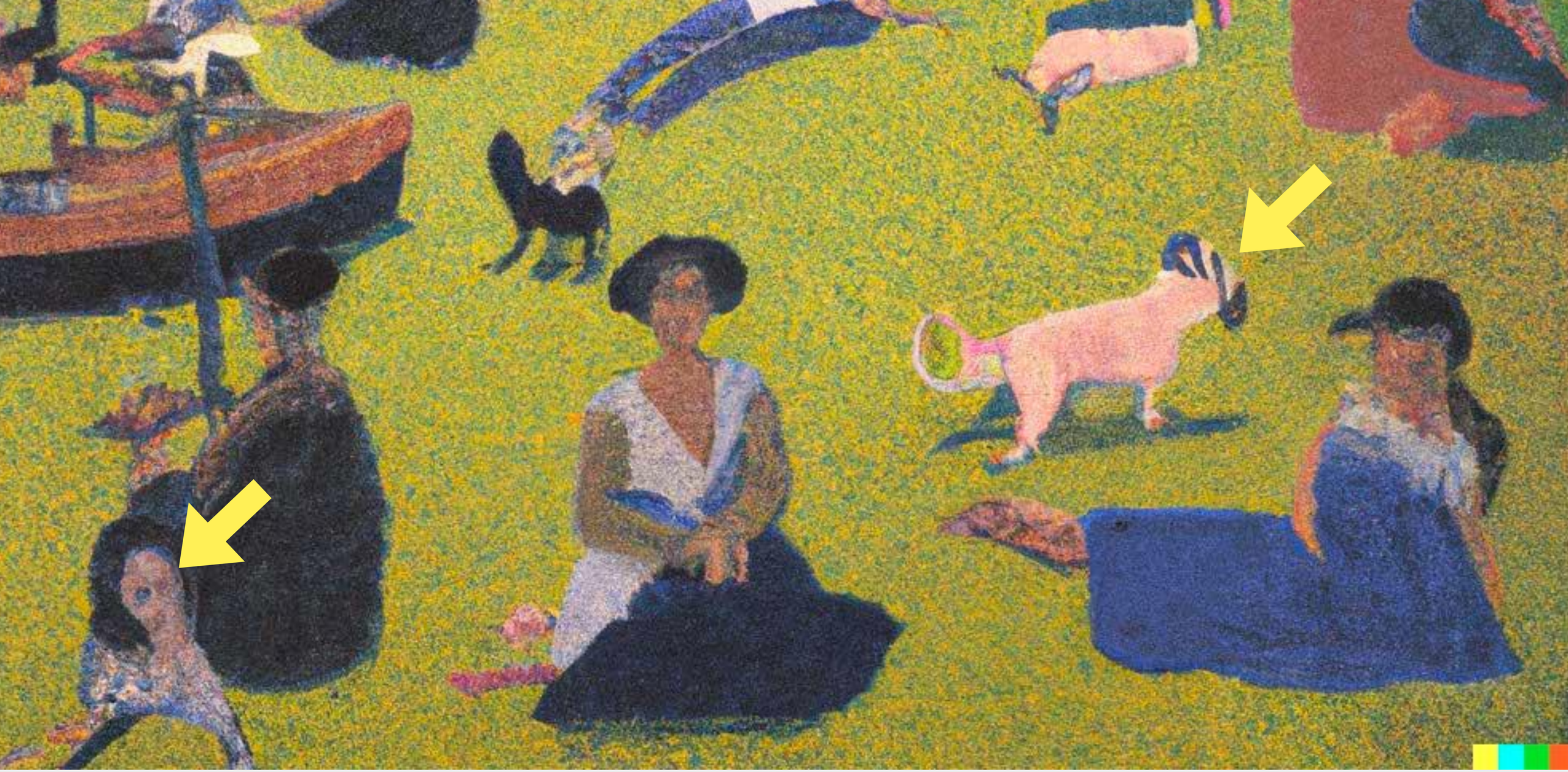


734
37
520
323
1023
14
592
842
164
325
296
820
893
621
924
724
422
342
290
76
584
⋮
891



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

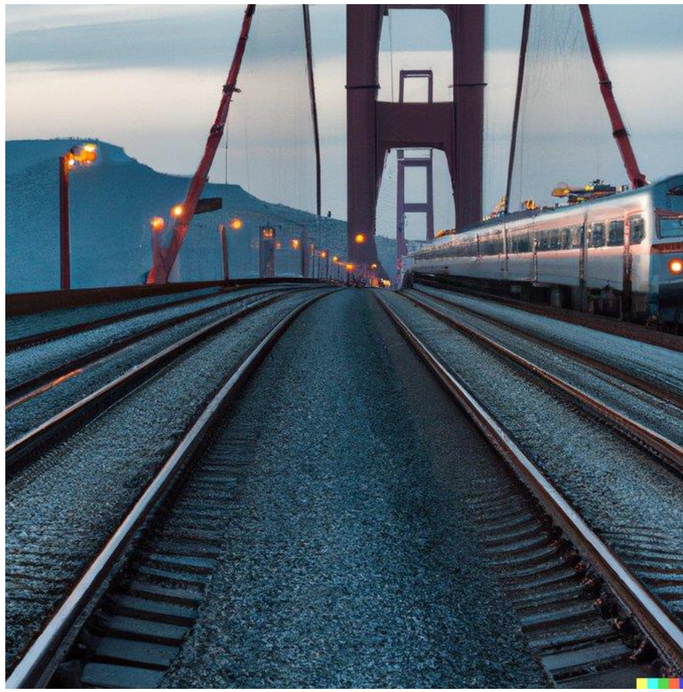
A teddy bear making chocolate guacamole pancakes

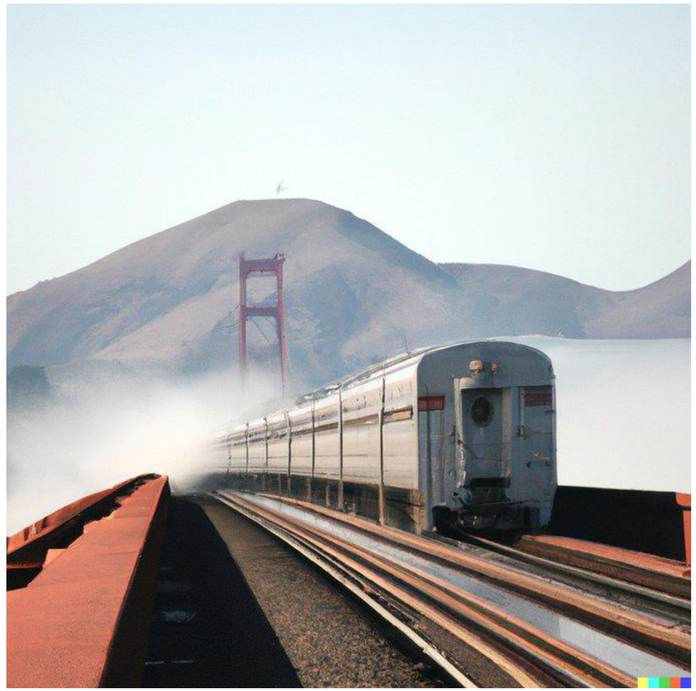
slide from Steve Seitz's video

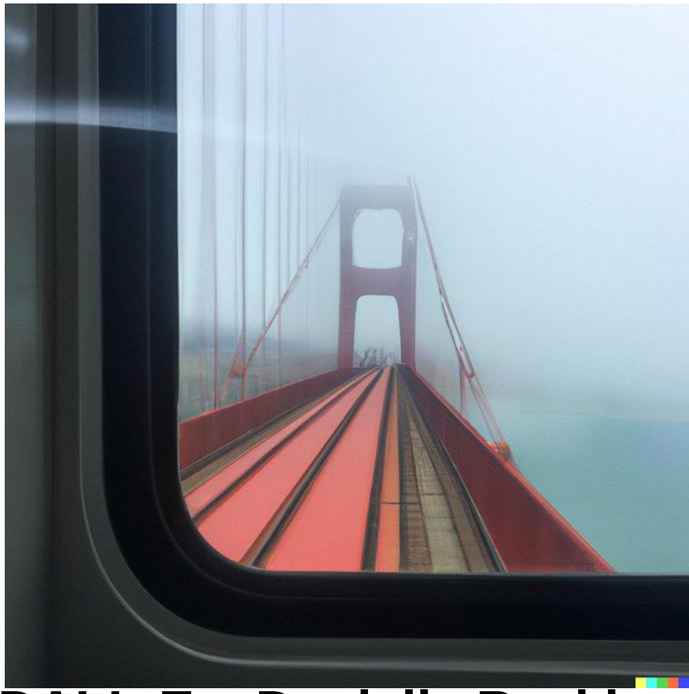
A dog looks curious in the mirror,
seeing a cat

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

Impressive compositionality:







DALL-E + Danielle Baskin