Lecture 15-1-Image Blending

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Course piazza link:
piazza.com/shanghaitech.edu.cn/spring2021/cs270spring2021

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Long history of fake images

Long history of fake images

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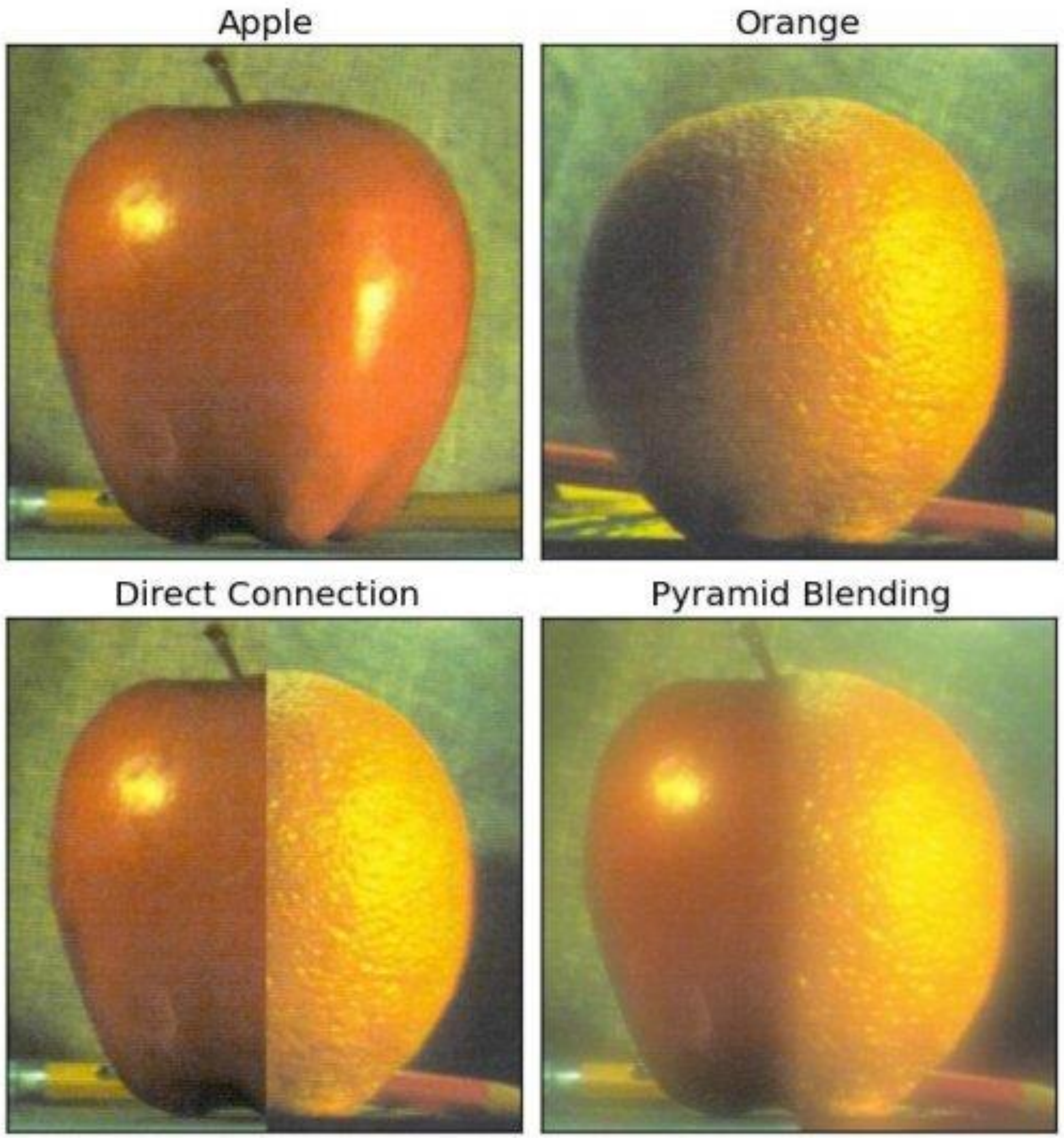
Long history of fake images

Hard edge composition vs Pyramid Blending



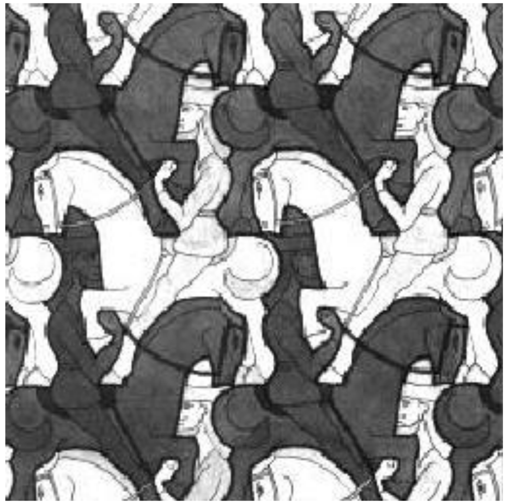
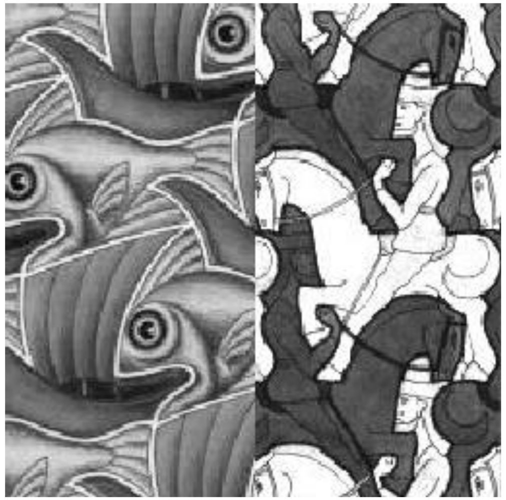
Hard compositing

- Hard compositing:

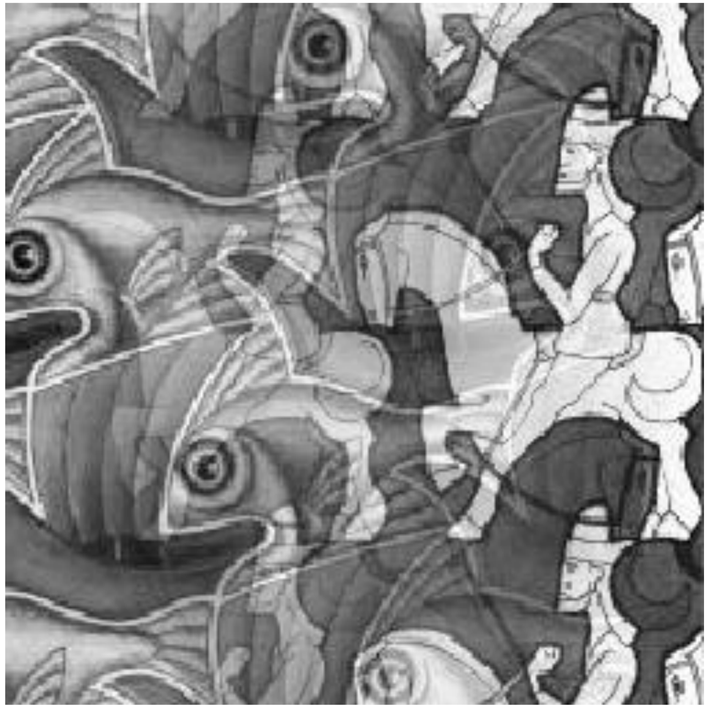
$$I(x,y) = M(x,y)S(x,y) + \left(1 - M(x,y)\right)T(x,y)$$

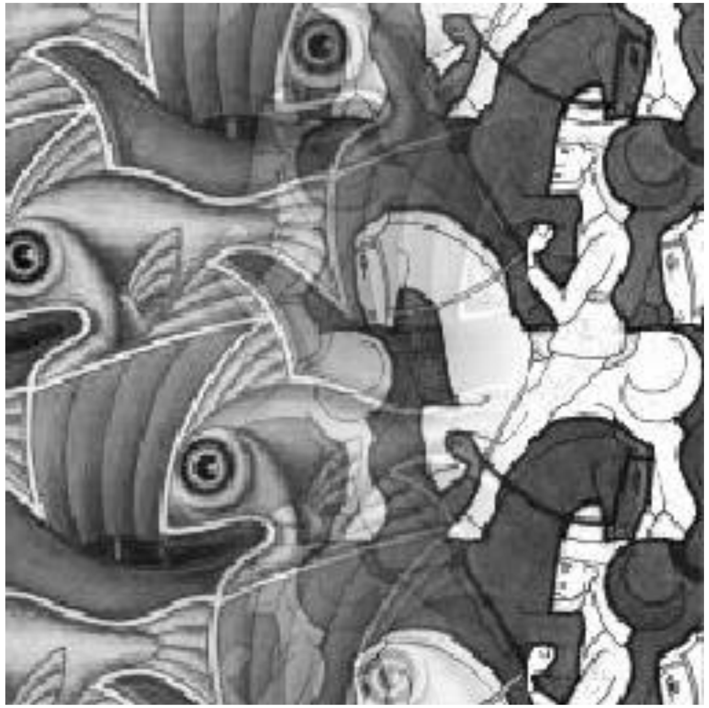
$$= \begin{cases} S(x,y) & M(x,y) = 1 \\ T(x,y) & M(x,y) = 0 \end{cases}$$

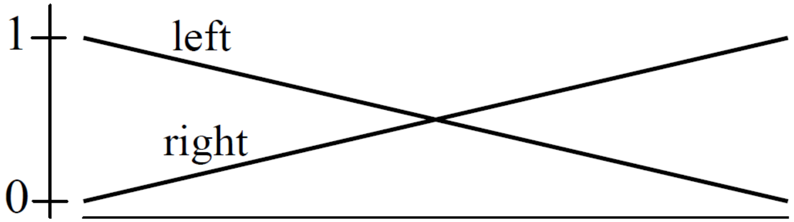
- Generally bad: seam/matte line is visible

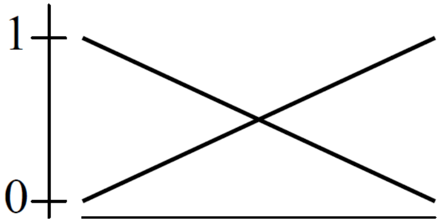




Weighted transition region:

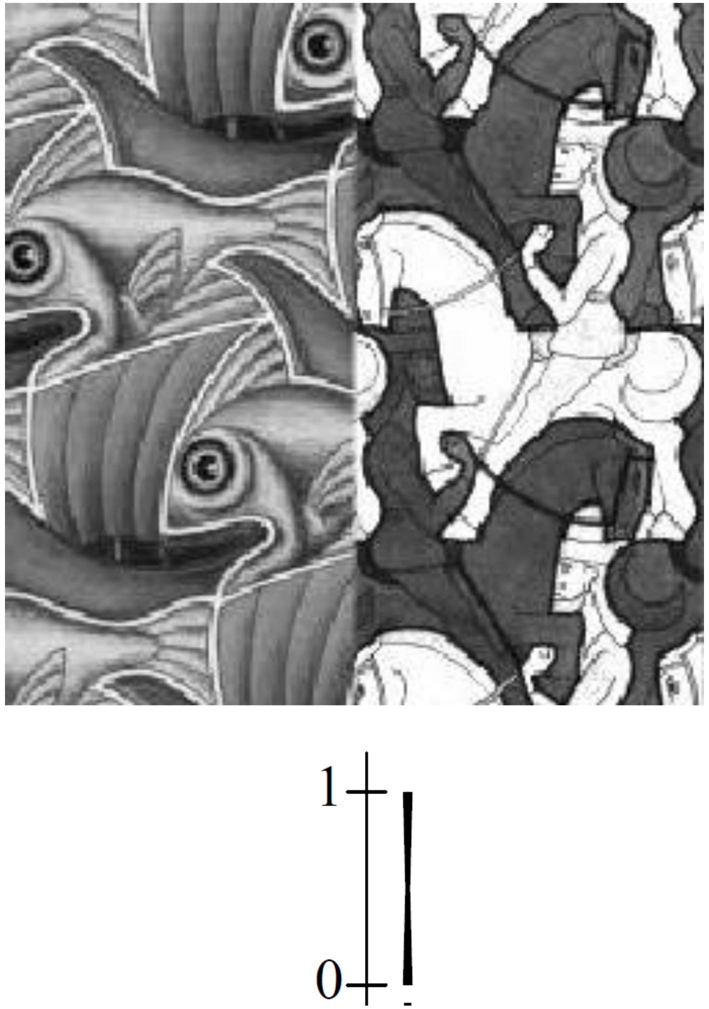




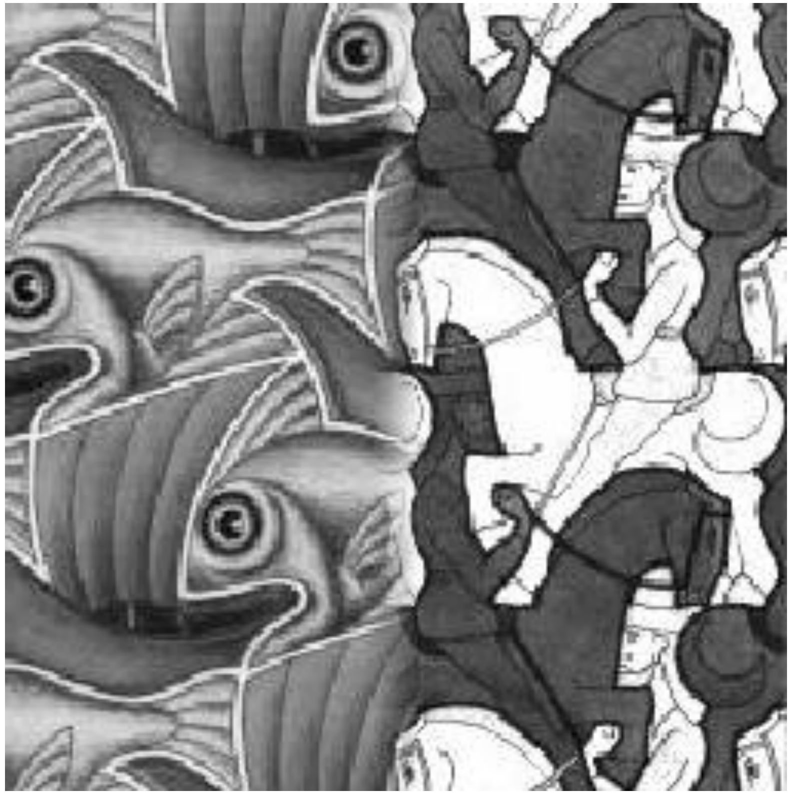


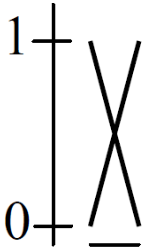


Weighted transition region:



Good window size





Pyramid Blending

➢ **Better idea: Multi-resolution blending with a Laplacian pyramid.**

- Idea: wide transition regions for low-frequency component, narrow transition regions for high-frequency component (edges).
- Gaussian pyramid:

  G = 5x5 Gaussian filter

  $\boldsymbol{I_0}$ = original image (full resolution)

  - $\boldsymbol{I}_{\mathrm{i}} = (\boldsymbol{G} * \boldsymbol{I}_{\mathrm{i}-1}) \downarrow 2$ ← Down-sample twice

    convolution

- Get a series of smaller and blurry images.

What does blurring take away?

What does blurring take away?

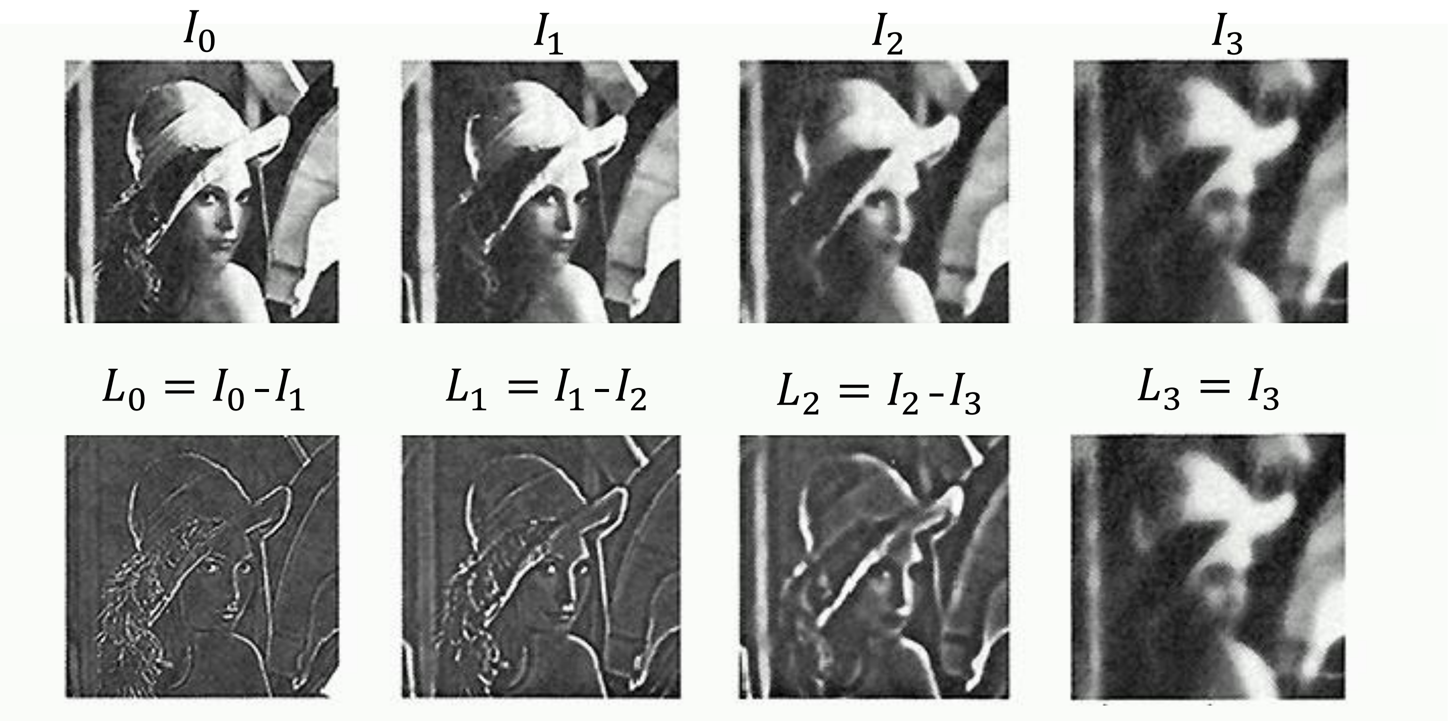
What does blurring take away?

Pyramid Blending

- **Difference of Gaussian at each scale:**

High-pass image at scale i → $\boldsymbol{L_i} = \boldsymbol{I}_{\mathrm{i}} - \boxed{(\boldsymbol{G} * \boldsymbol{I}_{\mathrm{i}}) \downarrow 2}$ ← Blurred version of level i

Gaussian pyramid image at scale i

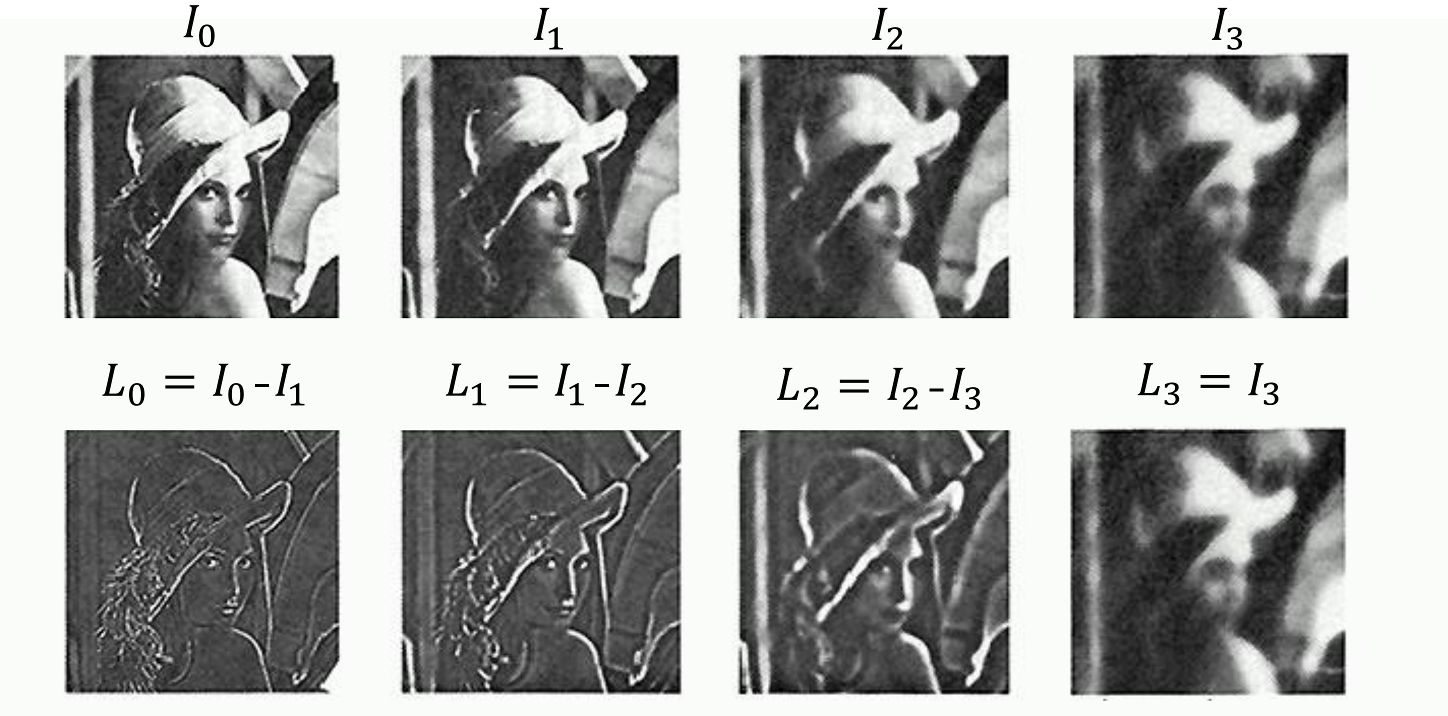


$\{L_i\}$ = the set of L_i form. A Laplacian pyramid $L_1, L_2, L_3 \cdots, L_n$

Pyramid Blending

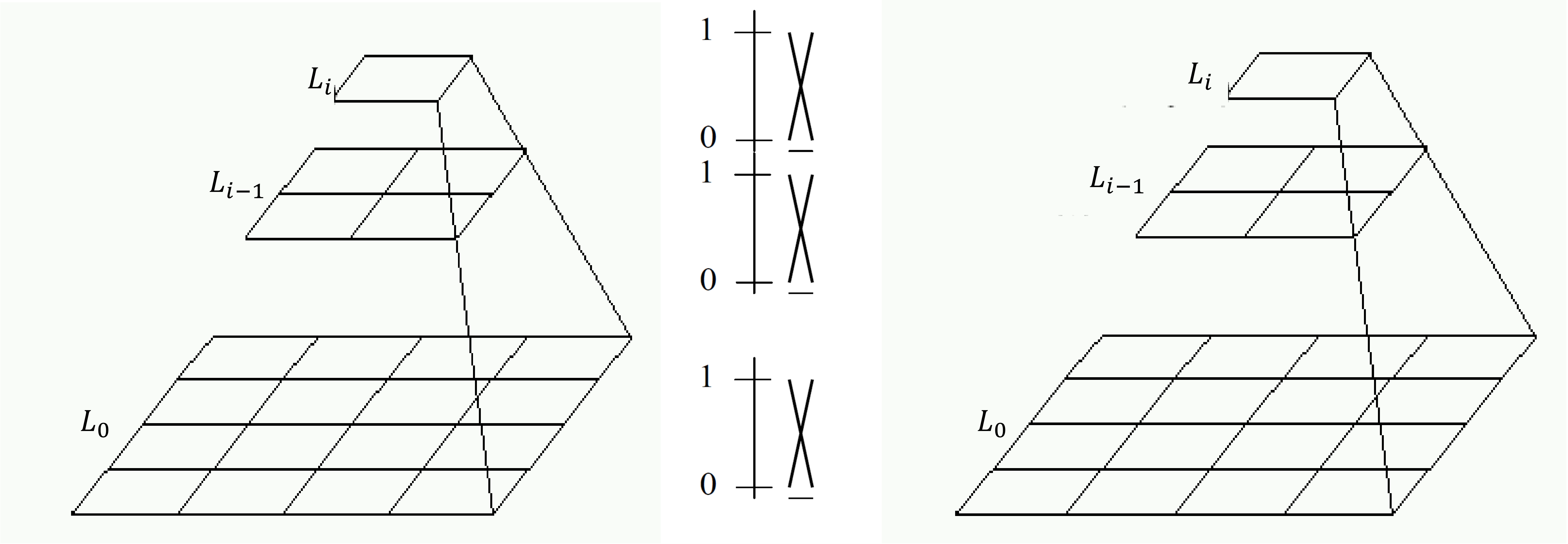
- **We can recover the original as:**

$$\boldsymbol{I} = \sum_{\boldsymbol{i}=\boldsymbol{0}}^{\boldsymbol{N}} (\boldsymbol{L_i}) \uparrow$$



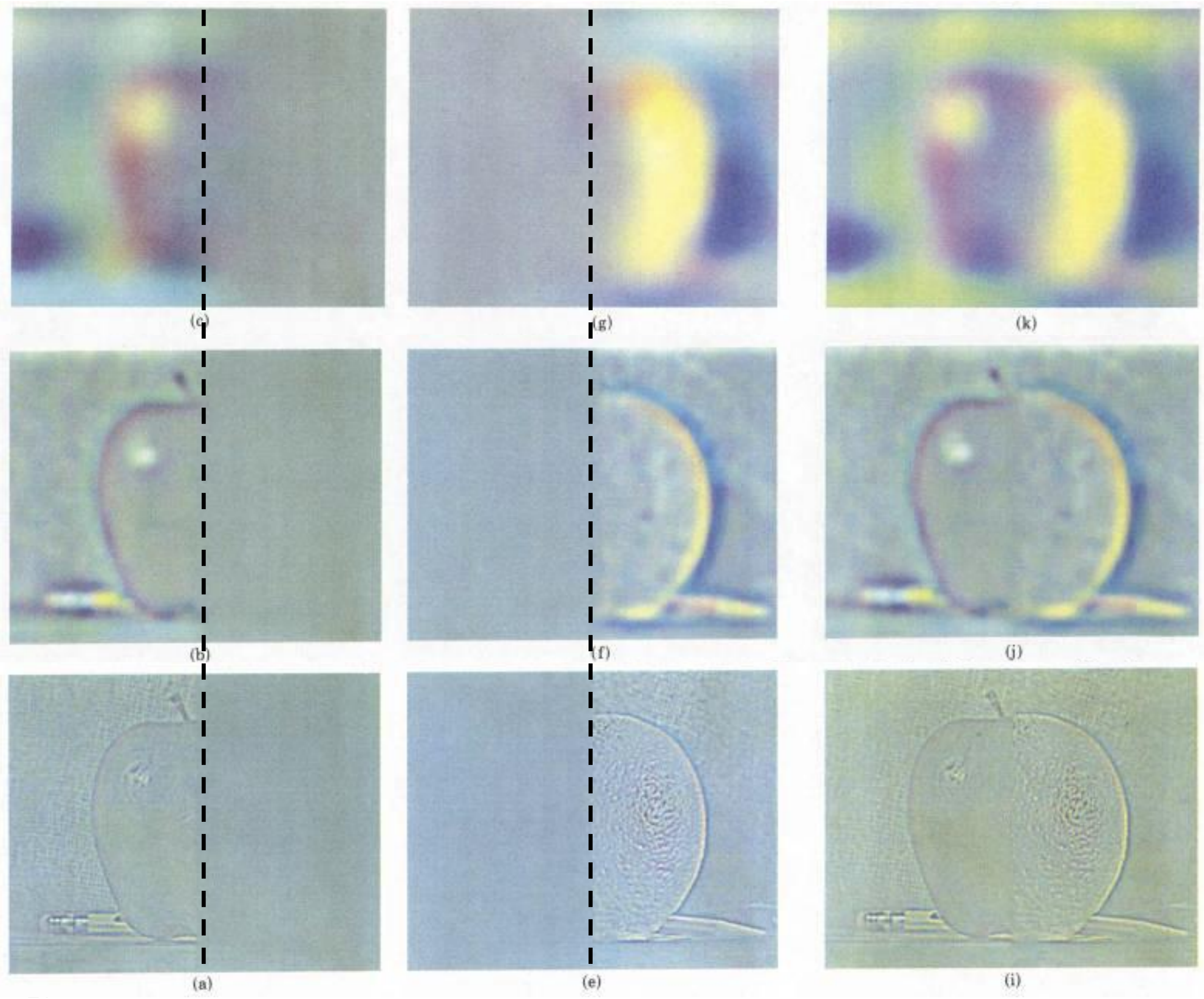
$\{L_i\}$ = the set of L_i form. A Laplacian pyramid L_1, L_2, $L_3 \cdots$, L_n

Pyramid Blending



Left pyramid　　　blend　　　Right pyramid

Pyramid Blending



Season Blending

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Season Blending

Target image

Target image with editing region

Source image

Result of pyramid blending

Poisson image editing

- A even better idea: to reduce the color mismatch between source and target, create composite in gradient domain.

- We want the gradient of the composite inside $\boldsymbol{\Omega}$ to look as close as possible to the source image gradient. The composite must match target image on the boundary $\boldsymbol{\partial\Omega}$.

Ω

$S(x, y)$

$$\min_{I(x,y)\epsilon\Omega} \sum \|\nabla I(x,y) - \nabla S(x,y)\|^2$$

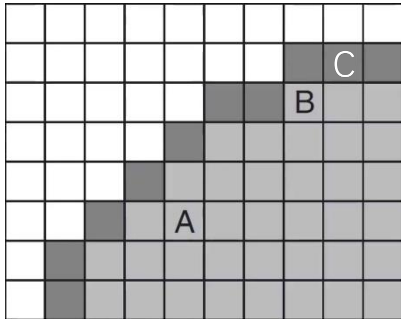
$T(x, y)$

$I(x, y)$

$$s.t. I(x,y) = T(x,y) \text{ on } \partial\Omega$$

- We want the gradient of the composite inside $\boldsymbol{\Omega}$ to look as close as possible to the source image gradient. The composite must match target image on the boundary $\boldsymbol{\partial\Omega}$.

Poisson image editing



- **Solution for this Pb:**

$$\nabla^2 I(x,y) = \nabla^2 S(x,y) \text{ in } \Omega$$

$$I(x,y) = T(x,y) \text{ on } \partial\Omega$$

- **Poisson equation**
- **Discretizing and solving the problem:**
- **1) For a pixel A inside Ω,**

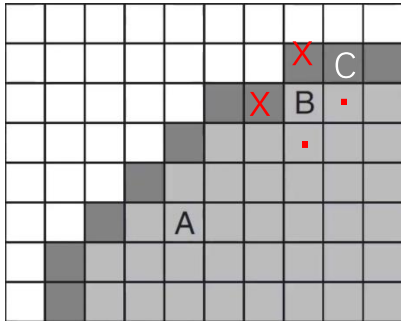
$$\nabla^2 I(x,y) = \nabla^2 S(x,y)$$

	1	
1	-4	1
	1	

$$I(x+1,y)+I(x,y+1)+ I(x-1,y)+I(x,y-1)- 4*I(x,y)$$

$$S(x+1,y)+S(x,y+1)+ S(x-1,y)+S(x,y-1)- 4*S(x,y)$$

Poisson image editing



➢ For a pixel B not inside Ω (whose neighbor is Ω).

$$\nabla^2 I(x,y) = \nabla^2 S(x,y)$$

$$\begin{matrix} I(x+1,y)+I(x,y+1)+ \text{ (xx)} \\ T(x-1,y)+T(x,y-1)- \text{ (..)} \\ 4*I(x,y) \end{matrix} \qquad \begin{matrix} S(x+1,y)+S(x,y+1)+ \\ S(x-1,y)+S(x,y-1)- \\ 4*S(x,y) \end{matrix}$$

- Big linear system: so in all there will be N unknowns and N equations that can be divided into 3 different groups

5 non-zeros values in a row

Less than 5 non-zeros values in a row

1 non-zeros value in a row

$$\begin{bmatrix} -4 & 1 & 0 & \dots & 0 & 1 & 0 & \dots & 0 \\ 1 & -4 & 1 & 0 & \dots & 0 & 1 & \dots & 0 \\ & & & & \vdots & & & & \\ \dots & 1 & -4 & 1 & 0 & \dots & 0 & 0 & 0 \\ & & & & \vdots & & & & \\ 0 & 0 & \dots & 1 & 0 & 0 & 0 & 0 & 0 \\ & & & & \vdots & & & & \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ \vdots \\ I_N \end{bmatrix} = \begin{bmatrix} \nabla^2 S^1 \\ \nabla^2 S^2 \\ \vdots \\ \nabla^2 S^n - \sum T_n \\ \vdots \\ T_N \end{bmatrix}$$

Group 1: $A \in \Omega$

Group 2: $B \in \partial\Omega \cap \Omega$

Group 2: $C \in \partial\Omega$

Source image

Target image

Poisson image editing result

Take home message

- Pyramid image blending is able to merge two images with similar background, however is not robust for color mismatch.
- Poisson image edit is more powerful on image blending Pbs with variations on background color.