# Lecture 13
# Image Blending


**Dr. Xiran Cai**

**Email: caixr@shanghaitech.edu.cn**

**Office: 3-438 SIST**

**Tel: 20684431**

**ShanghaiTech University**

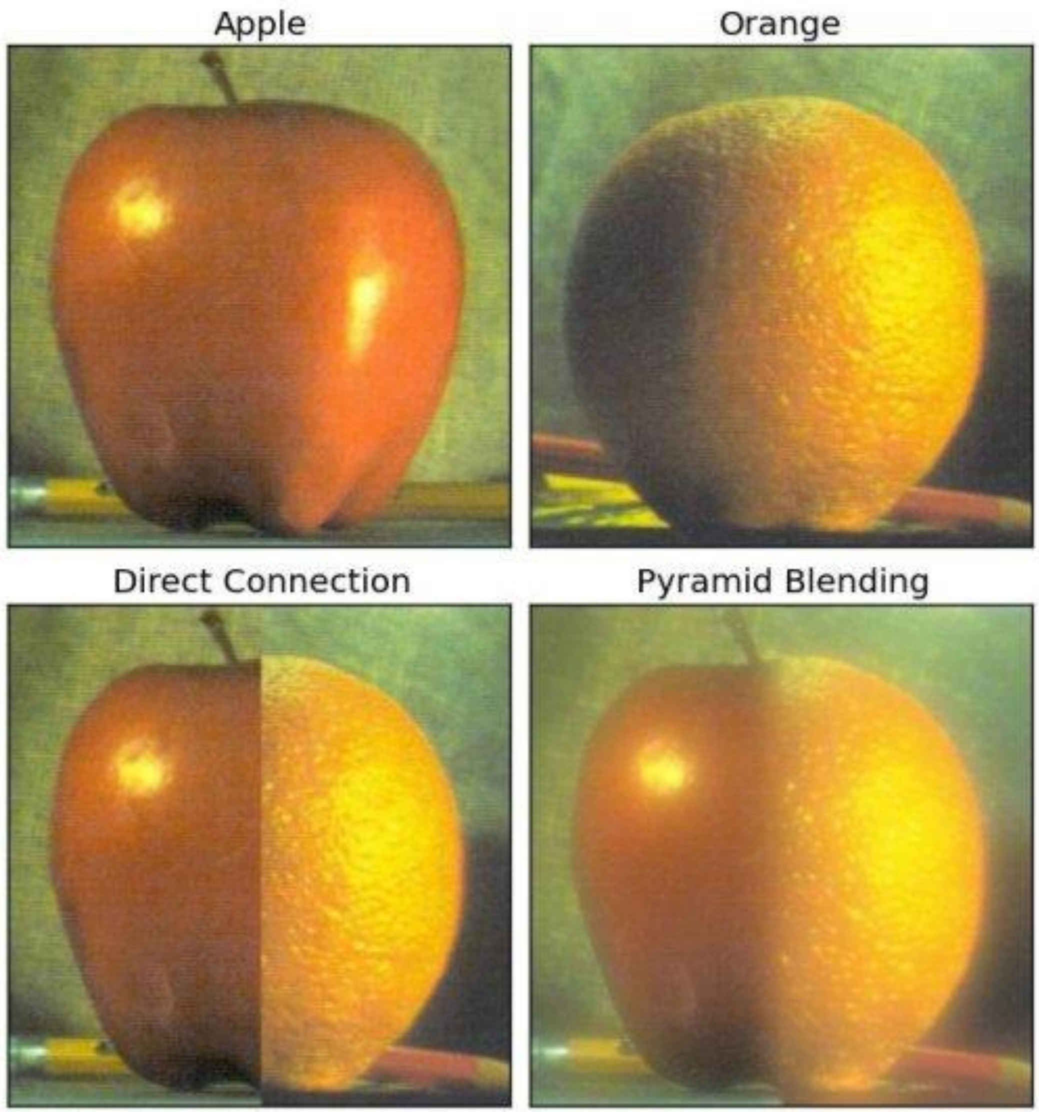

上海科技大学
ShanghaiTech University

# Long history of fake images

# Long history of fake images

# Long history of fake images

# Hard edge composition vs Pyramid Blending



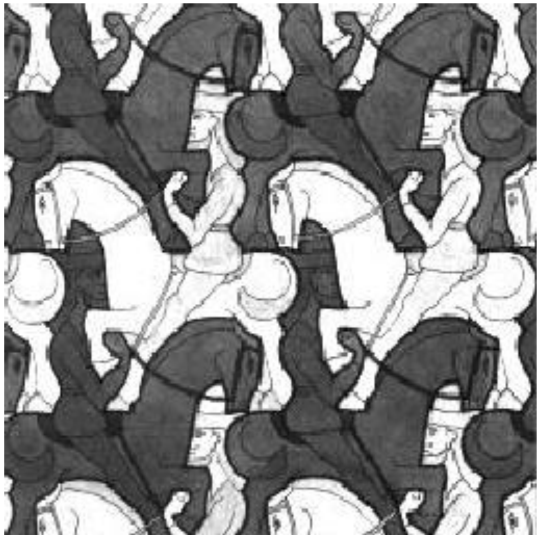
# Hard compositing

- Hard compositing:

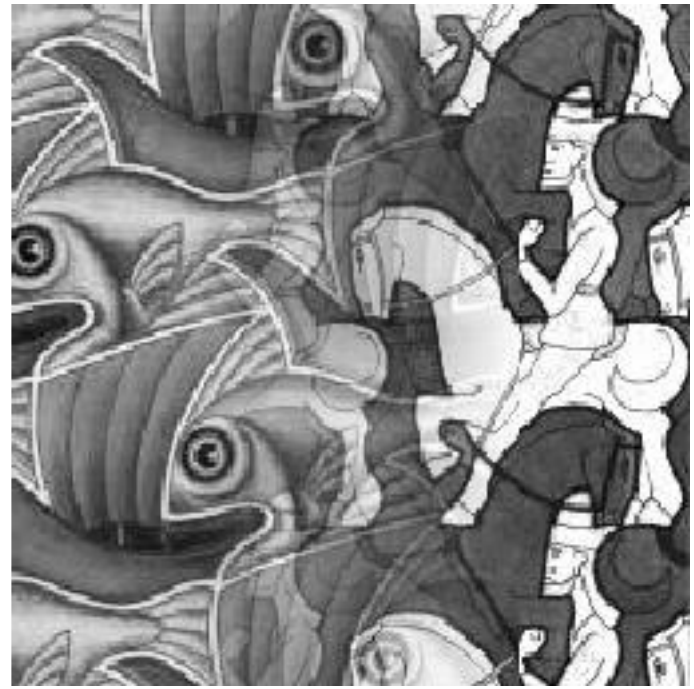
$$I(x,y) = M(x,y)S(x,y) + \big(1 - M(x,y)\big)T(x,y)$$

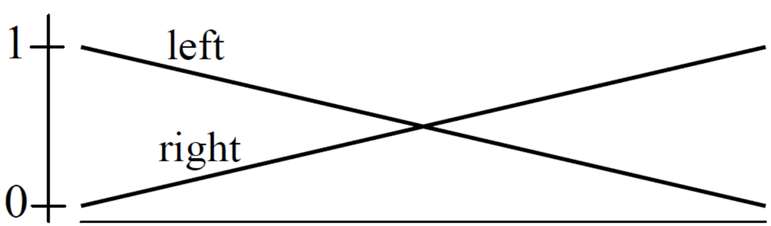
$$= \begin{cases} S(x,y) & M(x,y) = 1 \\ T(x,y) & M(x,y) = 0 \end{cases}$$

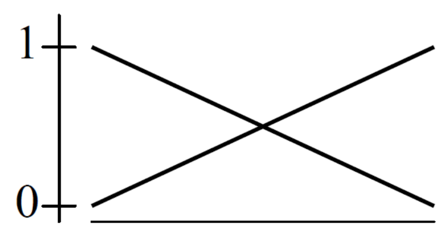
- Generally bad: seam/matte line is visible

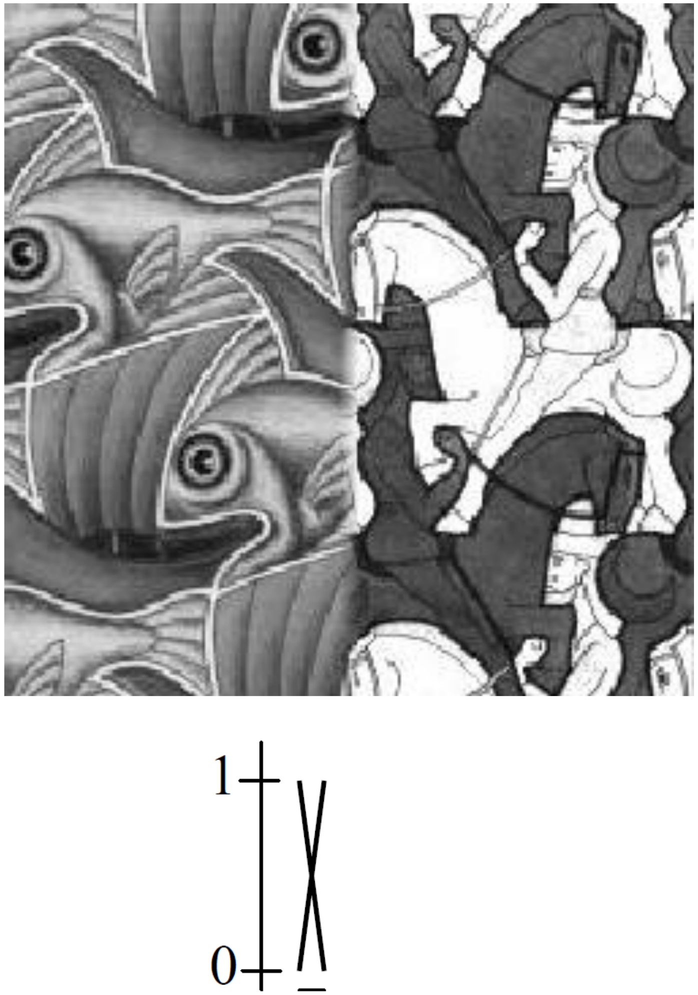

# Weighted transition region



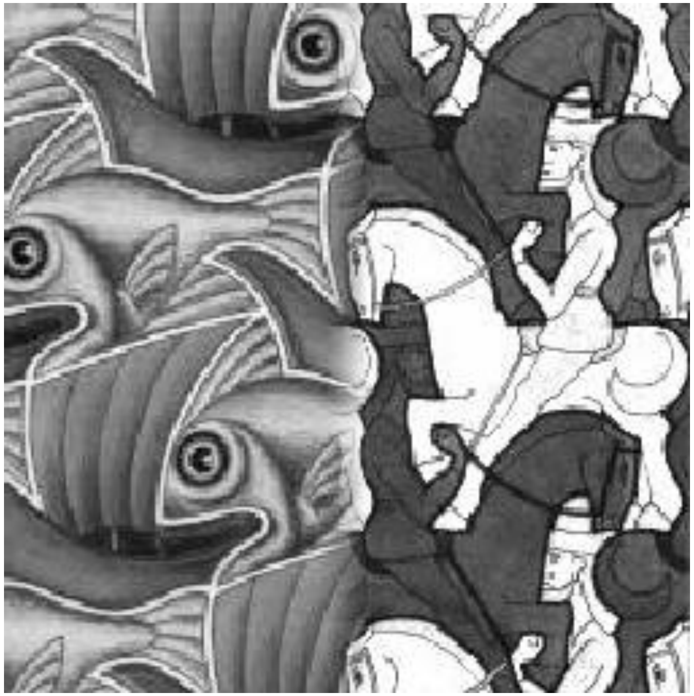


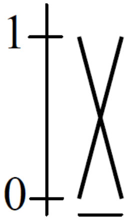



# Weighted transition region




# 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 by 2 in both directions

      ↑ Convolution
  - Get a series of smaller and blurry images.

# What does blurring take away?

# What does blurring take away?

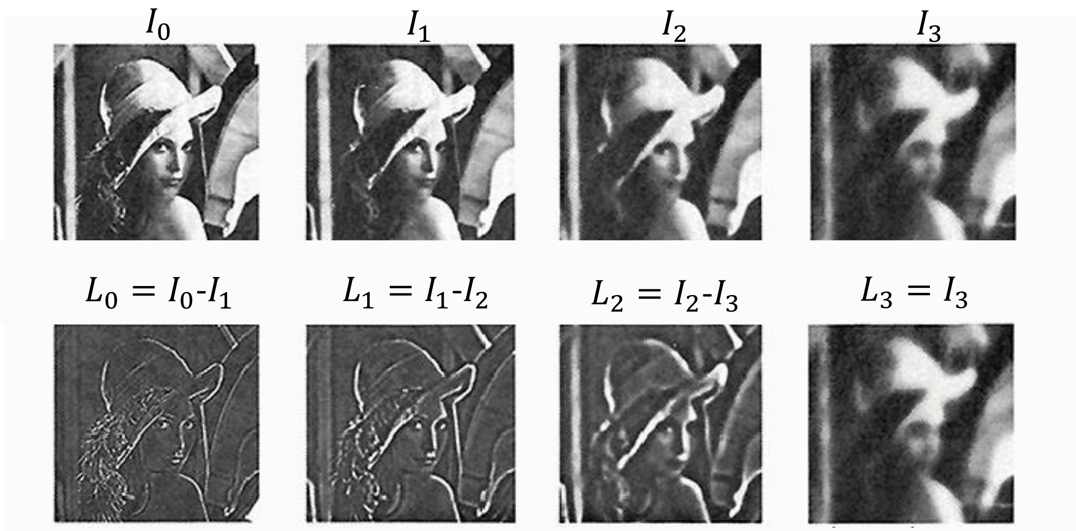
# What does blurring take away?

# 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 $i$

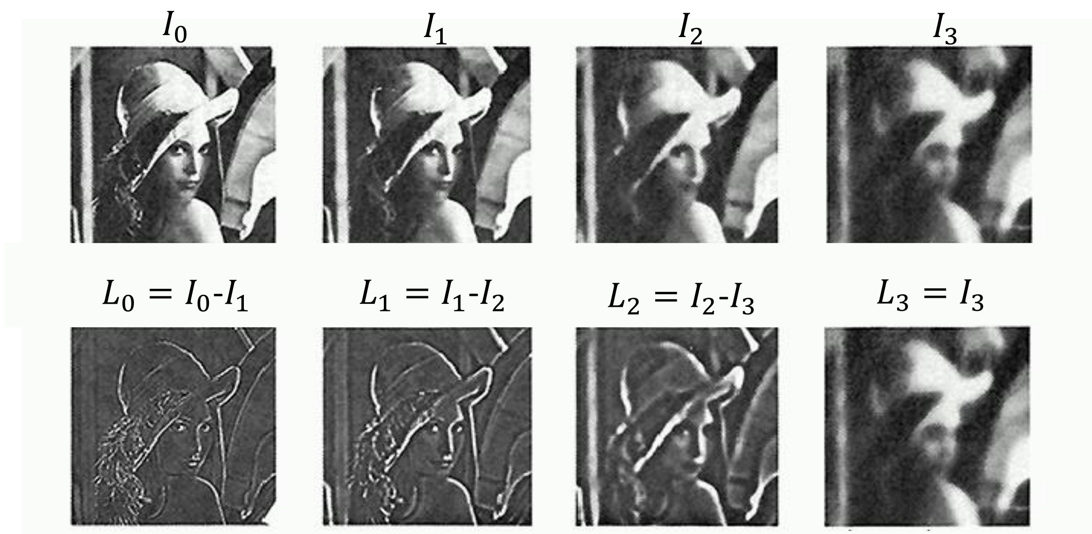



$\{L_i\}$ = the set of $L_i$ form. A Laplacian pyramid $L_1$, $L_2$, $L_3$..., $L_n$

# Pyramid blending

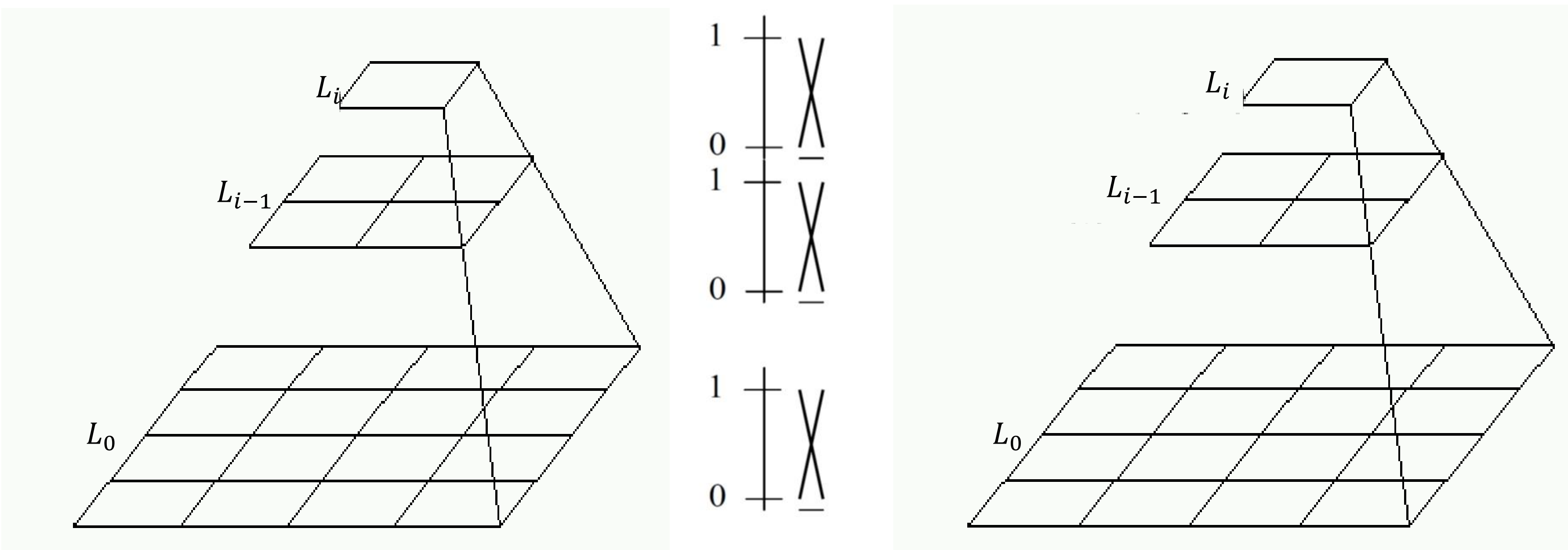
- We can recover the original as:

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



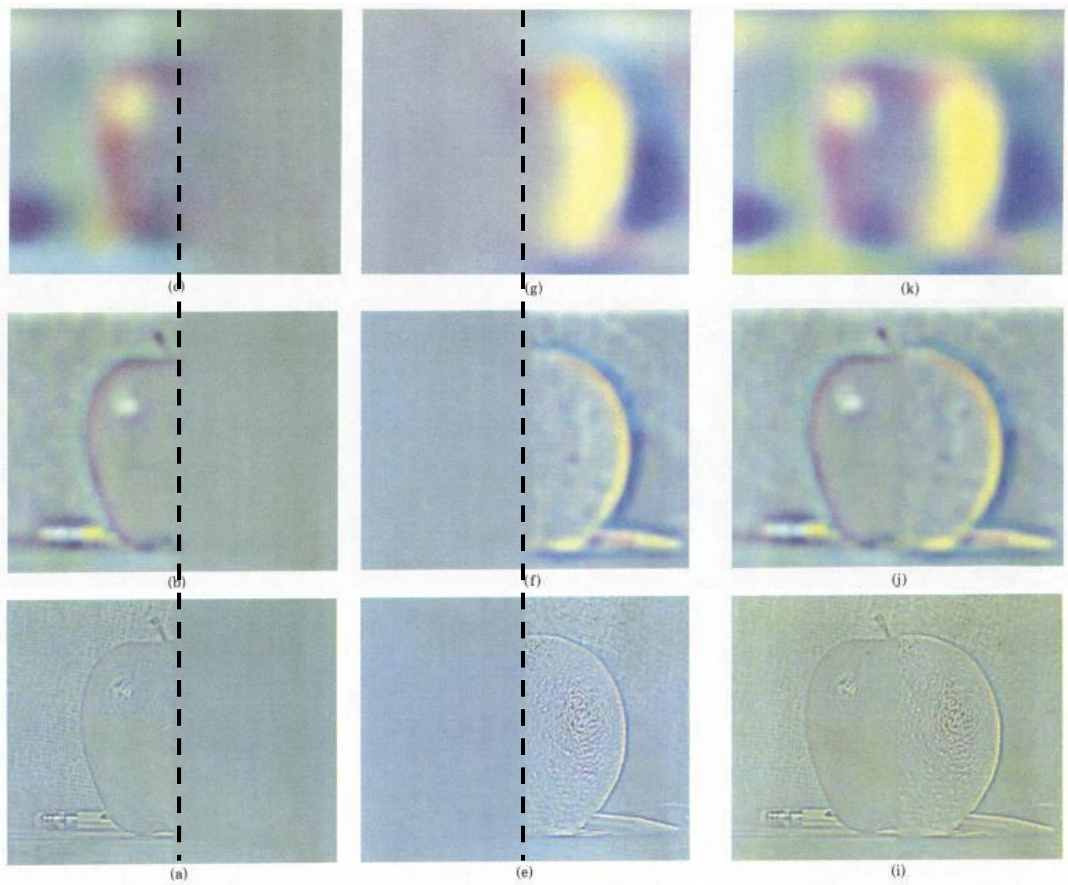

$\{L_i\}$ = the set of $L_i$ form. A Laplacian pyramid $L_1$, $L_2$, $L_3$..., $L_n$

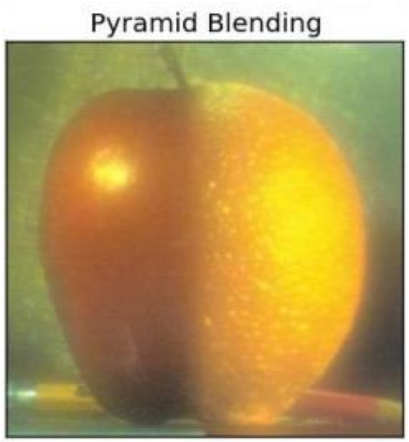
# Pyramid blending




Left pyramid | blend | Right pyramid

# Pyramid blending



# Season blending

# Season blending

**Target image**

**Target image with editing region**

**Source image**

**Result of pyramid blending**

# Poisson image editing

- A better idea: to reduce the color mismatch between source and target, create composite in gradient domain.
- We want the gradient of the composite inside Ω to look as close as possible to the source image gradient. The composite must match target image on the boundary ∂Ω.

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

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

$\Omega$

$S(x,y)$

$I(x,y)$

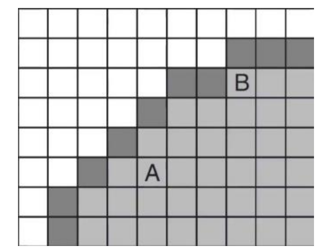
$T(x,y)$

# 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 $\Omega$,**

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

$$\uparrow \qquad\qquad\qquad \uparrow$$

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

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

| | | |
|---|---|---|
| | 1 | |
| 1 | -4 | 1 |
| | 1 | |

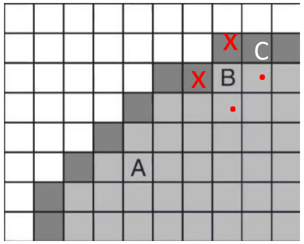
# Poisson image editing

- For a pixel B not inside $\Omega$ (whose neighbor is $\Omega$).

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

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

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




- **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

3 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 3: $C \in \partial\Omega$

Source image

Target image

Poisson image editing result

# Take home message

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