Mahidol University *Wisdom of the Land*

Chapter 4

Color Image Processing (Part 2)

Color Image Processing

Color Image Processing

Pseudo-color processing : grayscale image can be transformed into pseudo-color image by assigning the color values to the gray-level values based on a specific criterion.

- Intensity slicing

Full-color image processing: manipulating real color image.

- Color transformation
- Color complements
- Histogram equalization
- Color Image smoothing
- Color Image sharpening

Color Transformations

- In theory, any transformation can be performed in any color model.
- In practice, some operations are better suited to specific models.
- The cost of converting the color space in which to implement it.
- Example : To modify the intensity of the image in Fig. a) using

$$g(x,y) = kf(x,y)$$

- Where : $0 < k < 1$
- In the HSI color model, this can be done with the simple transformation :

$$s_3 = kr_3$$

- Where : $s_1 = r_1$ and $s_2 = r_2$

Color Transformations

- In the RGB color space, three components must be transformed :

$$s_i = kr_i \qquad i = 1,2,3$$

- In the CMY space, requires a similar set of linear transformations :

$$s_i = kr_i + (l - k) \qquad i = 1,2,3$$

- Regardless of the color space selected, the output is the same
  → Fig. b) (using)
- Fig. c) - e) : the mapping functions

Example : Color Transformations

- Formula for RGB :

$$s_R(x,y) = kr_R(x,y)$$
$$s_G(x,y) = kr_G(x,y)$$
$$s_B(x,y) = kr_B(x,y)$$

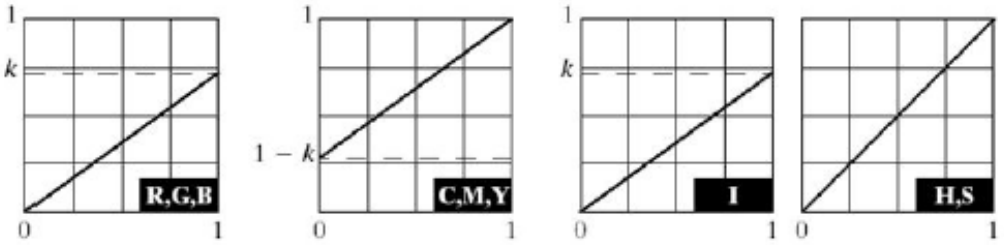
- Formula for HSI :

$$s_I(x,y) = kr_I(x,y)$$

- Formula for CMY :

$$s_C(x,y) = kr_C(x,y) + (1-k)$$
$$s_M(x,y) = kr_M(x,y) + (1-k)$$
$$s_Y(x,y) = kr_Y(x,y) + (1-k)$$

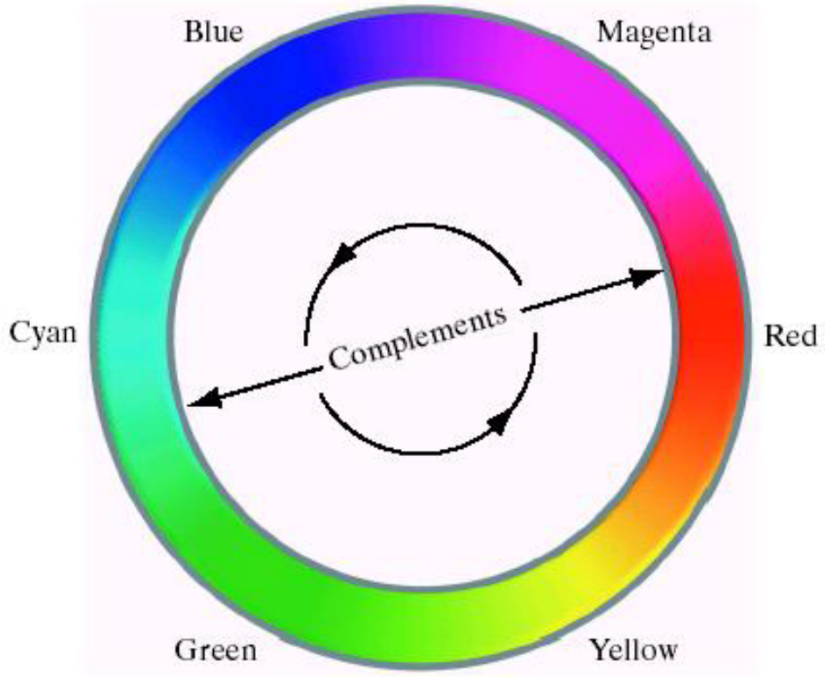
Adjusting the intensity of an image using color transformations.



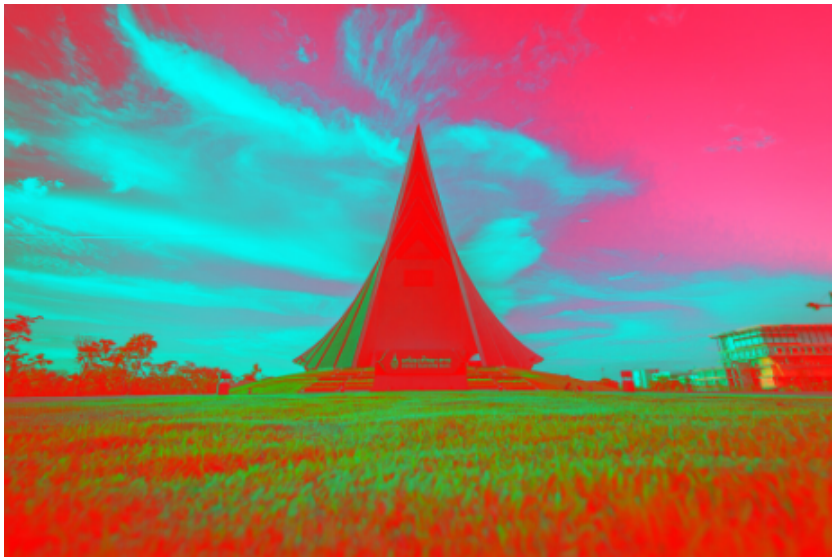
These 3 transformations give the same results.

Color Complements

- Color complement replaces each color with its opposite color in the color circle of the Hue component. This operation is analogous to image negative in a grayscale image.

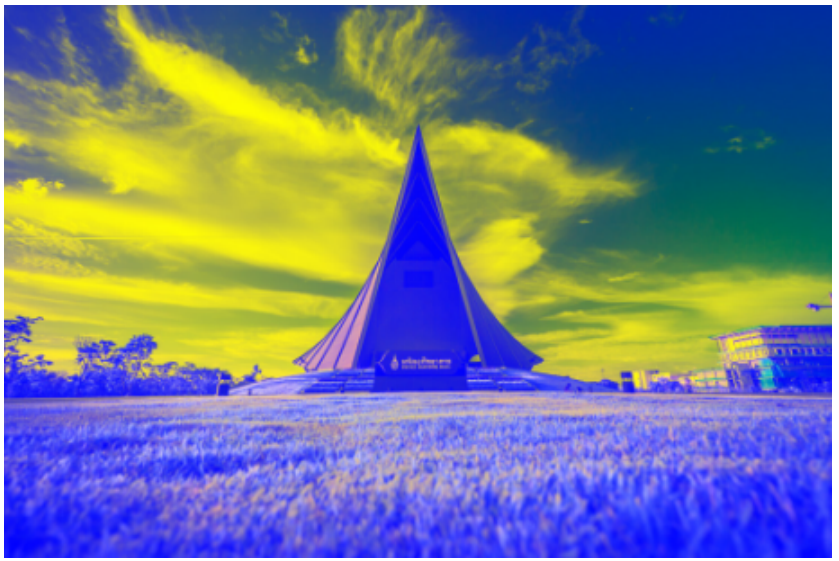


Example : Color Complements



R

G



B

Color Histogram Equalization

- Histogram equalization of a color image can be performed by adjusting color intensity uniformly while leaving color unchanged.
- It is generally unwise to histogram equalize the components of a color image independently. → results in erroneous color.
- A more logical approach is to spread the color intensities uniformly, leaving the colors themselves (e.g., hues) unchanged. → HSI color space is ideally suited to this type of approach.

Example : Color Histogram Equalization

Histogram Equalization

Method1: perform histogram equalization on RGB channels separately.

Method2: convert RGB to HSI, histogram equalize the intensity, convert back to RGB.

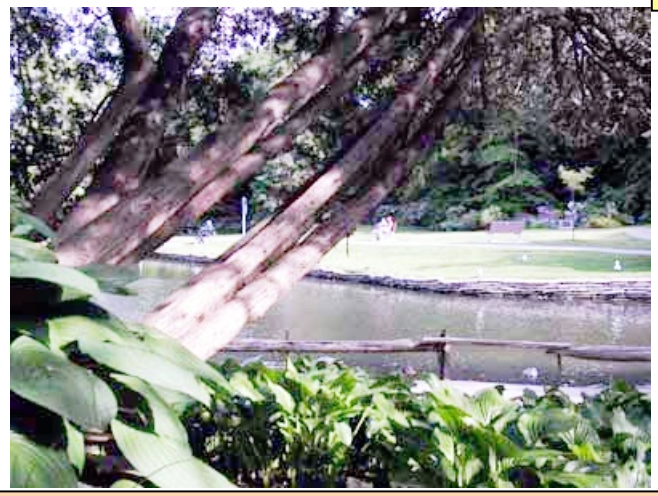
Method1: may cause alterations in the hue-which is undesirable.

Method2: will change only the intensity, leaving hue and saturation unchanged. It is the preferred method.

Note that two methods are not equivalent.

Example : Color Histogram Equalization

Original image



Method 1: after histogram equalization channel by channel (R,G,B)

Method 2: after histogram equalization on intensity of HSI and conversion

Example : Color Histogram Equalization

Original image

Method 1: after histogram equalization channel by channel (R,G,B)

Method 2: after histogram equalization on intensity of HSI and conversion

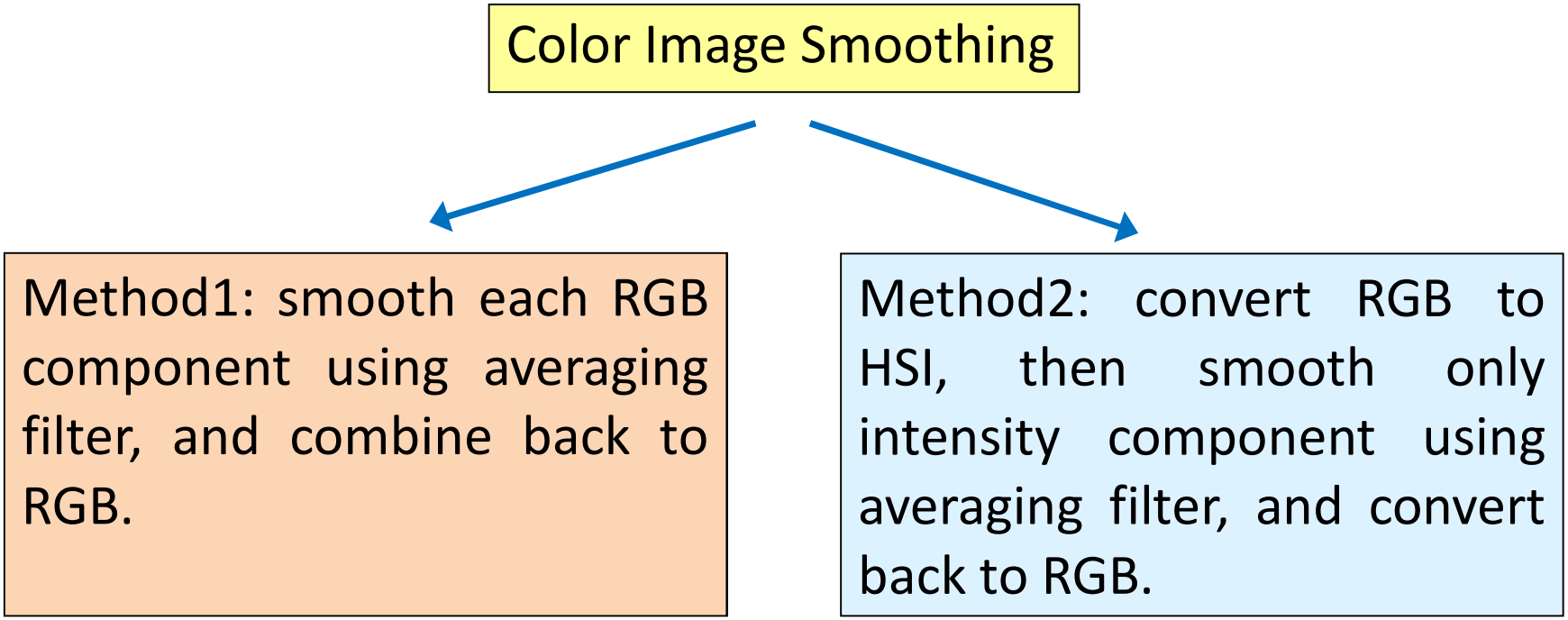
Color Image Smoothing

- Smoothing using averaging mask filter:

$$\bar{\mathbf{c}}(x,y) = \frac{1}{K}\sum_{(x,y)\in S_{xy}} \mathbf{c}(x,y) = \begin{bmatrix} \frac{1}{K}\sum_{(x,y)\in S_{xy}} R(x,y) \\ \frac{1}{K}\sum_{(x,y)\in S_{xy}} G(x,y) \\ \frac{1}{K}\sum_{(x,y)\in S_{xy}} B(x,y) \end{bmatrix}$$

- Where :
  - K is the number of pixels within the neighborhood of the averaging mask filter.
- Therefore, smoothing by neighborhood averaging can be done on a per-color-component basis.

Color Image Smoothing

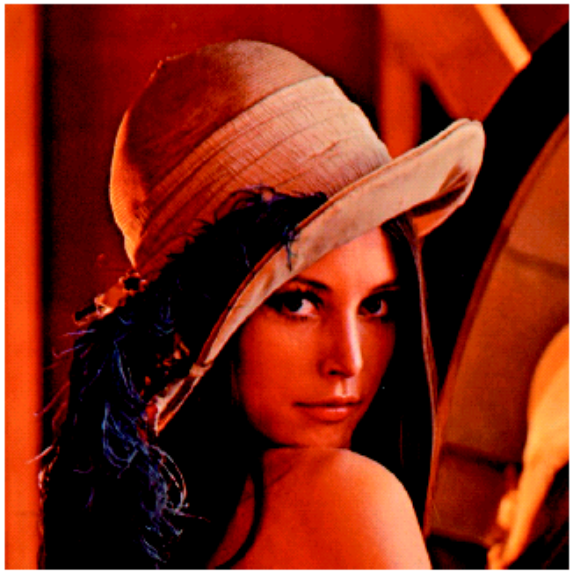


Note that two methods are not equivalent.

Example : Color Image Smoothing

- RGB

Color image



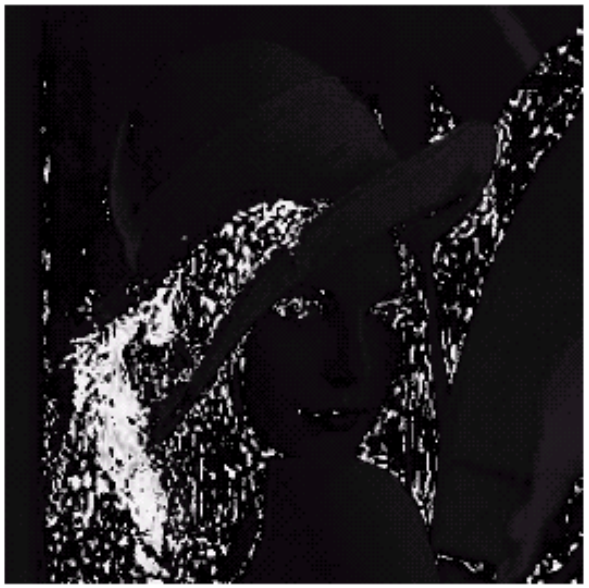
Red

Green

Blue

Example : Color Image Smoothing

- HSI

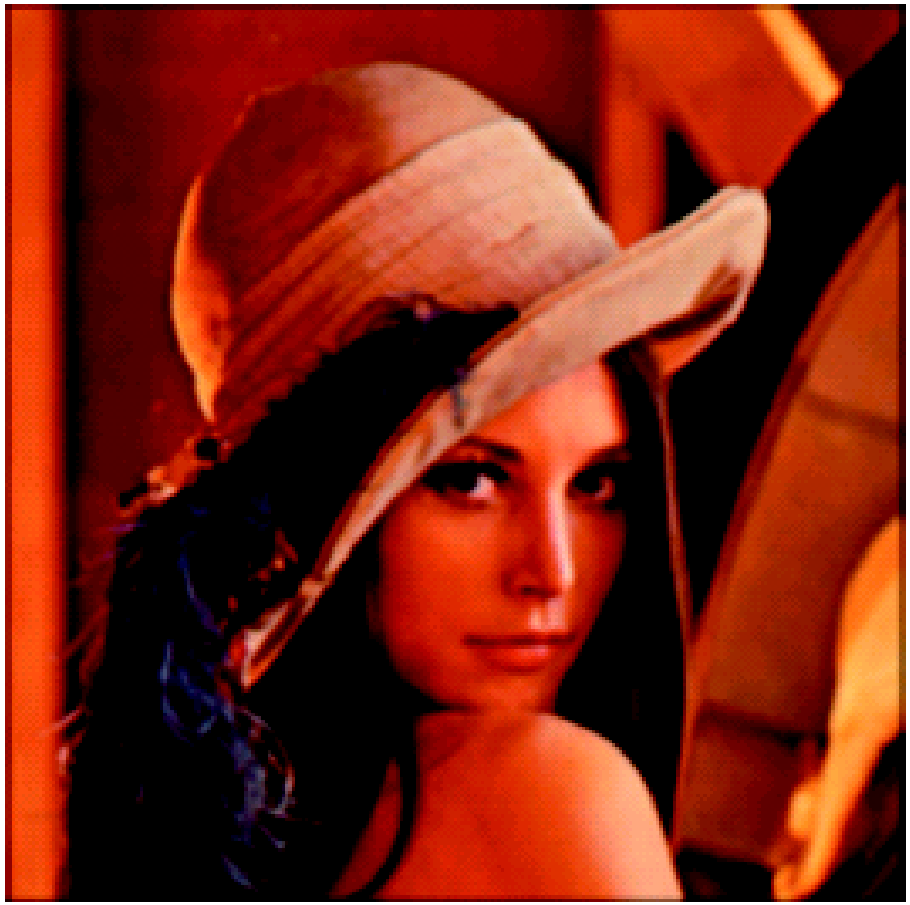


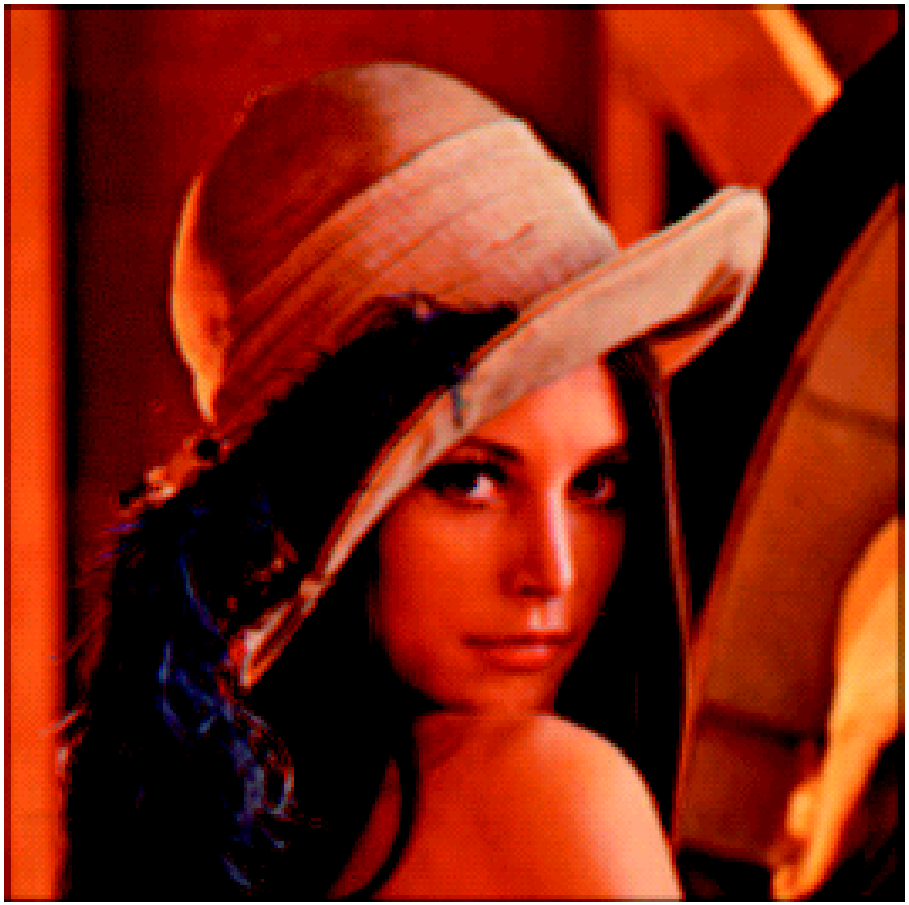
Hue

Saturation

Intensity

Color Image Smoothing

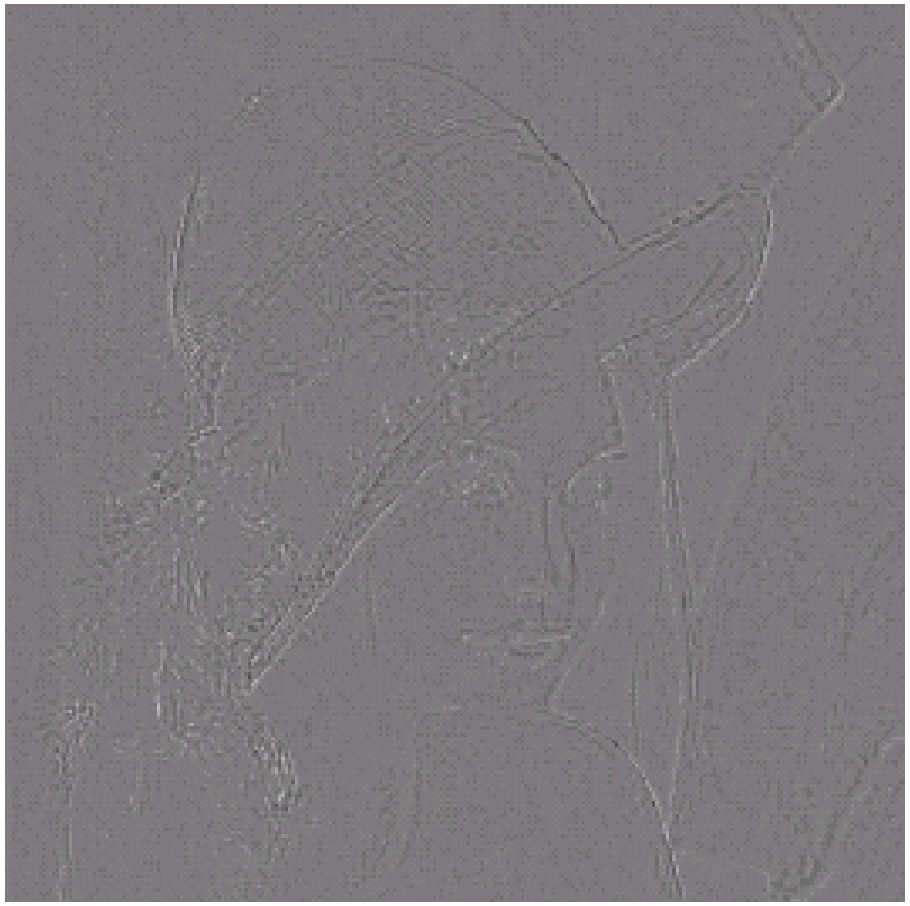




- Method 1 : Smoothing all RGB components
- Method 2 : Smoothing only I component of HSI

Example : Color Image Smoothing

- Difference between smoothed results from two methods.



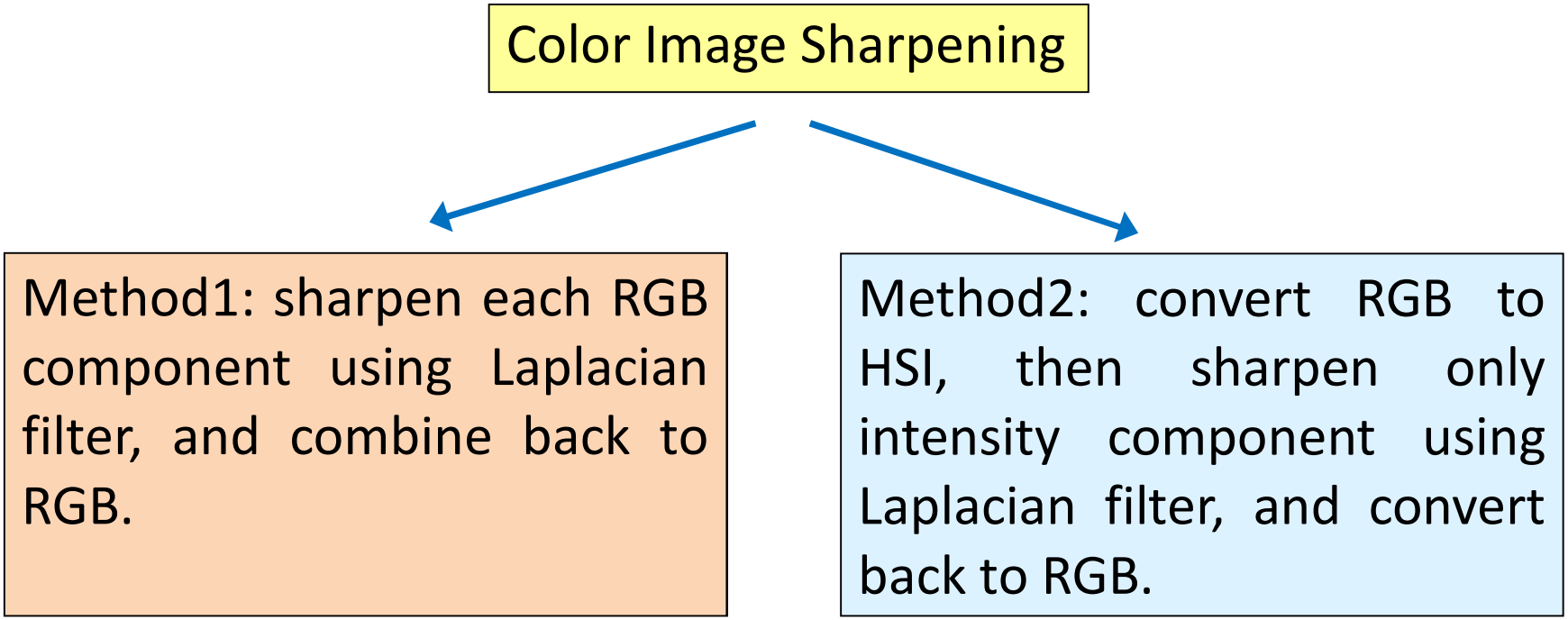
Color Image Sharpening

- Images can be sharpened by applying Laplacian operator. In the RGB color system, the Laplacian is defined as :

$$\nabla^2[c(x,y)] = \begin{bmatrix} \nabla^2 R(x,y) \\ \nabla^2 G(x,y) \\ \nabla^2 B(x,y) \end{bmatrix}$$

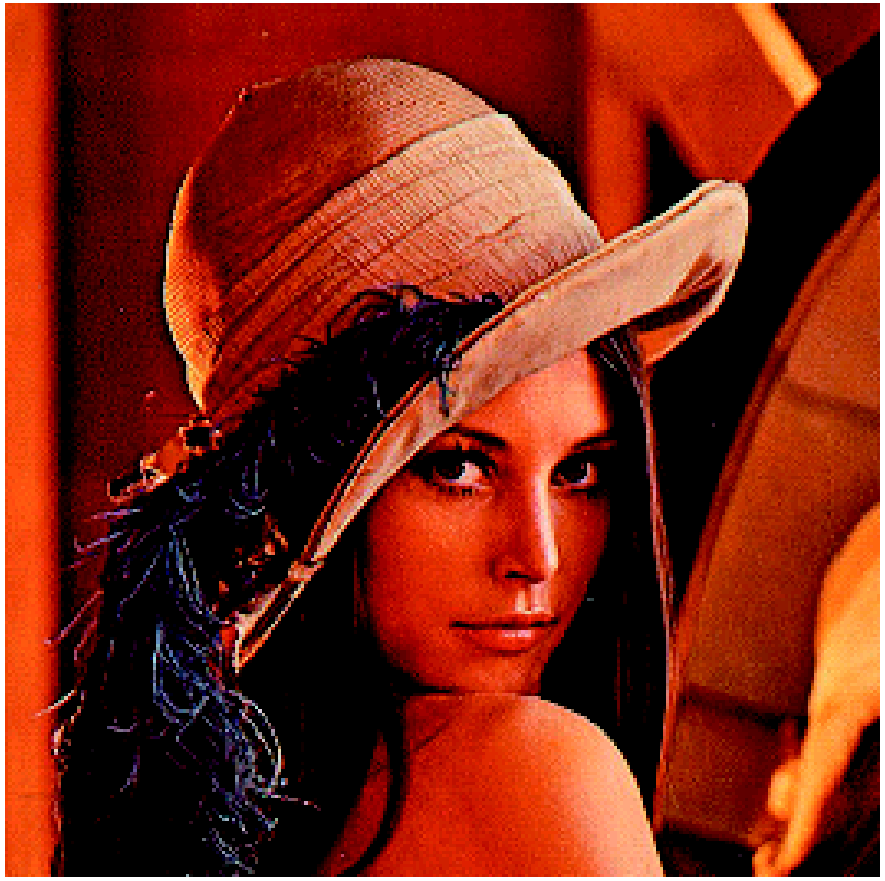
- which is a Laplacian operator applied to individual components of the image.
- Another approach is to apply Laplacian to the Intensity component only leaving color information unchanged.

Color Image Sharpening



Note that two methods are not equivalent.

Color Image Sharpening



- Method 1 : Sharpening all RGB components

- Method 2 : Sharpening only I component of HSI

Color Image Sharpening

- Difference between sharpened results from two methods.

Thanks for your attention