Principles and Applications of Digital Image Processing

B07611001 楊禮蔚

- Part 1: (30%)

2.5 You are preparing a report and have to insert in it an image of size 2048×2048 pixels.

(a)* Assuming no limitations on the printer, what would the resolution in line pairs per mm have to be for the image to fit in a space of size 5×5 cm?

(b) What would the resolution have to be in dpi for the image to fit in 2×2 inches?

(a)5cm = 50mm, the resolution would be 2048/2/50≒20lp/mm.
(b)2048/2 = 1024, dpi would be 1024.

2.12* Suppose that a flat area with center at (x_0, y_0) is illuminated by a light source with intensity distribution

$$i(x,y) = Ke^{-[(x-x_0)^2 + (y-y_0)^2]}$$

Assume for simplicity that the reflectance of the area is constant and equal to 1.0, and let $K = 255$. If the intensity of the resulting image is quantized using k bits, and the eye can detect an abrupt change of eight intensity levels between adjacent pixels, what is the highest value of k that will cause visible false contouring?

The image formed by illumination and reflection is given by

$$\mathrm{f}(\mathrm{x},\mathrm{y}) = \mathrm{i}(\mathrm{x},\mathrm{y}) * \mathrm{r}(\mathrm{x},\mathrm{y}) = 255 * \mathrm{e}^{-[(x-x_0)^2+(y-y_0)^2]} * 1.0 = 255\mathrm{e}^{-[(x-x_0)^2+(y-y_0)^2]}$$

If the intensities is quantized using m bits, the discretion would be D=(255+1)/2^m. so abrupt change of 8 intensity levels would be D=8=256/2^m=>m=5, so 32 bits, or fewer, would cause false contouring.

2.18 Consider the image segment shown in the figure that follows.

(a)* As in Section 2.5, let $V = \{0,1\}$ be the set of intensity values used to define adjacency. Compute the lengths of the shortest 4-, 8-, and m-path between p and q in the following image. If a particular path does not exist between these two points, explain why.

3	1	2	1 (q)
2	2	0	2
1	2	1	1
(p) 1	0	1	2

(b) Repeat (a) but using $V = \{1,2\}$.

(a)4-: no connectivity. Length=0.

3	1	2	1 (q)
2	2	0	2
1	2	1	1
(p) 1	0	1	2

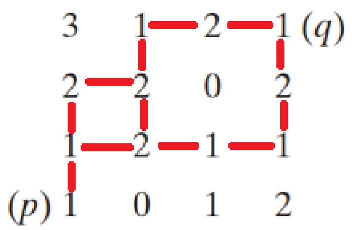
8-: have connectivity, multiple path. Length=4.

3	1	2	1 (q)
2	2	0	2
1	2	1	1
(p) 1	0	1	2

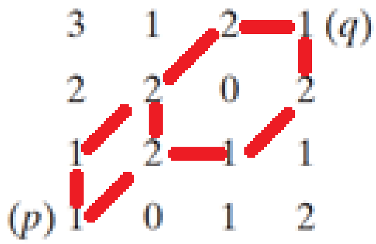
m-: have connectivity. Length=5.

3	1	2	1 (q)
2	2	0	2
1	2	1	1
(p) 1	0	1	2

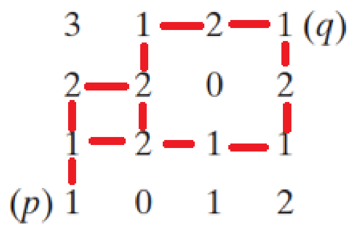
(b)4-: have connectivity. Length=6.



8-: have connectivity. Length=4…



m-: have connectivity. Length=6.



2.36 With reference to Table 2.3, provide single, composite transformation functions for performing the following operations:

(a)* Scaling and translation.

(b)* Scaling, translation, and rotation.

(c) Vertical shear, scaling, translation, and rotation.

(d) Does the order of multiplication of the individual matrices to produce a single transformations make a difference? Give an example based on a scaling/translation transformation to support your answer.

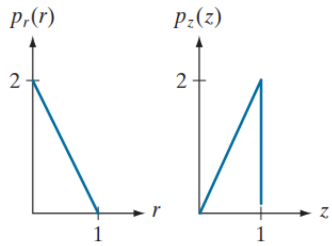
(a) $\begin{bmatrix} c_x & 0 & t_x \\ 0 & c_y & t_y \\ 0 & 0 & 1 \end{bmatrix}$

(b) $\begin{bmatrix} c_x \cos\theta & -c_y \sin\theta & t_x \cos\theta - c_y \sin\theta \\ c_x \sin\theta & c_y \cos\theta & t_x \sin\theta - c_y \cos\theta \\ 0 & 0 & 1 \end{bmatrix}$

(c) $\begin{bmatrix} c_x \cos\theta & c_x s_v cos\theta - c_y sin\theta & t_x cos\theta - t_y sin\theta \\ c_x \sin\theta & c_y cos\theta + c_x s_v sin\theta & t_x sin\theta - t_y cos\theta \\ 0 & 0 & 1 \end{bmatrix}$

(d)Yes, the order do matter. Assume two matrices A=$\begin{bmatrix} c_x & 0 & 0 \\ 0 & c_y & 0 \\ 0 & 0 & 1 \end{bmatrix}$, B=$\begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{bmatrix}$, and coordinate of P=$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$. Scaling first then translation: P'=BAP=$\begin{bmatrix} c_x x + t_x \\ c_y y + t_y \\ 1 \end{bmatrix}$, while translation first then scaling: P'=ABP=$\begin{bmatrix} c_x(x + t_x) \\ c_y(y + t_y) \\ 1 \end{bmatrix}$. The result is different. Because the matrix are not orthogonal.

3.12 An image with intensities in the range [0,1] has the PDF, $p_r(r)$, shown in the following figure. It is desired to transform the intensity levels of this image so that they will have the specified $p_z(z)$ shown in the figure. Assume continuous quantities, and find the transformation (expressed in terms of r and z) that will accomplish this.



(a)T(r)=-r^2 + 2r->z=sqrt(-r^2+2r)

3.21 Given the following kernel and image:

$$w = \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix} \quad f = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

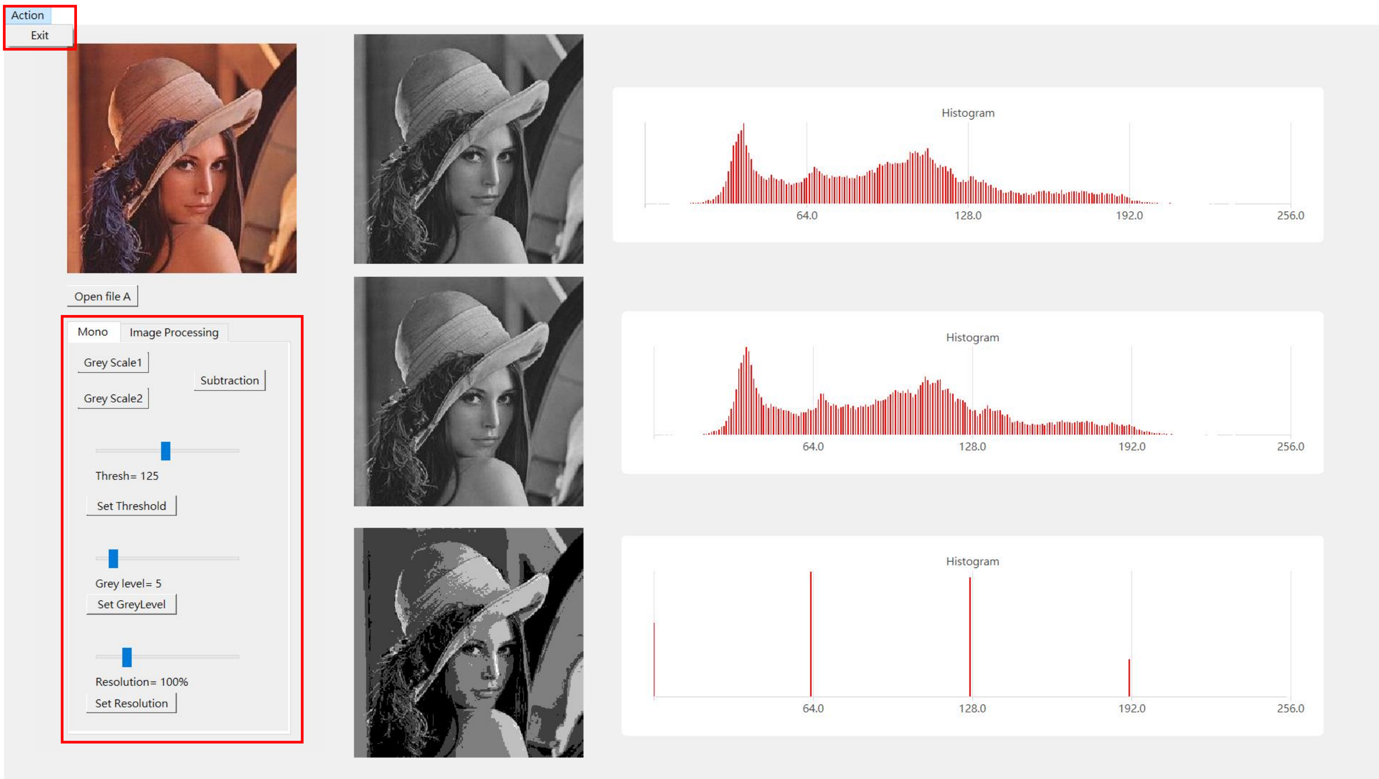
(a) Give the convolution of the two.

(b) Does your result have a bias?

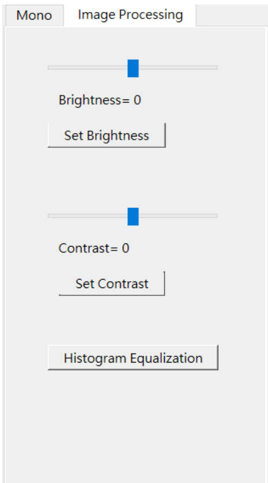
(a)$w * f = \begin{bmatrix} 9 & 12 & 12 & 12 & 9 \\ 12 & 16 & 16 & 16 & 12 \\ 12 & 16 & 16 & 16 & 12 \\ 12 & 16 & 16 & 16 & 12 \\ 9 & 12 & 12 & 12 & 9 \end{bmatrix}$

(b)Yes, because it do no have normalization multiplier.

- Part 2: (70%) Image File Reading, Display and Basic Processing
  - UI:



Use tab to switch manipulation option between grey scale image and color image.

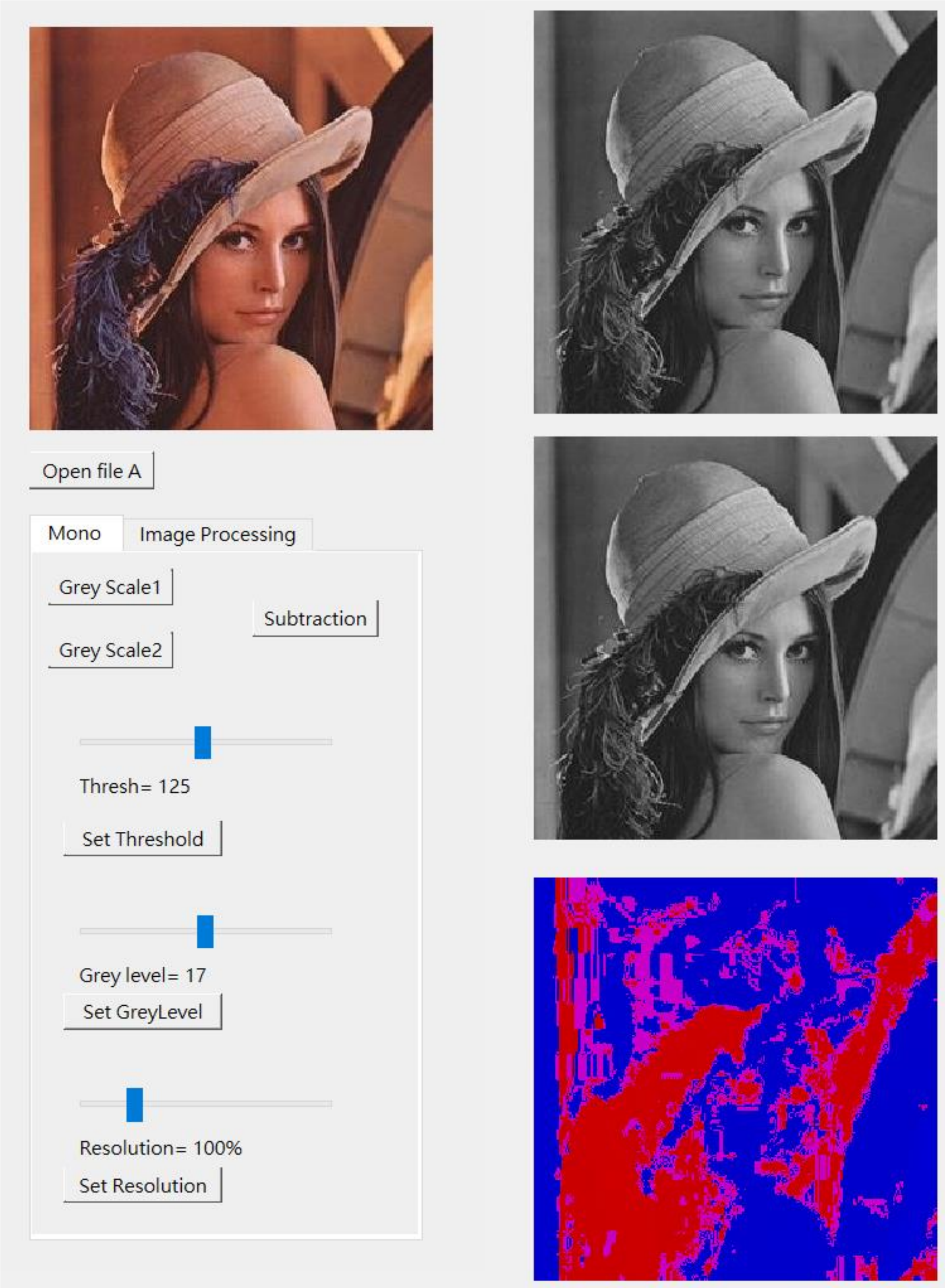


Grey Scale1-> A. GRAY = (R+G+B)/3.0

Grey Scale2-> B. GRAY = 0.299*R + 0.587*G + 0.114*B

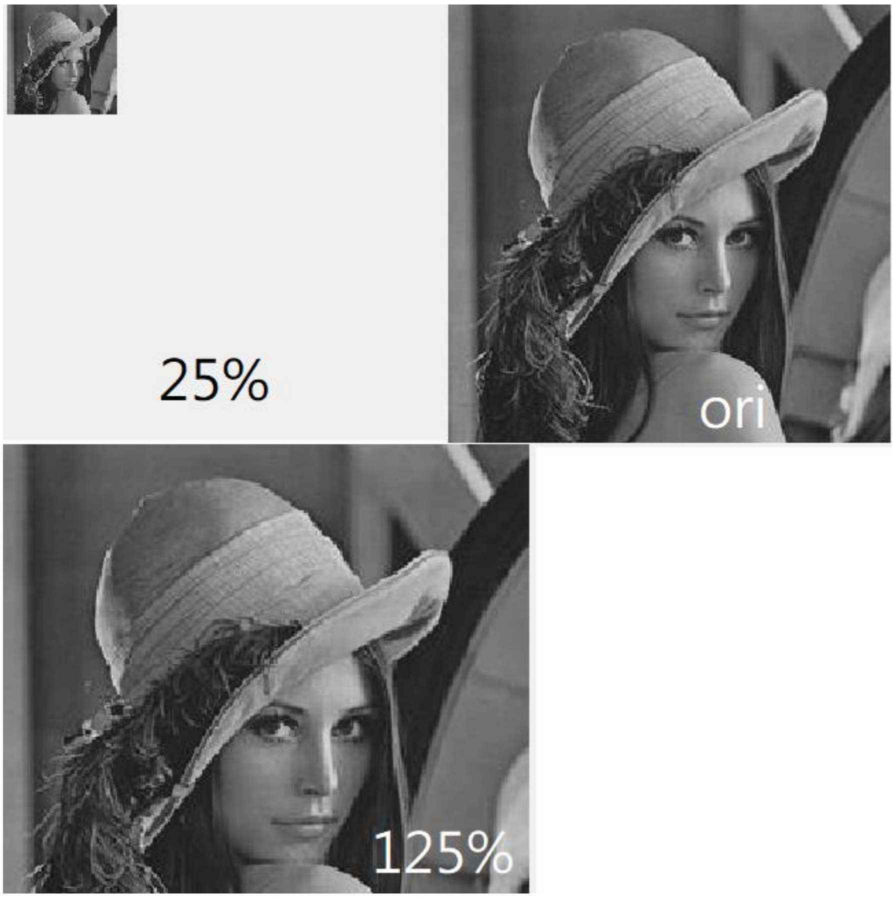
Subtraction->use a color image to compare two grey image. If the intensity in Grey Scale1 is larger, show red; if the intensity in Grey Scale2 is larger, show blue; if the intensity is equal, show purple.

- Discussion
  - Because blue's weight in grey2 is lower, after subtraction, the blue feather on the hat is marked by red, which means the intensity in grey1 is greater than grey2. As for the frame of the mirror, same result is shown.



◆ The effect when modify threshold.

◆ The effect when modify spatial resolution. As the length is set to 25%, the area ratio is 1/16. When enlarge image, the image is cropped due to window boundary. Further study in the layout system of QT may solve the problem.



- As grey level decrease, the effect of false contour becomes more salient.

- The effect when modify brightness. As we can see the effect is not comparable, the negative one we can barely distinguish Lena from the background. This implies the original image is darker than average.

- The effect when modify contrast. When -255, the image becomes totally grey; when 255, the red component of the image becomes more salient because the image red in nature.

- The result after histogram equalization.
  As we can see from the picture, the hue becomes more balanced, and the detail in the dark region becomes clear.