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HCMUTE

Lecture:
IMAGE PROCESSING

Chapter 5:
Image Enhancement

Nguyen Thanh Hai, PhD

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Image Enhancement

Introduction

- A graph of $P_r(r_k)$ often refers to as a histogram, image filtering, enhancement and restoration

- For dark images, the gray levels close to zero are very strong and a considerable position of the histogram energy is centered on its left-hand side.
- For bright images, the balance is visibly shifted toward higher gray levels (i.e., bright gray levels).
- The task of histogram equalization is to create a balance between all gray levels, and the histogram of the image can be close to the uniform distribution.

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Image Enhancement

Introduction

- Analyse certain regions in an image to find features for applications.
- Components of the image need to be emphasized and highlighted
- Image restoration and enhancement techniques

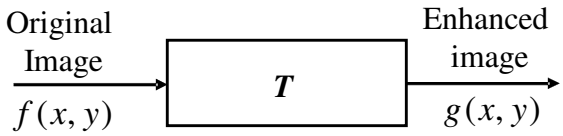

Fig. 5.1: Schematic diagram of image enhancement technique

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Image Enhancement

-Spatial Domain Image Enhancement Techniques: Basically two categories: mask processing and point processing as in Fig. 5.2.

1**. Point processing:** each pixel in original image at coordinates (x,y) is processed to create the corresponding pixel at coordinates (x,y) in the enhanced image

2**. Mask processing:** Not only the pixel in original image at coordinates (x,y) is processed, but also some neighboring pixels of this pixel at coordinates (x,y) in the enhanced image are involved in creating the new pixel.

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- Image is often describe in the space domain or the frequency domain.

Fig. 5.2(a): Schematic diagram of mask processing with many input pixels to produce one output pixel

(a)

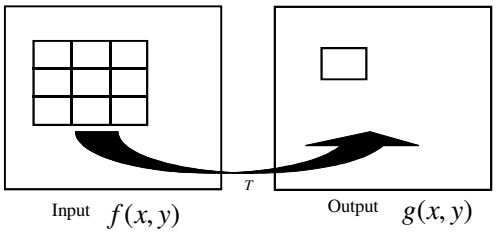
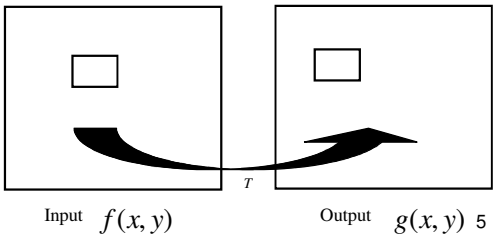


Fig. 5.2(b): Schematic diagram of point processing technique using one to one.

(b)



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Point processing: Use a mathematical transformation to modify the pixel values in the original image to produce the value of the corresponding pixels in the enhanced image.

- The mathematical expression is described as follows:

$$g(x,y) = T[f(x,y)] \quad (5.1)$$

where $f(x,y)$ is the original (input) image, f(x,y) is the enhanced (output) image and transformation between two images is ***T.***

-Point processing is to improve the image quality by manipulating its gray-level range.

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Contrast Enhancement

-Manipulate the image such that the object occupies a larger range of the gray level for increasing the visibility of the object.

-The exact shape of the transformation for stretching can be controlled by values of (r1, s1) and (r2, s2) as shown in Fig. 5.3.

-r1=s1 and r2=s2: no effect of the gray level of the original image.
- Input ***r*** of image (0-255) and its output ***S*** (0-255)

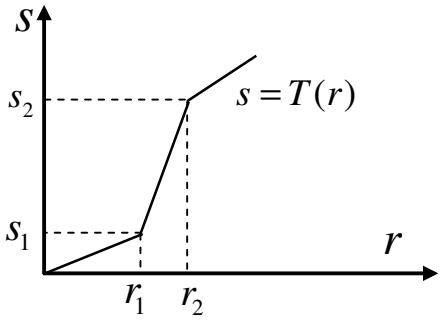

Fig. 5.3: Contrast Enhancement using point processing

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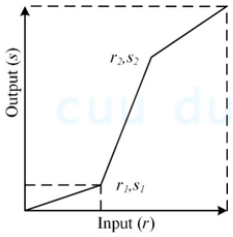
POINT PROCESSING

Point processing: each pixel in original image at the coordinate (x,y) is processed to create the corresponding pixel at coordinates (x,y) in the enhanced image without based on neighborhood pixels.



(a) Transform function

(b) Original Image

(c) Image after using transform

(d) Image after using threshold

Fig. 5.3: Enhancement technique

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Image Enhancement

EX 5.1: Express contrast enhancement as in Fig. 5.2

```
clear all;
f=imread('pout.tif');
r1=min(min(f));
r2=max(max(f));
for i=1:size(f,1)
   for j=1:size(f,2)
if f(i,j)==r1
          g1(i,j)=0;
      elseif f(i,j)==r2
          g1(i,j)=255;
else
          g1(i,j)=255/(r2-r1)*(f(i,j)-r1);
end
   end
end
g1=uint8(g1);
m=mean2(f);
for i=1:size(f,1)
   for j=1:size(f,2)
      if f(i,j) <= m
g2(i,j)=0;
      else
         g2(i,j)=255;
end
   end
end
g2=uint8(g2);
```


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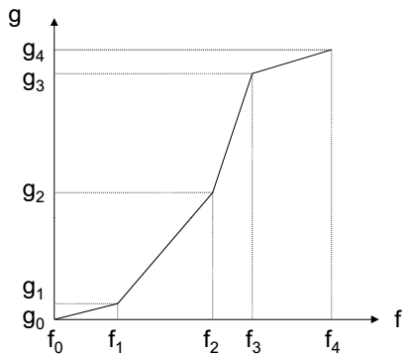
- *stretchlim* for finding the limit of the gray max-min values in contrast enlarger as well as *imadjust*

(a) (b)

Fig 5.3. *Enhancement of image by combination of stretchlim and imadjust: (a) original image; (b) Image after* contrast enlarger

Image Enhancement

K segments



$$g(f) = \frac{f - f_k}{f_{k+1} - f_k} * (g_{k+1} - g_k) + g_k;$$
$$for\ f_k < f \le f_{k+1}, \quad k = 0,1,...,K-1$$

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HISTOGRAM

Histogram of an image with gray *L*, the discrete function is expressed as follows:

$$h(r_k) = n_k$$

In which r_k is the gray value with *k* in interval [0, *L*-1] and n_k is the number of pixels corresponding to the gray value r_k. For example, the interval [0, 255], $r_0 = 0$, $r_1 = 1$, …

-Consider the gray level values of r, the probability density function $P_r(r_k)$ is represented as follows:

$$P_r(r_k) = \frac{n_k}{n} = \frac{h(r_k)}{n}, \qquad k = 0, 1, 2, \ldots, L-1$$

where *n* is the total number of pixels in the image and n_k represents the total number of pixels with the gray level r_k.

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HISTOGRAM

Sử dụng hàm imhist để thực hiện histogram của ảnh:
h = imhist(f, b)
Trong đó, f là ảnh cần thực hiện histogram, b là số đoạn biểu diễn (mặc định là 256). Nếu b nhỏ, giả sử b = *2*, thì thang cường độ sẽ chia làm 2 khoảng: 0 đến 127, 128 đến 255, trong đó h(1) là số pixels có giá trị trong đoạn [0, 127] và h(2) là số pixels có giá trị trong đoạn [127, 255]. Nếu không có thông số đầu ra thì hàm imhist biểu diễn cho histogram của ảnh.
Ngoài ra có thể có được hàm $p(r_k)$ qua dòng lệnh:
p = imhist(f,b)/numel(f);
Với numel là tổng số pixels có trong ảnh f.

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HISTOGRAM

Ví dụ 5.3: Một số dạng đồ thị dùng để biểu diễn histogram

```
clear all;
f=imread('pout.tif');
h=imhist(f);
imhist(f);
axis([0 255 min(h) max(h)]);
figure;bar(0:255,h);
axis([0 255 min(h) max(h)]);
figure;stem(0:255,h,'marker','none');
axis([0 255 min(h) max(h)]);
figure;plot(0:255,h);
axis([0 255 min(h) max(h)]);
```

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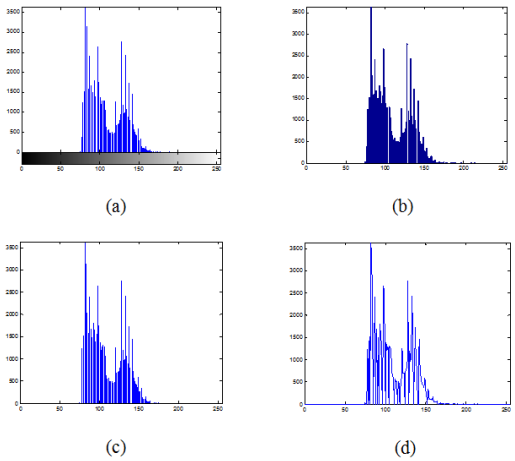
HISTOGRAM



Hình 5.4. *Một số dạng đồ thị có thể được dùng để biểu diễn histogram(a) imhist (dạng mặc định); (b) bar; (c) stem; (d) plot*

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HISTOGRAM EQULIZATION

Example 5.1: Determine the table of the grey histogram h(g) of the 4x4 image bellow and plot this histogram.

2	3	3	2
4	2	4	3
3	2	3	5
2	4	2	4

4x4 image

g					
h(g)					

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Histogram Equalization

- Histogram equalization to enhance image
- Due to the different gray levels of images, one needs to process to equalize the gray level distribution of the image before other processing steps.

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Example 5.2: There is an image matrix I with the gray levels of pixels and a table with the range of the gray levels g of the image I as shown the following figure.

$$I = \begin{pmatrix} 1 & 2 & 0 & 4 \\ 1 & 0 & 0 & 7 \\ 2 & 2 & 1 & 0 \\ 4 & 1 & 2 & 1 \\ 2 & 0 & 1 & 1 \end{pmatrix}$$

g	0	1	2	4
h(g)	5	7	5	2

Fig. 5.4: Representation of the gray levels of the image and the histogram equalization of the image

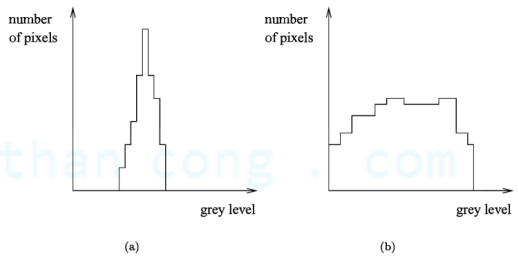

Fig. 5.5: (a) bad image; (b) good image.

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➢**Histogram Equalization** – Discrete intensity

$$s_k = T(r_k) = (L-1)\sum_{j=0}^{k} p_r(r_j)$$

$$s_k = T(r_k) = \frac{(L-1)}{M.N}\sum_{j=0}^{k} n_j ; 0 \le k \le L-1$$

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- PDF of original image

r_k	n_k	$p_r(r_k) = n_k / MN$
$r_0 = 0$	790	0.19
$r_0 = 1$	1023	0.25
$r_0 = 2$	850	0.21
$r_0 = 3$	656	0.16
$r_0 = 4$	329	0.08
$r_0 = 5$	245	0.06
$r_0 = 6$	122	0.03
$r_0 = 7$	81	0.02

Assume that: L = 8, M = N = 64 and M.N = 4096

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$$k = 0; s_0 = T(r_0) = 7.\sum_{j=0}^{0} p_r(r_j) = 7.p_r(0) = 1.33 \Rightarrow 1$$

$$k = 1; s_1 = T(r_1) = 7.\sum_{j=0}^{1} p_r(r_j) = 7.(p_r(0) + p_r(1)) = 3.08 \Rightarrow 3$$

$$k = 2; s_2 = T(r_2) = 7.\sum_{j=0}^{2} p_r(r_j) = 7.(p_r(0) + p_r(1) + p_r(2)) = 4.55 \Rightarrow 5$$

$$s_3 = 5.67 \Rightarrow 6; s_4 = 6.23 \Rightarrow 6; s_5 = 6.65 \Rightarrow 7; s_6 = 6.86 \Rightarrow 7; s_7 = 7.00 \Rightarrow 7$$

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Final transformation

r0 $\Rightarrow$ s0 = 1 $\Rightarrow$ 790 pixels map to1.
r1 $\Rightarrow$ s1 = 3 $\Rightarrow$ 1023 pixels map to 3.
r2 $\Rightarrow$ s2 = 5 $\Rightarrow$ 850 pixels map to 5.
r3 $\Rightarrow$ s3 = 6 $\Rightarrow$ 656+329 = 985 pixels map to 6.
r4 $\Rightarrow$ s4 = 6 $\Rightarrow$ 656+329 = 985 pixels map to 6.
r5 $\Rightarrow$ s5 = 7 $\Rightarrow$ 245+122+81 = 448 pixels map to 7.
r6 $\Rightarrow$ s6 = 7 $\Rightarrow$ 245+122+81 = 448 pixels map to 7.
r7 $\Rightarrow$ s7 = 7 $\Rightarrow$ 245+122+81 = 448 pixels map to 7.

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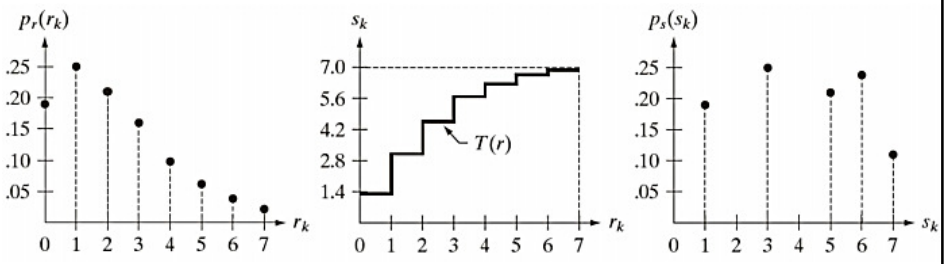

Original histogram Transfer function Equalized histogram

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```
function g=hist_equa(f);
h=histogram(f);
L=256;
for i=1:L
    s(i)=(L-1)*sum(h(1:i));
end
s=uint8(s);
for i=1:size(f,1)
    for j=1:size(f,2)
        g(i,j)=s(f(i,j)+1);
    end
end
end
```

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- MATLAB function

J=histeq(I, hgram)

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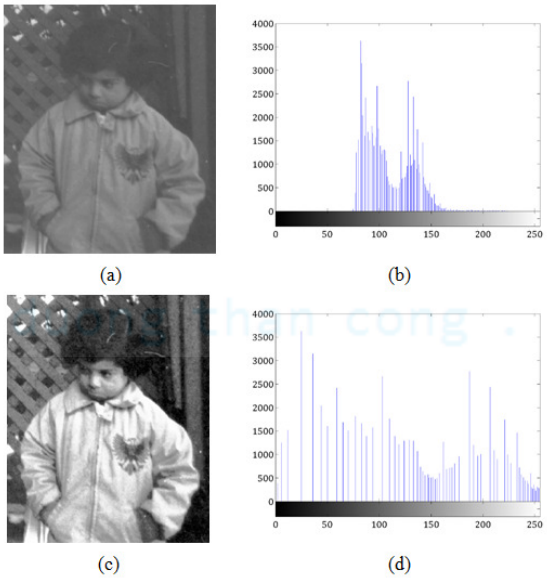

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Xử lý mặt nạ

- Nhiễu do nhiều nguyên nhân khác nhau làm cho chất lượng ảnh bị giảm xuống.
- Để giảm nhiễu và nâng cao chất lượng ảnh ta sử dụng những phương pháp lọc với các mặt nạ khác nhau

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Các bộ lọc làm mịn ảnh

- Làm mờ ảnh được sử dụng trong quá trình tiền xử lý ảnh.
  - Loại bỏ các chi tiết nhỏ ra khỏi ảnh trước khi tiến hành tách các thành phần lớn hơn khỏi ảnh.
  - Làm liền lại những đứt quãng nhỏ của đường thẳng hoặc đường cong.
- Cửa sổ lọc

$$w = \frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} \qquad w = \frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

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Các bộ lọc làm mịn ảnh

- Khảo sát các tùy chọn dùng lọc trung bình với cửa sổ lọc 15x15

```
clear all;
f=imread('check.tif');
h=ones(15)/(15^2);
g1=imfilter(f,h);
g2=imfilter(f,h,'replicate');
g3=imfilter(f,h,'symmetric');
g4=imfilter(f,h,'circular');
```


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Các bộ lọc làm mịn ảnh

Hình 5.14.*Kết quả dùng cửa sổ lọc 15x15 với các tùy chọn*

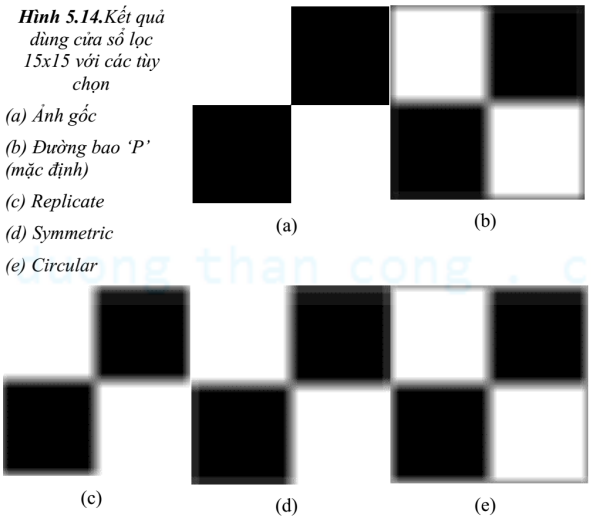
(a) Ảnh gốc

(b) Đường bao 'P' (mặc định)

(c) Replicate

(d) Symmetric

(e) Circular



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Các bộ lọc làm mịn ảnh

- Làm nổi bật các chi tiết trong ảnh hoặc làm sắc nét các chi tiết bị mờ bởi quá trình làm mịn ảnh.
- Tập trung vào sự sai lệch giữa các chi tiết trong ảnh, giống như phép toán vi phân.
- Đạo hàm bậc 2 được sử dụng nhiều hơn trong xử lý ảnh do nó làm nổi bật các chi tiết.

$$\frac{\partial^2 f}{\partial x^2} = f(x+1, y) + f(x-1, y) - 2f(x, y)$$

$$\frac{\partial^2 f}{\partial y^2} = f(x, y+1) + f(x, y-1) - 2f(x, y)$$

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Các bộ lọc làm sắc nét ảnh

- Toán tử Laplace trong không gian rời rạc 2 chiều

$$\partial^2 f = f(x+1, y) + f(x-1, y) + f(x, y+1) + f(x, y-1) - 4f(x, y)$$

- Có thể thực hiện đối với các phần tử của ảnh bằng cách nhân chập ảnh với ma trận:

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix} \quad \text{hoặc} \quad \begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

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Các bộ lọc làm sắc nét ảnh

- Mặt nạ Laplace

$$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$$

$$\nabla^2 = \frac{4}{(\alpha+1)} \begin{bmatrix} \frac{\alpha}{4} & \frac{1-\alpha}{4} & \frac{\alpha}{4} \\ \frac{1-\alpha}{4} & -1 & \frac{1-\alpha}{4} \\ \frac{\alpha}{4} & \frac{1-\alpha}{4} & \frac{\alpha}{4} \end{bmatrix}$$

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Các bộ lọc làm sắc nét ảnh

- Mặt nạ Laplace

```
fspecial('laplacian', alpha)
```

- Có thể dùng mặt nạ lọc trực tiếp

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix} \quad \text{hoặc} \quad \begin{bmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

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Các bộ lọc làm sắc nét ảnh

- Bộ lọc tăng cường cũng là một ứng dụng của toán tử Laplace

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & A+4 & -1 \\ 0 & -1 & 0 \end{bmatrix} \quad \text{hoặc} \quad \begin{bmatrix} -1 & -1 & -1 \\ -1 & A+8 & -1 \\ -1 & -1 & -1 \end{bmatrix} \quad \text{với } A \geq 1$$

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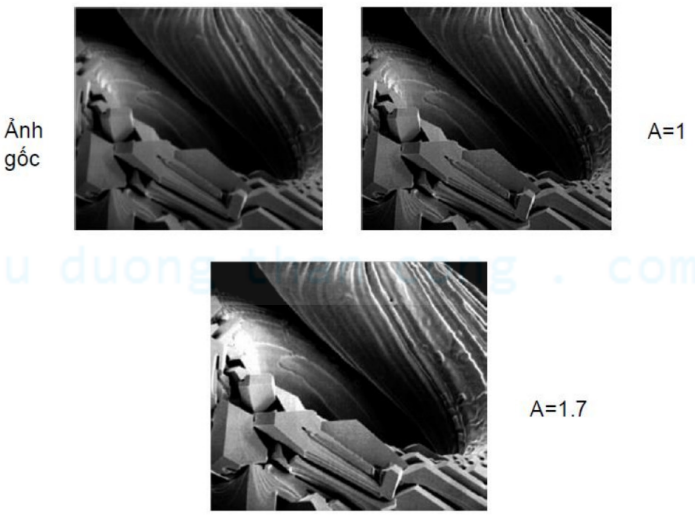
Các bộ lọc làm sắc nét ảnh



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Các bộ lọc làm sắc nét ảnh

- Viết hàm thực hiện lọc ảnh theo dạng tương quan với mặt nạ cho trước.
- Sử dụng hàm đã viết để lọc ảnh với mặt nạ lọc tăng cường

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The End

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