# CITY UNIVERSITY OF HONG KONG

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|---|---|---|
| Course code & title | : | EE4211 Computer Vision |
| Session | : | Midterm for Semester A 2020/21 |
| Time allowed | : | Two hours |

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*This is an **open-book, open-notes** examination.*

**Name:**

**Student ID:**

Question 1-15

**Question 1** 1 pts

Morphological processing can be utilized for ( ).

- [ ] detect skeletons
- [ ] Enhance image details
- [ ] hole filling
- [ ] Boundary extraction

**Question 2** 1 pts

In order to perform smoothing filtering on an image that is affected by the isolated noise points, which of the following filters can not achieve this goal?

- [ ] median filter
- [ ] high frequency filter
- [ ] neighborhood averaging filter
- [ ] sharpening filter

**Question 3** 1 pts

The following algorithms related to smoothing processing is ( )

- [ ] gradient sharpening
- [ ] Laplacian enhancement
- [ ] median filtering
- [ ] histogram equalization

**Question 4** 1 pts

How do we estimate the degradation function?

- [ ] Experimentation
- [ ] Do inverse filtering
- [ ] Mathematical Modeling
- [ ] Image observation

**Question 5** 1 pts

High pass filtering can be used to ( )

- [ ] denoise
- [ ] increase brightness
- [ ] object recognition
- [ ] sharpen edges

**1 ACD, 2 AC, 3 C, 4 ACD, 5 D**

**Question 6** 1 pts

Which of the following statement is right?

- [ ] The gaussian lowpass filter also has ringing effect in images
- [ ] Lowpass filter tends to preserve high-frequency information
- [ ] The ideal filter has ringing effect in images
- [ ] Lowpass filter can be used to remove noise

**Question 7** 1 pts

When the power transformation (the power is smaller than 1) is used for grayscale transformation, which of the following is right ( ).

- [ ] The whole image is blurred
- [ ] The image details look much clear
- [ ] The whole image is brighter
- [ ] The whole image is darker

**Question 8** 1 pts

Which of the following filters can well remove the periodic noise?

- [ ] Band-reject filtering
- [ ] Median filtering
- [ ] Low-pass filtering
- [ ] Notch filtering

**Question 9** 1 pts

After point processing, compared with the original images, the histogram of the processed image is ( ).

- [ ] invariant
- [ ] worse
- [ ] Undeterminable
- [ ] variable

**Question 10** 1 pts

The following algorithm related to point processing is ( ).

- [ ] Intensity-level slicing
- [ ] binaryzation
- [ ] Fourier transform
- [ ] Median filtering

**6 CD, 7 C, 8 AD, 9 C, 10 AB**

**Question 11** 1 pts

The order-statistics filters include ( ).

- [ ] contraharmonic mean filter
- [ ] median filter
- [ ] adaptive mean filters
- [ ] alpha-trimmed mean filter

**Question 12** 1 pts

The corresponding relations between an image and its gray histogram is ( ).

- [ ] one to one
- [ ] many to one
- [ ] one to many
- [ ] all false

**Question 13** 1 pts

In ( ) color space, the brightness and chroma are distributed over each of the three components

- [ ] YIQ
- [ ] CMYK
- [ ] YCbCr
- [ ] HSV

**Question 14** 1 pts

Which of the following features does Fourier transform have?

- [ ] original data can be fully recovered from the result of the transform
- [ ] It is optimal in a mean square error sense
- [ ] It has the concept of frequency domain
- [ ] It has the plural operation

**Question 15** 1 pts

High pass filtering can be used to ( )

- [ ] increase brightness
- [ ] sharpen edges
- [ ] object recognition
- [ ] denoise

**11 BD, 12 B, 13B, 14 ABD 15 B**

**Question 16** 1 pts

Image reverse operation is applied to enhance images with mainly brighter grayscale

- ○ True
- ○ False

**Question 17** 1 pts

Noise only has high-frequency components.

- ○ True
- ○ False

**Question 18** 1 pts

After image translation, the amplitude and phase characteristics of the Fourier transform are unchanged.

- ○ True
- ○ False

**Question 19** 1 pts

If the image is degraded, it should first make a restoration process, further enhancement.

- ○ True
- ○ False

**Question 20** 1 pts

Open operation could remove holes

- ○ True
- ○ False

**16 F, 17 F, 18F 19T 20 F**

**Question 21** 1 pts

Using low pass filter can achieve image smoothing?

- ○ True
- ○ False

**Question 22** 1 pts

Applying Fit to an entire image is denoted Erosion.

- ○ True
- ○ False

**Question 23** 1 pts

The degradation caused by blurring will decrease the spatial resolution of the image.

- ○ True
- ○ False

**Question 24** 1 pts

Band reject filtering can well remove the periodic noise.

- ○ True
- ○ False

**Question 25** 1 pts

High frequencies are mainly responsible for overall gray level display in smooth areas.

- ○ True
- ○ False

**21T 22T 23F, 24T, 25F**

**Question 26-28**

(a) There is an image shown as follows because of the noise interruption. How do you process the noisy image? Show the result.

| | | | | | |
|---|---|---|---|---|---|
| 86 | 72 | 1 | 88 | 78 | 64 |
| 72 | 255 | 82 | 83 | 83 | 93 |
| 73 | 73 | 255 | 94 | 89 | 83 |
| 73 | 63 | 73 | 255 | 1 | 96 |
| 83 | 1 | 94 | 85 | 255 | 83 |
| 82 | 73 | 84 | 86 | 87 | 81 |

(b) Illustrate the motivation of Homomorphic Filtering.
(c) Explain the image degradation model described in the lecture notes, and how to use inverse filters for image restoration.
(d) Inverse filters may encounter numerical problem in practice. Provide one solution to overcome this instability.

**Solutions:**

(a) This image is interrupted by pepper and salt noise. Median filter can be used to remove this noise. The filtered image is showing as following with zero padding methods.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 86 | 72 | 1 | 88 | 78 | 64 | 0 |
| 0 | 72 | 255 | 82 | 83 | 83 | 93 | 0 |
| 0 | 73 | 73 | 255 | 94 | 89 | 83 | 0 |
| 0 | 73 | 63 | 73 | 255 | 1 | 96 | 0 |
| 0 | 83 | 1 | 94 | 85 | 255 | 83 | 0 |
| 0 | 82 | 73 | 84 | 86 | 87 | 81 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| 0 | 72 | 72 | 82 | 83 | 0 |
| 72 | 73 | 83 | 83 | 83 | 78 |
| 73 | 73 | 83 | 83 | 93 | 83 |
| 73 | 73 | 85 | 94 | 89 | 83 |
| 73 | 73 | 86 | 87 | 86 | 81 |
| 0 | 73 | 73 | 85 | 85 | 0 |

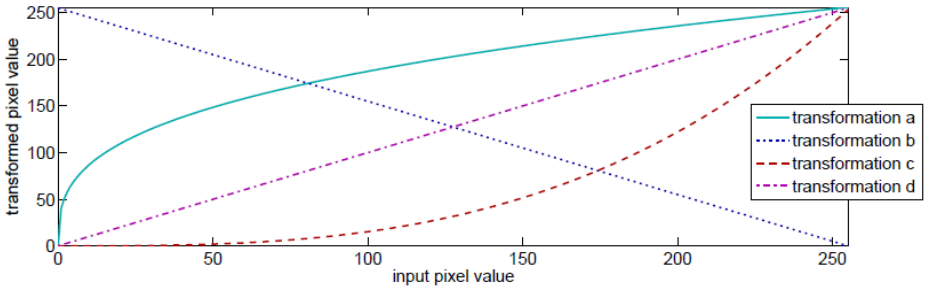
(b) Please see lecture 3B-page36-40.
(c) In the spatial domain, the model is $g(x, y) = h(x, y) * f(x, y) + \eta(x, y)$, where $g(x, y)$ is the observed image at position $(x, y)$, $f(x, y)$ is the original image, $\eta(x, y)$ is the spatial noise, and the convolution $h(x, y) * f(x, y)$ corresponds to the image degradation

process, where h(x, y) is the spatial representation of the degradation operator. In the frequency domain, the model becomes G(u, v) = H(u, v)F(u, v) + N(u, v). Suppose the noise is zero, then we have F'(u, v) = G(u,v) H(u,v) , which is called inverse filter and can be used to estimate the Frequency response of the original image hence restoring the original image.

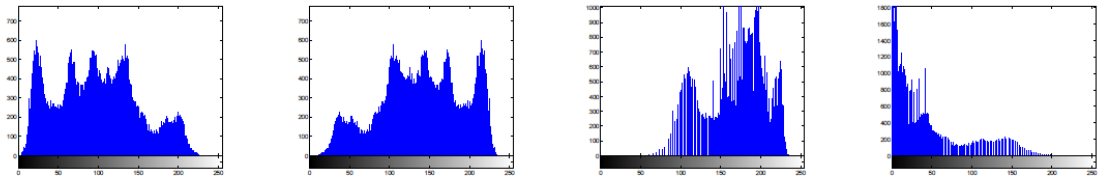
(c) In practice the denominator H(u, v) may have too small magnitude in the high frequency part, making the inverse filter highly unstable. To prevent this, we can (1) confine the inverse filter operation only to the low frequency part; or (2) add a small constant in the denominator of the inverse filter process, similar to Wiener filter.

**Question 29**

We compute the histogram of the image 'lena' after performing four different pixel transformations (A, B, C and D) shown in the following figure.




(a) As a result of the pixel transformations, we obtain the following histograms.



histogram 1 (original) histogram 2 histogram 3 histogram 4

Which transformation gives which histogram? (4 marks)

**Solution:**
transformation a -> histogram 3
transformation b -> histogram 2
transformation c -> histogram 4
transformation d -> histogram 1

(b) These histograms correspond to the following images:

image 1 (original) image 2 image 3 image 4

Which histogram belongs to which image? (4 marks)

Solution:

histogram 1 -> image 1,

histogram 2 -> image 3,

histogram 3 -> image 4,

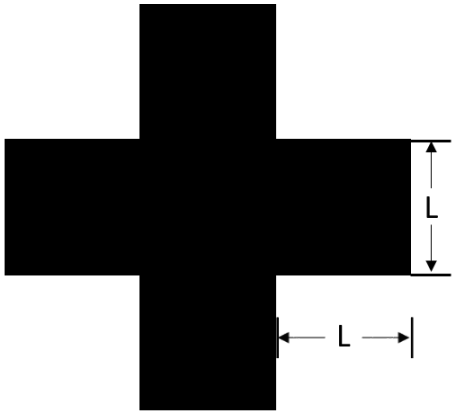
histogram 4 -> image 2.

**<u>Question 30</u> (14%)**

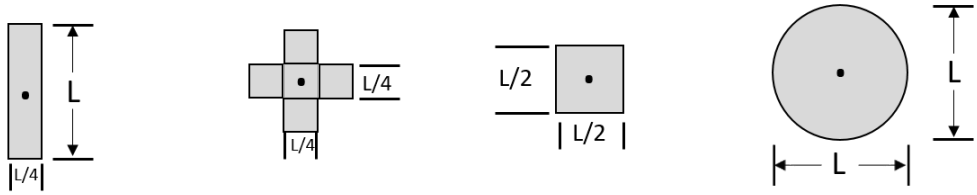
Let A denote the set shown shaded in the following figure. Refer to the structuring elements shown (the black dots denote the origin). Sketch the result of the following morphological operations.

(a) $Y1 = (A \Theta B^4) \oplus B^2$ where $\Theta$ denotes the morphological erosion operator and $\oplus$ denotes the morphological dilation operator; (8 marks)

(b) $Y2 = (A \Theta B^1) \oplus B^3$. (7 marks)




A



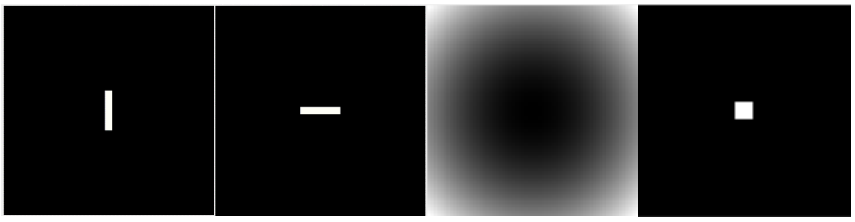

$B^1$ $B^2$ $B^3$ $B^4$

**Solution:**

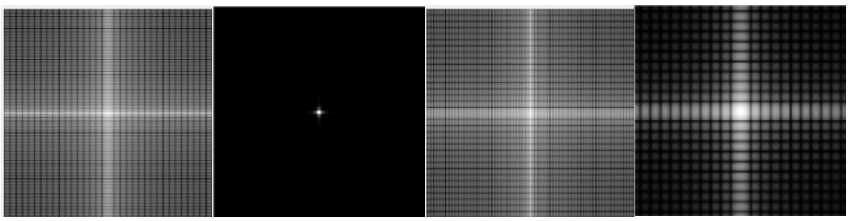
Please see my lecture notes

**<u>Question 31</u> (14%)**

(a) Match the images below to their corresponding Fourier transform spectrum and explain the reason.



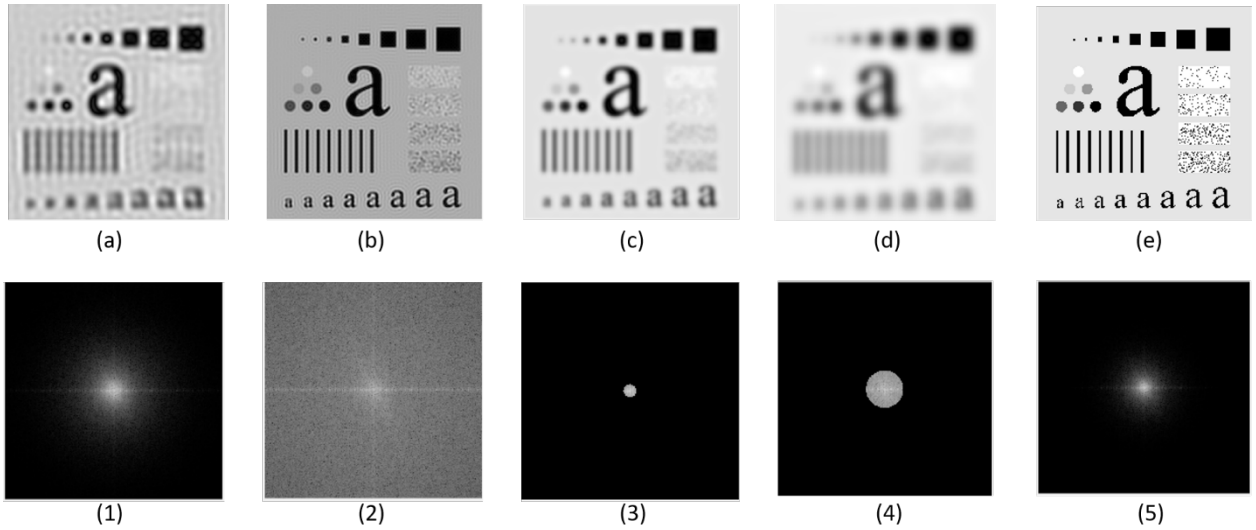
**1** **2** **3** **4**



**A** **B** **C** **D**

**Solutions**: 1->A; 2->C; 3->B; 4->D

(b) Match the images below to their corresponding Fourier transform spectrum and explain the reason.



(a) (b) (c) (d) (e)

(1) (2) (3) (4) (5)

**Solutions**: a ->3; b->4; c->1; d->5; e->2

a ->3; b->5; c->1; d->4; e->2

**Question 32** (10%) (randomly choose one of two questions)

32-1A 5*5 grayscale image is given by

| | | | | |
|---|---|---|---|---|
| 2 | 5 | 5 | 9 | 1 |
| 3 | 4 | 7 | 6 | 2 |
| 4 | 6 | 5 | 4 | 2 |
| 9 | 7 | 6 | 3 | 1 |
| 8 | 6 | 3 | 2 | 3 |

Please calculate the results with the
(a) Arithmetic mean filter after replicate padding (filter size 3*3).
(b) Midpoint filter after replicate padding (filter size 3*3).
(c) Median filter after zero padding (filter size 3*3).
(d) Laplacian filter after zero padding (filter size 3*3).
(e) Alpha-trimmed Mean Filter with d=4 after zero padding (filter size 3*3).

**Solutions:**
(a)

| | | | | |
|---|---|---|---|---|
| 3.1111 | 4.2222 | 6.1111 | 5 | 3.5556 |
| 3.6667 | 4.5556 | 5.6667 | 4.5556 | 3.2222 |
| 5.4444 | 5.6667 | 5.3333 | 4 | 2.5556 |
| 6.7778 | 6 | 4.6667 | 3.2222 | 2.3333 |
| 7.6667 | 6.2222 | 4.2222 | 2.8889 | 2.3333 |

(b)

| | | | | |
|---|---|---|---|---|
| 3.5000 | 4.5000 | 6.5000 | 5 | 5 |
| 4 | 4.5000 | 6.5000 | 5 | 5 |
| 6 | 6 | 5 | 4 | 3.5000 |
| 6.5000 | 6 | 4.5000 | 3.5000 | 2.5000 |
| 7.5000 | 6 | 4.5000 | 3.5000 | 2 |

(c)

| | | | | |
|---|---|---|---|---|
| 0 | 3 | 5 | 2 | 0 |
| 3 | 5 | 5 | 5 | 2 |
| 4 | 6 | 6 | 4 | 2 |
| 6 | 6 | 5 | 3 | 2 |
| 0 | 6 | 3 | 2 | 0 |

(d)

| | | | | |
|---|---|---|---|---|
| 0 | -9 | 1 | -24 | 7 |
| -2 | 5 | -8 | -2 | 1 |
| 2 | -4 | 3 | 0 | -1 |
| -17 | -1 | -6 | 1 | 4 |
| -17 | -6 | 2 | 1 | -9 |

or

| | | | | |
|---|---|---|---|---|
| -4 | -19 | -9 | -51 | 9 |
| -3 | 5 | -12 | -13 | 6 |
| -3 | -3 | 3 | 0 | 0 |
| -41 | -9 | -12 | 2 | 6 |
| -42 | -15 | 0 | 0 | -18 |

32-2 A 5*5 grayscale image is given by

| | | | | |
|---|---|---|---|---|
| 2 | 5 | 5 | 9 | 1 |
| 3 | 4 | 7 | 6 | 2 |
| 4 | 6 | 5 | 4 | 2 |
| 9 | 7 | 6 | 3 | 1 |
| 8 | 6 | 3 | 2 | 3 |

Please calculate the results with the
(a) Arithmetic mean filter after zero padding (filter size 3*3).
(b) Midpoint filter after zero padding (filter size 3*3).
(c) Median filter after replicate padding (filter size 3*3).
(d) Laplacian filter after replicate padding (filter size 3*3).
(e) Alpha-trimmed Mean Filter with d=4 after zero padding (filter size 3*3).

**Solutions:**
(a)

| | | | | |
|---|---|---|---|---|
| 1.5556 | 2.8889 | 4.0000 | 3.3333 | 2 |
| 2.6667 | 4.5556 | 5.6667 | 4.5556 | 2.6667 |
| 3.6667 | 5.6667 | 5.3333 | 4 | 2 |
| 4.4444 | 6.0000 | 4.6667 | 3.2222 | 1.6667 |
| 3.3333 | 4.3333 | 3 | 2.0000 | 1 |

(b)

| | | | | |
|---|---|---|---|---|
| 2.5000 | 3.5000 | 4.5000 | 4.5000 | 4.5000 |
| 3 | 4.5000 | 6.5000 | 5 | 4.5000 |
| 4.5000 | 6 | 5 | 4 | 3 |
| 4.5000 | 6 | 4.5000 | 3.5000 | 2 |
| 4.5000 | 4.5000 | 3.5000 | 3 | 1.5000 |

(c)

| | | | | |
|---|---|---|---|---|
| 3 | 5 | 5 | 5 | 2 |
| 4 | 5 | 5 | 5 | 2 |
| 4 | 6 | 6 | 4 | 2 |
| 7 | 6 | 5 | 3 | 2 |
| 8 | 6 | 3 | 3 | 3 |

(d)

| | | | | |
|---|---|---|---|---|
| 4 | -4 | 6 | -15 | 9 |
| 1 | 5 | -8 | -2 | 3 |
| 6 | -4 | 3 | 0 | 1 |
| -8 | -1 | -6 | 1 | 5 |
| -1 | 0 | 5 | 3 | -3 |

or

| | | | | |
|---|---|---|---|---|
| 4 | -4 | 6 | -15 | 9 |
| 1 | 5 | -8 | -2 | 3 |
| 6 | -4 | 3 | 0 | 1 |
| -8 | -1 | -6 | 1 | 5 |
| -1 | 0 | 5 | 3 | -3 |

**<u>Question 33</u> (12%)**

(a) A 7 x 7 image with eight gray levels is given below:

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 1 | 3 | 6 | 6 | 5 |
| 1 | 2 | 2 | 4 | 5 | 7 | 6 |
| 1 | 0 | 2 | 5 | 6 | 7 | 7 |
| 0 | 2 | 3 | 6 | 6 | 7 | 7 |
| 1 | 4 | 3 | 5 | 7 | 7 | 6 |
| 3 | 0 | 4 | 4 | 5 | 7 | 7 |
| 2 | 0 | 3 | 5 | 6 | 6 | 6 |

(a) Obtain the histogram of the image. Noted that histogram is not the pdf.
(b) Apply histogram equalization on the above image and determine the new intensity values of the histogram equalized image.

**Solution:**

(a)

| Gray level | hk | sk |
|---|---|---|
| 0 | 4 | 7*4/49 ->1 |
| 1 | 5 | 7*9/49->1 |
| 2 | 6 | 7*15/49->2 |
| 3 | 5 | 7*20/49->3 |
| 4 | 4 | 7*24/49->3 |
| 5 | 6 | 7*30/49->4 |
| 6 | 12 | 7*42/49->6 |
| 7 | 7 | 7*49/49->7 |

(b)

| Gray level | hk |
|---|---|
| 1 | 9 |

| | |
|---|---|
| 2 | 6 |
| 3 | 9 |
| 4 | 6 |
| 6 | 12 |
| 7 | 7 |

---

(a)

| Gray level | hk | sk |
|---|---|---|
| 0 | 4 | 7*4/49 ->1 |
| 1 | 5 | 7*9/49->1 |
| 2 | 6 | 7*15/49->2 |
| 3 | 5 | 7*20/49->3 |
| 4 | 4 | 7*24/49->3 |
| 5 | 6 | 7*30/49->4 |
| 6 | 10 | 7*40/49->6 |
| 7 | 9 | 7*49/49->7 |

(b)

| Gray level | hk |
|---|---|
| 1 | 9 |
| 2 | 6 |
| 3 | 9 |
| 4 | 6 |
| 6 | 10 |
| 7 | 9 |