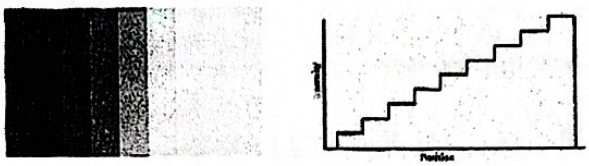
Image Processing Exam, Total: 100 pts

1. (4 pts) There are two major objectives for image processing. (a) What are they? (b) For each objective, give at least two example tasks.

2. (4 pts) There are two kinds of resolution involved in an image sampling. (a) What are they? (b) Address their differences.

3. (3 pts) Mathematically, a scene, an image and a digital image can all be expressed as functions. Address the differences between the functions representing a scene, an image, and a digital image.

4. (3 pts) In the following two figures, the left one shows an image containing a number of vertical stripes of constant intensity. The right figure shows the physical intensity profile of the image. Draw a perceived intensity profile of the image by the visual system that tends to undershoot or overshoot around the boundary of the stripes.



5. (2 pts) Regardless of file formats, two major components constituting an image file. What are the two components?

6. (4 pts) The following table shows the GIF file format of an image:

Name	Size	Description
Signature	6 bytes	'GIF87a' or 'GIF89a'
GlobalDescriptor	7 bytes	global descriptor, always present
Width	2 bytes	width in pixels
Height	2 bytes	height in pixels
Flags	1 byte	global descriptor flags
GlobalColorMap	bit 7	=1 if GlobalColorMap exists (should be true in almost all cases) =0 if default map is used, or if every image has a LocalColorMap
ColorResolutionBits	bits 6-4	+1 = significant bits per color in GlobalColorMap
reserved	bit 3	=0
PixelBits	bits 2-0	+1 = ColorDepth, NumberOfGlobalColors := $2^{ColorDepth}$
BackgroundColor	1 byte	background color number (from GlobalColorMap or default map)
AspectRatio	1 byte	usually =0
GlobalColorMap	NumberOfGlobalColors * 3	global color table, present only when GlobalDescriptor.Flags.GlobalColorMap = 1
Red	1 byte	red intensity of color (not necessarily 8 significant bits)
Green	1 byte	green intensity of color (not necessarily 8 significant bits)
Blue	1 byte	blue intensity of color (not necessarily 8 significant bits)
repeated NumberOfGlobalColors times		

Show the width and height of the image according to its hexadecimal dump shown below.

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47 49 46 38 39 61 3D 00 38 00 F7 00 00 FF D4 26
FF E3 71 FD B1 48 FF DE 59 EC 54 34 59 85 32 A8
8B 07 FF F4 C7 70 8C 31 2A 2A 2A FF D2 1B FF E9
92 FF 23 1F 9D 7B 0B 4C 7B 31 FF F1 BB D8 D2 58
FD CB 39 FF D4 2F F0 29 20 FF E7 85 BE C4 60 FF
FB E6 69 92 47 FF F8 D8 FE DA 43 FD CA 00 38 70
2E AB B0 54 4D 8A 3F F8 87 4A AA AA AA FE D9 3D
95 A6 50 FF EC A1 E9 BD 32 E0 25 14 FF FD F3 FB
6C 45 CB D5 6C E1 17 1F FF B4 03 93 B1 67 E7 DC
56 FE DC 4D DF C8 48 E9 D6 50 FF D0 13 E5 B7 00
F6 C9 2B D1 A7 00 72 A0 50 FF E0 63 FF CE 0A 8E
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7. (2 pts) How many gray levels does (a) a 4-bit grayscale image have and (b) a binary image have?

8. (2 pts) How many bit planes can be formed from a grayscale image with 64 gray levels?

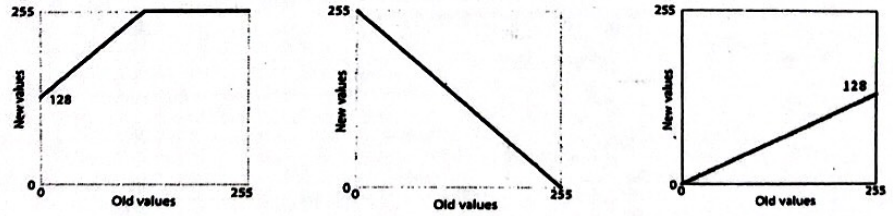
9. (2 pts) Explain the dithering process.

10. (4 pts) Describe the steps of the halftoning process.

11. (3 pts) Considering a dithering process, how many tones, i.e., shades of gray or patterns of dots can be represented by an 8 by 8 image?

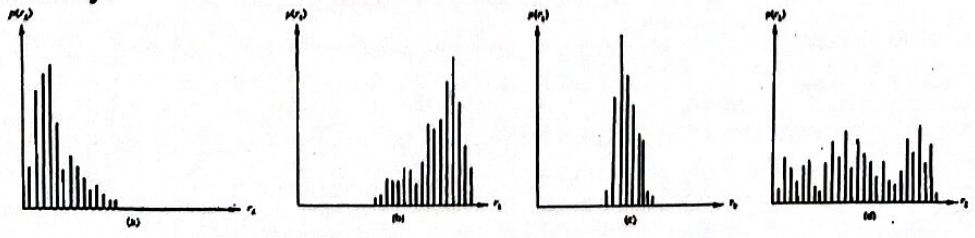
12. (2 pts) Tell differences between point and neighborhood image processings.

13. (4 pts) Point processing is often performed according to a transfer function. Write the equations of the following transfer functions.



(a) (b) (c)

14. (4 pts) Illustrate the characteristics of the images with the following histograms, respectively.



15. (2 pts) What is the transfer function used by the histogram equalization technique?

16. (8 pts) Suppose we have the histogram of an 18 by 20 image shown below. There are 16 gray levels in the image. During performing the histogram equalization of the image, we compute a transfer function and then transfer the image using the function.
(a) Give the transfer function and the histogram of the transferred image.
(b) Graphically show the histogram of the input image, the transfer function, and the histogram of the transferred image.

Gray Level l	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
#pixels n_l	15	0	0	0	0	0	0	0	0	70	110	45	80	40	0	0

17. (4 pts) A filter and an image neighborhood around pixel (x, y) are shown below. Write the expression of their linear combination.

mask values

$m(-1,-2)$	$m(-1,-1)$	$m(-1,0)$	$m(-1,1)$	$m(-1,2)$
$m(0,-2)$	$m(0,-1)$	$m(0,0)$	$m(0,1)$	$m(0,2)$
$m(1,-2)$	$m(1,-1)$	$m(1,0)$	$m(1,1)$	$m(1,2)$

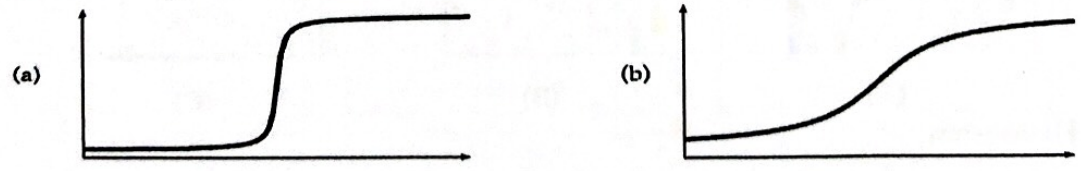
pixel values

$p(x-1,y-2)$	$p(x-1,y-1)$	$p(x-1,y)$	$p(x-1,y+1)$	$p(x-1,y+2)$
$p(x,y-2)$	$p(x,y-1)$	$p(x,y)$	$p(x,y+1)$	$p(x,y+2)$
$p(x+1,y-2)$	$p(x+1,y-1)$	$p(x+1,y)$	$p(x+1,y+1)$	$p(x+1,y+2)$

18. (3 pts) Separate the 3×3 filter $\begin{bmatrix} 1 & -2 & 1 \\ -2 & 4 & -2 \\ 1 & -2 & 1 \end{bmatrix}$ into a 3×1 filter and a 1×3 filter.

19. (4 pts) Let an $n \times n$ separable filter be decomposed into an $n \times 1$ filter and a $1 \times n$ filter. Analyze the time complexities (a) when applying the $n \times n$ filter to an image and (b) when applying the $n \times 1$ filter followed by the $1 \times n$ filter to the same image.

20. (4 pts) Figure (b) is the smoothing result of Figure (a) using a 3 by 3 averaging filter. (i) Show the figure of $(a) - k \times (b)$, where $0 < k < 1$. (ii) Design a 3 by 3 filter to perform the operation $(a) - k \times (b)$.



21. (4 pts) The 1-D Fourier transform (FT) is defined as
$F(\omega) = \Im(f(x)) = \frac{1}{2\pi}\int_{-\infty}^{\infty} f(x)\exp(-j\omega x)dx$. Show the linearity of (FT), i.e.,
$\Im(f+g) = \Im(f) + \Im(g)$

22. (4 pts) Tell the difference between image enhancement and image restoration.

23. (4 pts) (a) Formulate the degradation model and (b) give its Fourier transform version.

24. (5 pts) Given an image, address the steps of determining the probability distribution of noise and estimating its parameters.

25. (2 pts) Describe the steps of the median filter.

26. (3 pts) Formulate the degraded image $g(x,y)$ due to image $f(x,y)$ undergoing a planar motion $(x_0(t), y_0(t))$ during time interval T.

27. (10 pts) Use the following image as the input.

What is the result after applying the following codes to the input image?

(1) Average,

(A)

(B)

(C)

(2) Laplace of Gaussian,

(A)

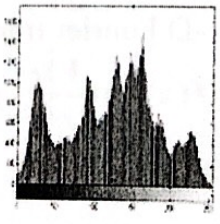
(B)

(C)

(3) Histogram,

(A)

(B)



(C)

(4) Salt and pepper,

(A)

(B)

(C)

(5) Applying noise removal to the result of (4)?

(A)

(B)

(C)