भारतीय सूचना प्रौद्योगिकी संस्थान
इलाहाबाद

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Department of Information Technology
Image and Video Processing, C1 Review Test
B.Tech. IT and IT-BI (V semester)

Duration: 90 min. **Maximum Marks: 20**

Note: *All questions are compulsory. All the subparts of a question are to be attempted together.*

Q1. An 8-bit digital image of size 12×10 has a histogram where the gray levels are equally distributed in the range from 161 to 220 (uniform distribution). Sketch the histogram. Describe the produced effect on the image contrast and brightness in the following cases:

a. Calculation of the image negative. **[1]**

The new image will have the order of the gray levels reversed. All the pixels which were 161 will become 255-161=94, and all the pixels which were 220 will be 35. The image will be the inverse (the brighter areas will be darker, and vice-versa). The image will still have low contrast but now it will be darker. The new histogram will have values from 35 to 94. The transformation function is a line with a negative slope.

b. Addition of 50 to all pixel gray levels. **[1]**

This will lighten the image while maintaining a poor contrast as only a limited range of gray scale values are used. It will force all pixels which previously had a grayscale value between 206 and 220 to grayscale 255. This will make more of the pixels have value 255, reducing the contrast. The histogram ranges from 210 to 254, uniformly, but 255 now has more values. The transformation is a line starting at point (0,50) ending at (205,255) and keeps a 255 value after 205.

c. Application of thresholding function where the threshold is selected as gray level 128. **[1]**

This will make the entire image white as the threshold is set below every gray scale value in the image. The new histogram will have values only at 255. The transformation function is a typical threshold.

Q2. For the matrix given below, consider the two highlighted pixels and find

a. 3(2)^1/2
b. 6
c. 3

4	5	6	5	4	4
3	3	5	1	4	4
3	2	1	6	8	3
4	5	3	5	3	3
6	3	7	4	6	1
3	6	3	4	5	4

a. Euclidean distance **[1]**

b. City-block distance **[1]**

Assuming (0,0) index,
$P(x,y) = P(1,4)$

c. Chessboard distance **[1]**

B) City-Block distance,

$D_4(P,Q) = |x-s| + |y-t|$

$= |(1-4)| + |(4-1)|$

$= 3+3$

$= 6$

$\therefore D_4(P,Q) = 6$

C) Chess-Board Distance;

$D_8(P,Q) = \max(|x-s|, |y-t|)$

$= \max(|1-4|, |4-1|)$

$= 3$

$\therefore D_8(P,Q) = 3$

Q3. Answer the following.

a. What type of noise is shown in the image below? **[1]**

25	43	35	255	69	0
78	0	56	0	255	98
255	65	0	76	255	0
45	0	255	89	90	255

Solution:

Salt and pepper noise.

b. What filter is most suitable for removing such noise? **[1]**

Solution: Median filter

c. Explain how it achieves this function. **[2]**

Solution: Salt & pepper noise does not have this zero-mean property. When an averaging filter is applied to an image containing salt & pepper noise the effect of the noise largely remains in the image albeit with lower intensity and blurred with the rest of the image.
In order to effectively remove salt & pepper noise we need to use a median filter. A median filter works by evaluating a region of pixels around a pixel of interest. The median value of the region of pixels is calculated (the value of the pixel of interest is included). The value of the pixel of interest is then replaced with the calculated median which will be the value of a pixel in the region being filtered. This filter operates on the assumption that values of neighbouring pixels are not likely to differ dramatically.

d. Given such a filter of dimension 3x3 and the below image, what will be the output of the center pixel? **[1]**

25	43	35
78	0	56
255	65	0

Solution: 43 (order is 0 0 25 35 43 56 65 78 255. Median is 43)

Q4. Consider the following two 8 * 8 images. Perform histogram matching for the image on the left using the reference image on the right. **[5]**

0	5	7	7	5	8	7	8
7	2	6	2	6	5	6	8
6	9	7	7	0	7	2	7
6	6	1	7	6	7	7	5
9	6	0	7	8	2	6	7
2	8	8	2	7	6	7	8
7	3	2	6	1	7	5	8
9	9	5	6	7	7	7	7

2	6	7	8	5	0	6	8
7	2	6	2	6	2	6	7
6	8	9	2	0	7	3	7
7	6	1	4	6	0	5	9
9	7	0	9	8	4	6	7
9	8	9	4	7	1	7	8
7	3	5	5	1	3	5	7
5	8	8	4	6	2	7	6

Original Image   Reference Image

Solution:

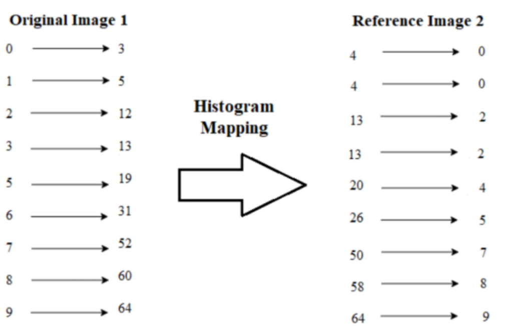
Pixels Histogram (Number of Pixels) Equalized Histogram (CDF) – for Original Image

Pixels	Histogram (Number of Pixels)	Equalized Histogram (CDF)
0	3	**3**
1	2	3 + 2 = **5**
2	7	5 + 7 = **12**
3	1	12 + 1 = **13**
5	6	13 + 6 = **19**
6	12	19 + 12 = **31**
7	21	31 + 21 = **52**
8	8	52 + 8 = **60**
9	4	60 + 4 = **64**

Pixels Histogram (Number of Pixels) Equalized Histogram (CDF) – Reference Image

Pixels	Histogram (Number of Pixels)	Equalized Histogram (CDF)
0	4	**4**
1	3	4 + 3 = **7**
2	6	7 + 6 = **13**
3	3	13 + 3 = **16**
4	4	16 + 4 = **20**
5	6	20 + 6 = **26**
6	11	26 + 11 = **37**
7	13	37 + 13 = **50**
8	8	50 + 8 = **58**
9	6	58 + 6 = **64**

Final Output Image:



0	4	7	7	4	8	7	8
7	2	5	2	5	4	5	8
5	9	7	7	0	7	2	7
5	5	0	7	5	7	7	4
9	5	0	7	8	2	5	7
2	8	8	2	7	5	7	8
7	2	2	5	0	7	4	8
9	9	4	5	7	7	7	7

New Resultant Matching Image

Q5. Answer the following.

a. Consider a 1-D function f and a filter w given below:

f								
1	2	3	4	5	6	7	8	9

and

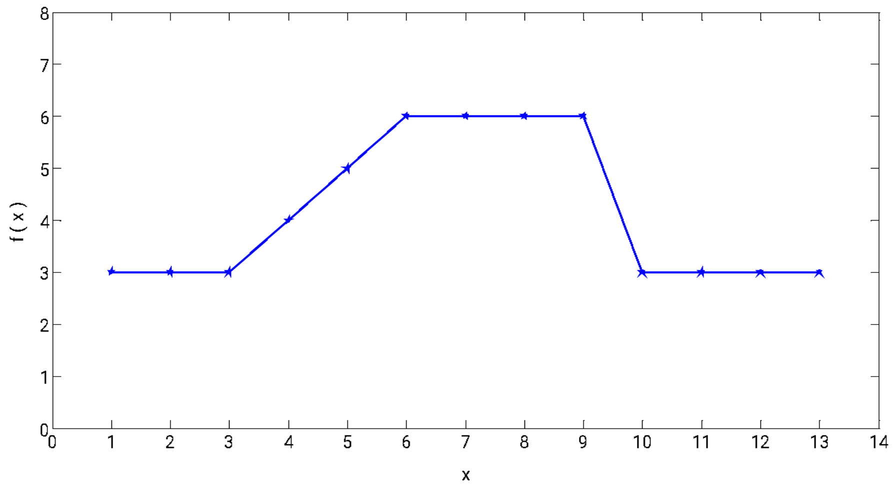
w				
1	2	3	2	1

Show the result of the enhanced signal after applying the convolution operator. Use zero padding, if required. **[1]**

Solution:

f'
10,18,27,36,45,54,63,62,50

b. Compute the first-order and second-order derivatives of the 1-D signal shown below. **[2]**



Solution:

Input	3	3	3	4	5	6	6	6	6	3	3	3	3
1st derivative	-	0	0	1	1	1	0	0	0	-3	0	0	-
2nd derivative	-	0	1	0	0	-1	0	0	-3	3	0	0	-

c. State TRUE or FALSE with proper justification: A small-sized box filter does more smoothing than a large-sized box filter. **[1]**

Solution: FALSE. The box filter, also known as the average filter, is used to smooth signals or images by averaging the values in a neighborhood around each pixel. The size of the window determines the degree of smoothing. A large-sized box filter (i.e., a filter with a larger kernel or mask) includes more neighboring pixels in the averaging process. As a result, it produces a stronger smoothing effect. The larger the filter, the more prominent the smoothing, and fine details in the image or signal are more likely to be lost. A small-sized box filter includes fewer neighboring pixels in the averaging process. This results in less smoothing or blurring of the image or signal. Smaller filters preserve finer details but may not effectively reduce noise or remove high-frequency variations.