Shiv Nadar University Chennai

Mid Semester Examination 2023-2024 Even

Solutions

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AI & DS A

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1	
a	Which are the three major sub systems of a digital camera? Explain any two important functions performed by the DSP sub system **Solution**: Three major Sub-systems: 1. Camera Body 2. Sensor Chip 3. Image Signal Processor (ISP) Digital Signal Processor or Image Signal Processor functions: 1. Denoise & Sharpen 2. De-mosaic 3. White Balancing 4. Gamma Correction 5. Image Compression
b	A manufacturing company purchased an imaging system whose function is to either smooth or sharpen images. The results of using the system on the manufacturing floor have been poor, and the plant manager suspects that the system is not smoothing and sharpening images the way it should. You are hired as a consultant to determine if the system is performing these functions properly. How would you determine if the system is working correctly? *Hint: You may use the solution in Question 3 to answer this Question .* **Ans:** • If sum of pixel values of input image and sum of pixel values of Filtered output image, remains approximately same after smoothing, then it means filter is redistributing pixel values to overall intensity, i.e., smoothing is proper. • If sum of pixel values in sharpened image is close to 0, it means filter is emphasizing edges and details without altering brightness, i.e., sharpening is proper. So, with these methods, we can determine if the system is working properly.
2.	Consider the sequences, x(n) = {1, 2, 3,5} and h(n) = {0.5, 0.5}
a	Find the correlation and convolution between the sequences x(n) and h(n). **Ans:** Kernel coefficient sum= 0.5 + 0.5 =**1** **(**i.e., Sharpening**)**

	Correlation: x(n) * h(n) = {0.5, 1.5, 2.5, 4, 2.5} Convolution: x(n) * h'(n) = {0.5, 1.5, 2.5, 4, 2.5} Sum of pixel values before convolution = Sum after convolution = **11**
b	For the above problem, let y(n) = x(n) * h(n). Find $\sum_{k=-\infty}^{\infty} y(n)$. Also find $\sum_{k=-\infty}^{\infty} y(n)\ if$ h(n) = {0.5, -0.5}. **Ans**: To find: If h(n) = {0.5, 0.5},→ Sum of kernel coefficients = 1, i.e., Sharpening • $\sum_{k=-\infty}^{\infty} y(n)$ = 11 If h(n) = {0.5, -0.5}, → Sum of kernel coefficients = 0, i.e., Smoothing • $\sum_{k=-\infty}^{\infty} y(n)$ = 0 For Sharpening, Sum of pixel values before convolution = Sum after convolution For Smoothing, Sum of pixel values of filtered image = 0
3. a	An image is filtered with a kernel whose coefficients sum to 1. What is the relation between sum of the pixel values in the original and filtered images. Prove the result mathematically. *(a) I'(x,y) =* $\sum_{i=-\infty}^{\infty} \sum_{j=-\infty}^{\infty} I(i,j)\, K\, (x-i, y-j)$ *Since kernel coefficients sum to 1, Kij =1, this implies the kernel is a smoothening kernel* *∑ I' = ∑I*
b	An image is filtered with a kernel whose coefficients sum to 0. What is the sum of the pixel values in the filtered image? Prove the result mathematically. *Hint: You may use the solution in Question 2 to answer Question 3.* *(b) I'(x,y) =* $\sum_{i=-\infty}^{\infty} \sum_{j=-\infty}^{\infty} I(i,j)\, K\, (x-i, y-j)$

	Since kernel coefficients sum to 0, Kij =0, this implies the kernel is a sharpening or edge detection kernel $\sum I' = 0$
4. a	Suppose the normalized grey values in an image are uniform in the interval [0,10]. (Let the grey values to be continuous.). It is required to transform these grey values to a new set of values so that the histogram of the transformed values should be exponential in nature. Derive an appropriate expression for the required transformation.

B

If a 3x3 box filter is applied on the image shown in Question 5(a), what is the filtered output corresponding to the center pixel in the input image.

Box Filter

$$\frac{1}{9} \times \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} \quad *$$

7	**2**	**1**
0	**0**	**1**
3	**2**	**4**

= 20/9

= 2.222

= 2

5. Consider the following 3-bit 5x5 image and plot the histogram of its negative.

3 bit representation

$2^3 = 8$ possible combinations

Range 0 to 7

Maximum bit representation – 7

Negative of an Image is given by:

$n(x,y) = 7 - i(x,y)$

a

Original image:

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

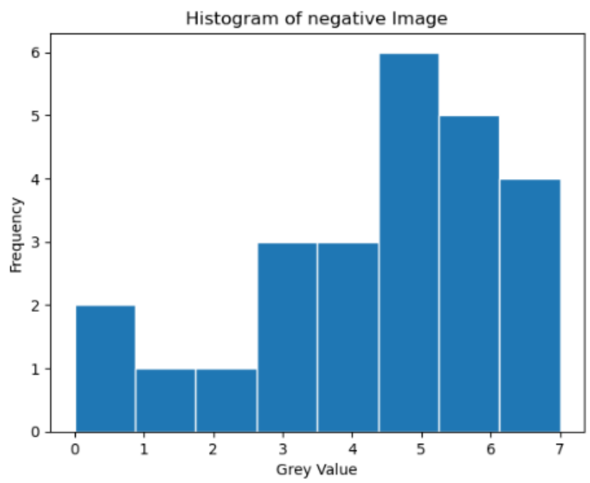
Negative image:

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

Histogram of Negative image

In [3]:
```
import matplotlib.pyplot as plt

height = [5,2,3,4,0,7,0,5,6,6,4,7,7,6,6,5,4,5,3,1,
6,5,5,3,7]
plt.title("Histogram of negative Image")
plt.xlabel("Grey Value")
plt.ylabel("Frequency")
plt.hist(height, edgecolor="white", bins=8)
plt.show()
```



b Perform histogram equalization on the above image and obtain the equalized image.

Grey Value (r_k)	Frequency (n_k)	*pdf (n_k/n)*	*cdf*	*Denormalization*	Histogram equalized Image
0	4	4/25	4/25	4/25 * 7	1.12 ~ 1
1	5	5/25	9/25	9/25 * 7	2.52 ~ 3
2	6	6/25	15/25	15/25 * 7	4.2 ~ 4
3	3	3/25	18/25	18/25 * 7	5.04 ~ 5
4	3	3/25	21/25	21/25 * 7	5.88 ~ 6
5	1	1/25	22/25	22/25 * 7	6.16 ~ 6
6	1	1/25	23/25	23/25 * 7	6.44 ~ 6
7	2	2/25	25/25	25/25 * 7	7 ~ 7

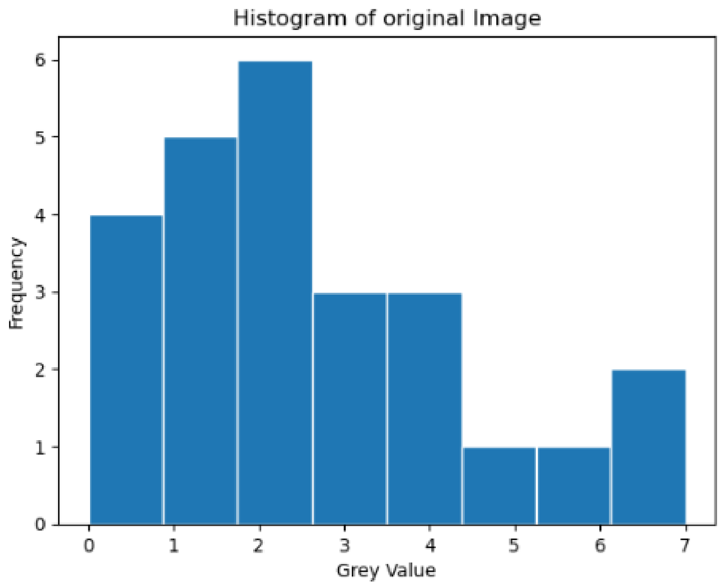
Original image:

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

Original Image histogram

In [16]:
```
import matplotlib.pyplot as plt

height = [2,5,4,3,7,0,7,2,1,1,3,0,0,1,1,2,3,2,4,6,1,2,2,4,0]
plt.title("Histogram of original Image")
plt.xlabel("Grey Value")
plt.ylabel("Frequency")
plt.hist(height, edgecolor="white", bins=8)
plt.show()
```



Equalized image:

4	6	6	5	7
1	7	4	3	3
5	1	1	3	3
4	5	4	6	6
3	4	4	6	1

Equalized Image Histogram

In [17]:
```
import matplotlib.pyplot as plt

height = [4,6,6,5,7,1,7,4,3,3,5,1,1,3,3,4,5,4,6,6,3,4,4,6,1]
plt.title("Histogram of Equalized Image")
plt.xlabel("Grey Value")
plt.ylabel("Frequency")
plt.hist(height, edgecolor="white", bins=[0,1,2,3,4,5,6,7,8])
plt.show()
```