M-23

Q Nomaw - IP - MID

Nowadays Image Processing based autonomous vehicle & quadcopter are widely used - Explain the fields of Image Processing used in statement.

(I) objects detection: finds & recognizes things like people, cars, obstacles.

(II) Image segment: Breaks images into parts to see different objects clearly.

(III) Pattern recognition: spots familiar shapes or signs, like road lines or landing areas.

(IV) Stereo vision: Uses two Camera to see how far things are, helping with safe driving or flying.

(V) optical flow: watches how things move in the images, keeping vehicles or drones steady.

(VI) Feature extraction: picks out important details from images, like edges or shapes.

(VII) Machine learning: learns from lots of images to get better at recognizing and Predicting things.

Q. A digital images is a representation of a two-Dimentional images as a finite set of digital values — do you agree with the statement? Explain with a mathematical formula —

The statement "A digital images is a representation of a two-Dimension image as a finite of 3-digital values -

(i) Important the image via image acquisition tools.
(ii) Analysis & manipulating the images.
(iii) output in which result can be altered image or a report which is based on analysis that image.

An Image is defined as a two-dimensional function, $F(x,y)$, where x & y are spatial coordinates and amplitude of F at any pair of coordinates (x,y) is called intensity of that image at that point. When x, y and amplitude values of F are finite, we called it digital images.

Types:

(i) Binary images: The binary image as its name suggests, contain only two pixel as 1, where 0 refers to black & 1 refers to white.

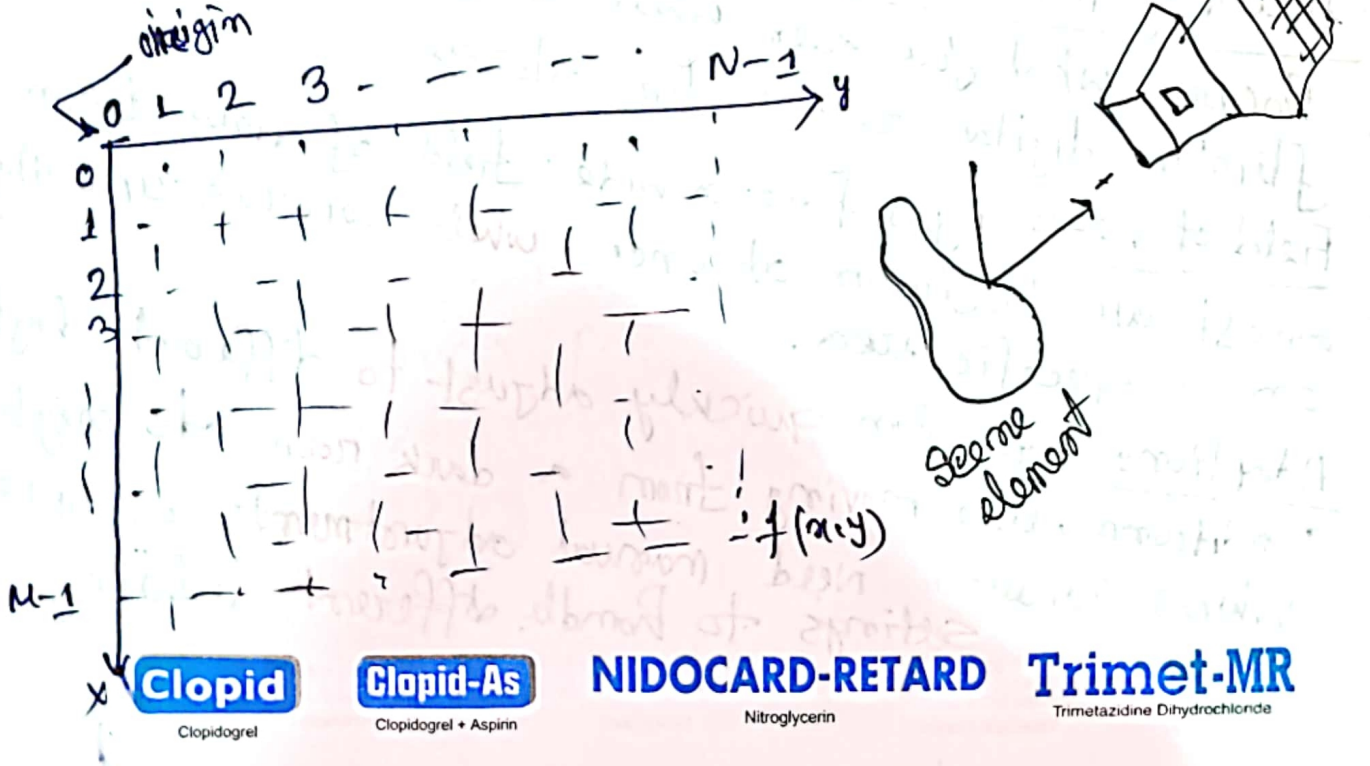
(ii) Black & white: This images is consists of only black & white color is called Black & white images.

(III) 8 bits color format: It is the most famous images format, has 256 different shades of colors in it & Commonly knowns as Grayscale images.

(IV) 16 bit Color format: It is the color image format. It has 65536 different colors in it, it also known as High color format.

Images represents in rows & columns we have following syntax in which images are represented.

$$f(x,y) = \begin{bmatrix} f(0,0) & f(0,1) & f(0,2) & \cdots & f(0,N-1) \\ f(1,0) & f(1,1) & f(1,2) & \cdots & f(1,N-1) \\ \vdots & & & & \\ f(M-1,0) & f(M-1,1) & f(M-1,2) & \cdots & f(M-1,N-1) \end{bmatrix}$$



Write the similarity & difference between eyes & camera.

Similarity:

Capturing Images: Both eyes & cameras capture images, Eyes use light to see objects, just like a camera use light to take pictures.

Lenses: Both have lenses. In the eye, the lens focuses light a form a clear image, similar to how a camera lens focuses light onto a sensor.

Adjusting focus: your eyes can adjust focus to see things near & far, just like a camera can zoom in & out to focus on different objects.

Differents:

How they Process images: Eyes send signals to the brain to process what you see, while a camera records images on film or digital sensor for storage.

Field of View: Eyes have a wide field of view & can see in almost all directions at once, while cameras usually focus on a specific area.

Adaption: Eyes can quickly adjust to different lighting conditions, like moving from a dark room to bright sunlight, whereas cameras need manual adjustments or special settings to handle different lighting.

In some devices CCD based cameras are used where other uses CMOS based cameras, Justified the significance of the statement & write the benefits of using both.

⊛ The statement highlights that different devices may use CCD - based cameras or CMOS - based cameras depending on their specific needs & application requirements.
CCD & CMOS sensors have their unique ~~issues~~ advantages and the choice between them depends on factors like image quality, power consumption, cost & specific use cases.

✓ Significant: Devices uses different Camera sensors based on what they are designed to do. Ex→ Professional Cameras might used CCD sensors ~~used~~ because they can capture really clear & detailed picture. Smartphones & smaller devices often uses CMOS sensors because they use less battery & fit better with other part of the device.
Sometimes, image quality is the priority, while other times, saving power or keeping costs low is more important. Manufacturer pick the sensor that best fits what the device needs to do, whether it is taking sharp photos or working efficiently on less power.

Benefits of CCD:

- CCD camera can capture very clear & detailed images. This is useful for Professional photography, medical images, situation where need to high-quality pictures.
- CCD cameras usually provide even & smooth images accross the entire picture. This makes them good for Professional work where images consistency is important.
- CCD cameras work better in low-light conditions, making them ideal for night photography or security cameras.

Benefits of CMOS:

- CMOS cameras use less power, which is great for devices that run on batteries, like smartphones or tablets.
- CMOS sensors are less expensive & easier to produce in large numbers. That is why they are commonly used in everyday devices like phones.
- CMOS camera can take & process images quickly. CMOS sensors are smaller, allowing for more compact camera designs, which is why they are often used in tiny cameras inside smartphones.

On Aug 23, 2023, the indian space Research organizations (ISRO) chandrayan 3 mission landed near the moon's pole, and a day later, the rover took a walk on the lunar surface. Write applications of images Processing used in this expedition.

Images Processing was crucial for making sure the Chandrayaan-3 mission could land safely, move the rover around, & explore the moon, especially in the tricky south Pole area.

(i) Landing Navigation: Images Processing was used to analyze the lunar surface & identify a safe landing spot. The system Processed images to detect craters, rocks, & other obstacles, ensuring a smooth landing.

(ii) Moving the Rover: The rover used image Processing to see where it was going. It looked at Pictures to avoid obstacles & Pick the safest path to move around on the moon.

By standing Pictures of the ground the rover could tell if the surface was too steep or rough, helping it move safely & avoid dangers.

(III) Exploring the moon:

- The rover took high-quality pictures of the moon's surface. These pictures were processed to help scientists learn more about the moon's soil & rocks.
Image Processing helped create 3D maps of the moon's landshape. These maps show the shaped & features of the moon's South pole area.

(IV) Sending Data back to Earth:

The images taken by the rover were made smaller through image Processing so they could be sent back to Earth more Easily without losing important details.

(V) Finding interesting Things:

Image Processing helped find and study specific things on the moon, like craters or interesting rocks. This helped scientists make accurate measurements & do experiments.

A Grayscale images has pixel intensities ranging from 0 to 255. Design a piecewise linear transformation function to achieve the following. → Enhance constrast middle intensity range (50-150).

→ clip low-intensity values (0-49) to, black (0).

→ clip high-intensity values (151-255) to white (255)

① clip low-Intensity values (0-49) to Black (0):

$$T(x) = 0 \quad \text{for } 0 \le x \le 49.$$

② Enhance Constrast the middle intensity Range (50-150) we want to stretch this range to utilize the full grayscale range. we can map the interval [50, 150] linearly to [0, 255]. The linear transformation function,

$$T(x) = \frac{255}{150-50} \times (x-50)$$

$$= 2.55 \times (x-50) \quad \text{for } 50 \le x \le 150.$$

$$T(x) = 2.55x - 127.5 \quad \text{for } 50 \le x \le 150.$$

③ Clip-High values (151-255) white (255):

$$T(x) = 255 \quad \text{for } 151 \le x \le 255.$$

Final piecewise transformation function,

$$T(x) = \begin{cases} 0 & \text{for } 0 \le x \le 49 \\ 2.55x - 127.5 & \text{for } 50 \le x \le 150 \\ 255 & \text{for } 151 \le x \le 255. \end{cases}$$

(8) One Picture is worth more than ten thousand
Explain the fields of images 2 processing used
in the statement →

⇒ → highlights the Power of images to convey complex information quickly & effectively.

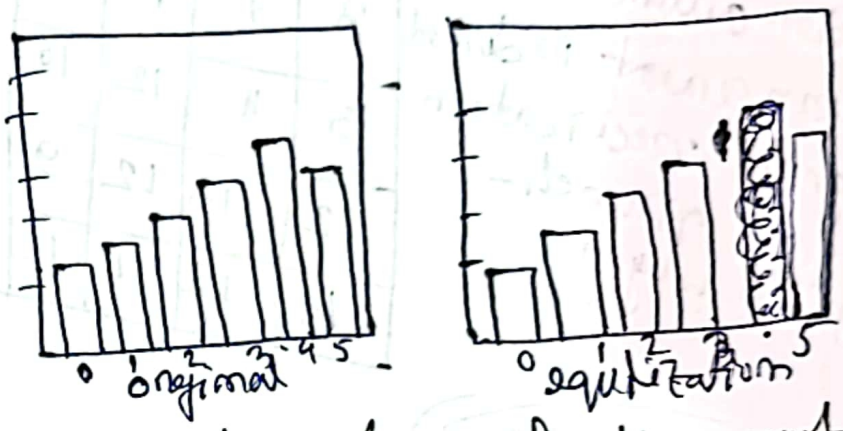
- Making pictures cleaner or more detailed so they Communicate better, like sharpening or adjusting brightness.
- Reducing the file size of an image without losing too much quality, making it easier to share or store.
- Identifying objects or patterns in a Picture, like facial recognization in smartphones.

(8) find the resolution of a 20' monitor working with 1024 X768.

The resolution of a monitor, like 1024 X 768, tells You many are used to created the image on the screen.

- 1024 Pixels wide → The screen has 1024 pixels from left to right.
- 768 pixels tall → The screen has 768 pixels from top to bottom.

A. Histogram equalization, why transform function must be behaved strictly monotonically increasing? Explain with Proper diagram.



In Histogram equalization, the transform function must be strictly monotonically increasing to ensure that the relative brightness of pixels is Preserved. This means that if one pixel is brighter than another before the transformation, it should remain brighter afterward. If the function isn't strictly increasing, different intensity values could be Mapped to the same output, leading to a loss of images detail & distortion.

Justify the statement. Blurring of images can significantly reduce noise. Explain with Proper example——

Blurring images can help reduce noise by smoothing out the random variations or graininess in an image. Noise often appears as tiny specks or dots that disrupt the Picture. When we blur a image, these tiny(ছোট) specks blend with the surrounding pixels,

→Imagine we have a photo of a clear blue sky, but there are small random white dots scattered across it. If you apply a blur, these dots will blend into the blue, making the sky look smoother & cleaner, reducing the visible noise.

(4) A 4x4 pixel original image is given by (3bits/pixel)

3	7	8	9
13	11	12	10
12	13	12	9
14	12	11	12

(i) When automatic enhancement is done, Histogram specification is a good approach- agree? why?

(ii) Apply histogram equalization to the image rounding the resulting image pixels to integers.

(iii) Sketch the histograms of the original images & histogram equalized image

P.T.O. Answer types

(ii) Sketch Histogram →

. The original image histogram is more clustered with many pixels having the same value, particularly around the values 12 & 13.

. The equalized images Histogram is more spread out, making pixel intensities more uniformly distributed across the range.

(iii) Automatic Enhancement with Histogram specification.

yes, I agree Histogram specification is a good approach when automatic enhancement is desired because it allows us to adjust the image to a specific desired Histogram, thereby improving the contrast & visual quality of the image based on a reference Histogram.

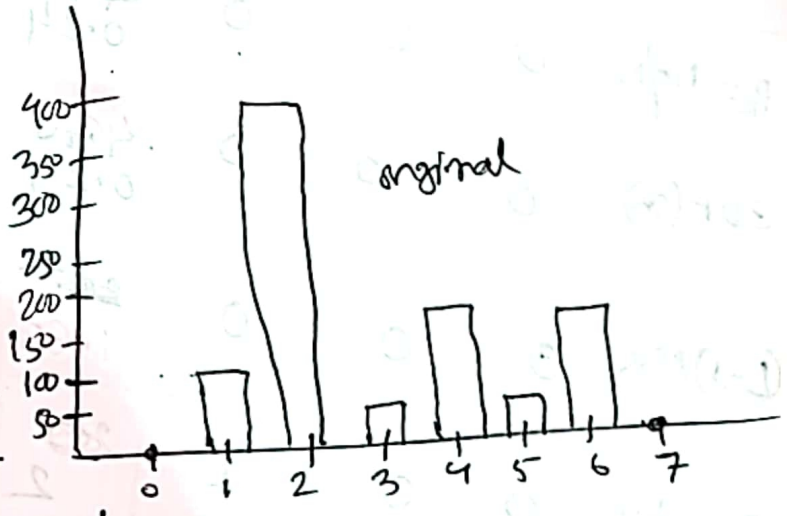
⊗ Histogram equalization on the Gray Level Distributions:

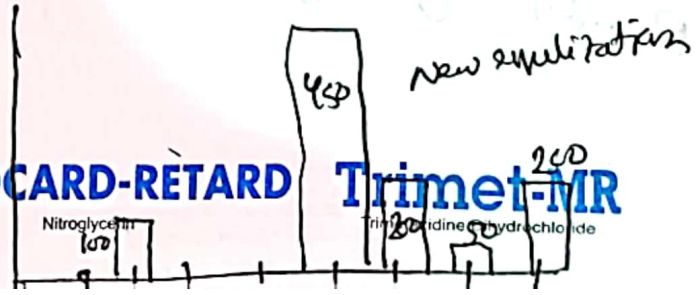
Gray level	0	1	2	3	4	5	6	7
Num of Pixels	0	100	400	50	200	50	200	0

$\therefore n = \sum n_x = 0 + 100 + 400 + 50 + 200 + 50 + 200 + 0 = 1000$.

Gray Level	0	1	2	3	4	5	6	7
~~PDF~~ N_K	0	100	400	50	200	50	200	0
$P_R = N_K/N$	0	0.1	0.4	0.05	0.2	0.05	0.2	0
CDF (S_K)	0	0.1	0.5	0.55	0.75	0.8	1	1
$(L-1) * S_K$	0	0.7	3.5	3.85	5.25	5.6	7	7
Rounding	0	1	4	4	5	6	7	7

Old gray level	No. of Pixel	New Gray level
0	0	0
1	100	1
2	400	4
3	50	4
4	200	5
5	50	6
6	200	7
7	0	7





Histogram Equalization

4	4	4	4	4
3	4	5	4	3
3	5	5	5	3
3	4	5	4	3
4	4	4	4	4

- Max power value = 5.
- No of gray level = 2^k - No of bits
- max pixel value 5, that is 3 bits (5 = 101)
- So, Num of gray level = $2^k = 2^3 = 8$ levels that is (0-7).

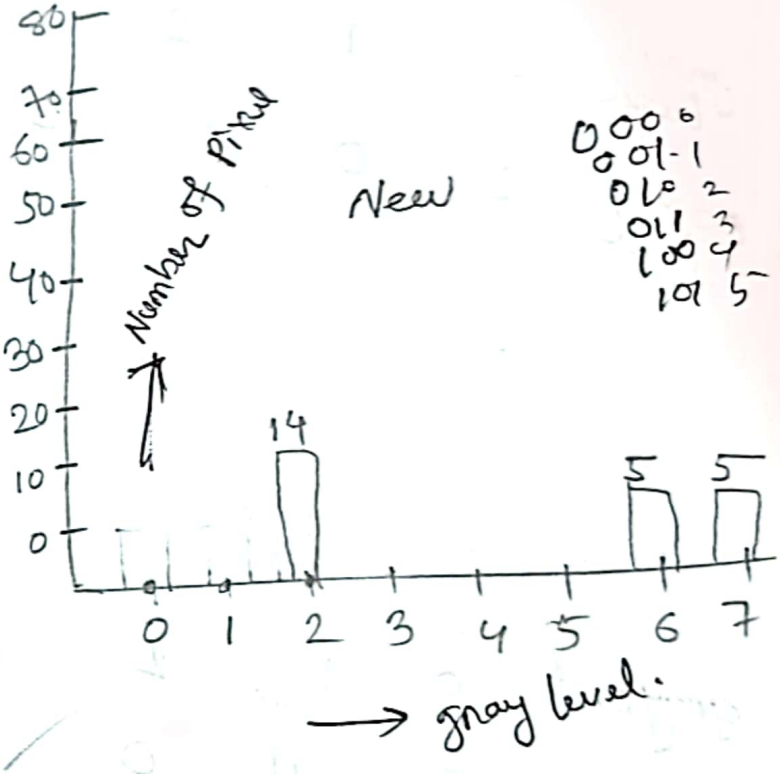
gray level	0	1	2	3	4	5	6	7
No of Pixel	0	0	0	6	14	5	0	0

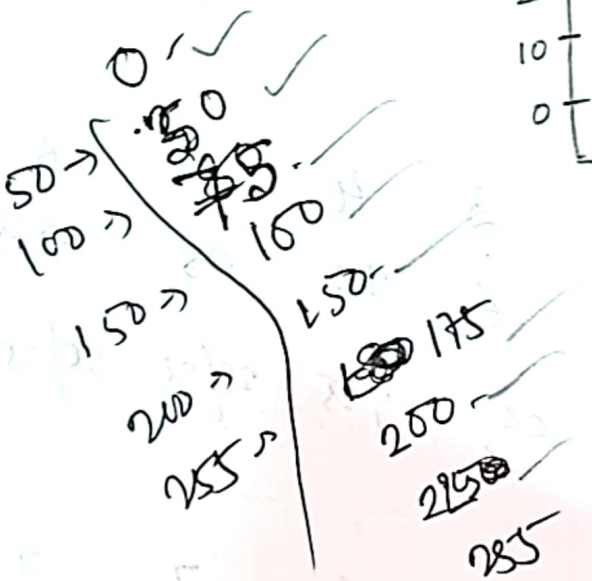
$N = \sum n_k = 0+0+0+6+14+5+0+0 = 25$

original image to Equalization histogram.

Gray level	0	1	2	3	4	5	6	7	
Nk	0	0	0	6	14	5	0	0	
$P_k = N_k/N$	0	0	0	0.24	0.56	0.2	0	0	
CDF(Sk)	0	0	0	0.24	0.8	1.0	1.0	1.0	
(L-1)Sk	0	0	0	1.68	5.6	7	7	7	
Rounding	0	0	0	2	6	7	7	7	

old grey	No. of Pixel	New grey level
0	0	0
1	0	0
2	0	0
3	6	2
4	14	6
5	5	7
6	0	7
7	0	7





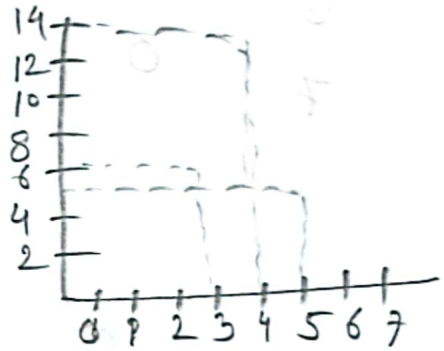
Histogram Neumerical:

$$\begin{bmatrix} 4 & 4 & 4 & 4 & 4 \\ 2 & 4 & 5 & 4 & 3 \\ 3 & 5 & 5 & 5 & 3 \\ 3 & 4 & 5 & 4 & 3 \\ 4 & 4 & 4 & 4 & 4 \end{bmatrix}$$

— max pixel value in img = 5
— no of gray level = 2^k ⇒ No of bits
— 5 represents (101) = 3 bits.
— so sum of gray level = $2^k = 2^3 = 8$ (0-7).

Histogram of IP image.

gray level	0	1	2	3	4	5	6	7
No of pixel	0	0	0	6	14	5	0	0

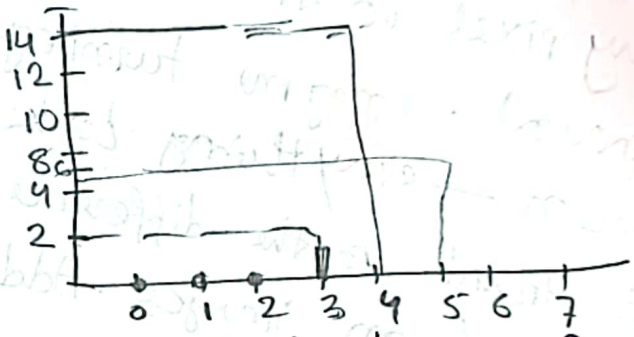


gray level	0	1	2	3	4	5	6	7
Running sum	0	0	0	6	20	25	25	25
Running sum / Total num of pixel	0/25	0/25	0/25	6/25	20/25	25/25	25/25	25/25
Running sum / Total num of pix × Max gray level	0	0	0	2	6	7	7	7

Now,
orginal image to New Image

$$\begin{bmatrix} 4 & 4 & 4 & 4 & 4 \\ 3 & 4 & 5 & 4 & 3 \\ 3 & 5 & 5 & 5 & 3 \\ 3 & 4 & 5 & 4 & 3 \\ 4 & 4 & 4 & 4 & 4 \end{bmatrix} \Rightarrow \begin{bmatrix} 6 & 6 & 6 & 6 & 6 \\ 2 & 6 & 7 & 6 & 2 \\ 2 & 7 & 7 & 7 & 2 \\ 2 & 6 & 7 & 6 & 2 \\ 6 & 6 & 6 & 6 & 6 \end{bmatrix}$$

graph
⇒



⇒ why histogram equalization not produce a perfectly flat histogram?

Histogram equalization doesn't produce a perfectly flat histogram because the pixels values in the original image are not evenly distributed. Some intensity levels have more pixels than others, and when the values are spread out during equlization, it can't completly flatten the histogram, especially in small images with limited intensity levels.

(4) Analyze the effect of adding a constant value to a grayscale images on its overall brightness & Constraint. How images addition is used in images averaging?

⇒ Effect of Adding a constraint to a Grayscale Images: →

→ When we add a constraint value of a grayscale image, every pixel in the images becomes brighter by that amount. Imagine turning up the brightness on our screen — everything look lighter.

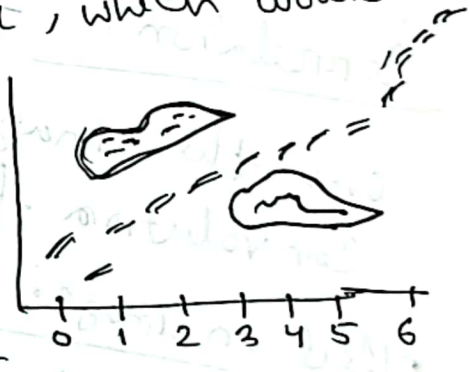
→ Constraint is the difference between the light and dark areas of an images. Adding a constraint value does not changes this differences, it only shifts all pixel values higher. So, while the image gets brighter, the relative constrast between the light & dark parts stays the same.

⇒ How images Addition is used in Image Averaging: →

→ Suppose you have multiple images of the same scene, but they have slight differences, like noise or variations in lighting. By adding these images together pixel by pixel & then dividing the sum by the number of images, you create an average images.

This process smooths out random variations and results in a clearer, more consistent images. It's like combining several slightly different photos of the same scene to get one that looks better & more accurate.

(H) Justify the statement, "Applying low-pass filter on an image result in a blurrier image. Example — In Histogram equalization, the transform function must be strictly monotonically increasing to make sure that the order of pixel brightness is preserved. This means that if one pixel is brighter than another in the original images, it stays brighter in together, which would cause a loss of detail.



→ Imagine a graph where the ax-axis represents original pixel values, & y-axis represents new pixel values after equalizations.

→ In the graph, the line always moves upward, showing that as the original pixel value increases, the new value also increases. This keeps the images structure intact & ensures that all pixel values are mapped uniquely without overlapping.

~~NITROCARD-RETARD~~ ~~Trimet-MR~~

#4 If you use convolve & correlation on images with the matrix given below, what would be the relation between the original & modified images?

0	0	0
0	0	1
0	0	0

Convolution:

This usually means flipping the matrix & then sliding it over the image to apply it. In this case, flipping doesn't change anything because the matrix is the same in both directions & correlation will end up doing the same thing here.

Correlation: This means just sliding the matrix over the images without flipping. It's the same as convolution for this matrix.

Effect on Image:

When we convolve or correlate an image with this kernel, we are essentially performing a very localized operation.

- The kernel has a value of '1' in the center & '0's elsewhere.

For each pixel, in the image, the kernel will align with that pixel, & only the value at the center of the kernel will be considered in the output.

The value of each pixel in the output image will be same as the value of the corresponding pixel in the input image.

(11) What are the difference between spatial domain & frequency domain enhancement?

Spatial & frequency domain enhancement are two methods used improve the quality of images in image processing.

⇒ Spatial domain directly changes the pixels. It changes the brightness or constrast of the pixels to make the image clearer. If an image is too dark, spatial domain enhancement can brighten the pixels to make it easier to see.

⇒ Frequency Domain ~~Enhancement~~ works on the images after its converted into its frequency components. It focus on improving the images by modifying these frequency components, like filtering out noise or sharping the images. If an images is blurray, frequency domain enhancement can be used to sharpen the details by adjusting certain frequencies.

(iii) Median filter technique is the best way to de-noise the images — justify the statement —

① Effectiveness in Removing Noise:
The median filter works by replacing each pixels value with the median value of the surrounding pixels. The median is the middle value when the pixels are sorted by brightness. This technique is especially good at removing salt & pepper noise, which appears as random white & black dots on a image. The median filter can effectively remove these dots without effecting the order details in the image.

② Preserves Edges:
Unlike other filters that might blur the edges in an images, the median filter preserves these edges. Since the filter uses the median value, it doesn't average the pixels, so it doesn't blur the sharp edges where there's a sudden change in brightness. In a photo of a building, the edges of the building will stay sharp even after applying the median filter, while the noise is removed.

③ Simple & Non-Destructive: The median filter is simple to implement and doesn't cause much distortion in the image. By only changing the noisy pixels, it leaves most of the image intact, maintaining the overall appearance. If you have a picture with some noise, using a median filter will clean up the noise & keep the important details like faces or text clear

(4) Write a short note with your own word to explain how to do human beings perceive color? Given a color images represented in terms of RGB components, how are the corresponding CMY & HIS coordinates derived?

Human beings perceive color through three types of cone cells in the eyes, which are sensitive to different wavelengths of light — red, green & blue. These cells detect light, and the brain combines the signals from them to form the full range of colors we see.

Colors are typically represented in terms of RGB components, where each pixel is defined by a combination of Red, green, blue (R,G,B) values. These values range of (0-255), and by mixing them, a variety of colors can be produced.

Conversion of CMY coordinates:

The CMY color model is based on subtractive color, where cyan (C), Magenta (M), & yellow (Y) are used Primary colors. To convert RGB to CMY, the following formulas are used,

$C = 1 - R$.
$M = 1 - G$.
$Y = 1 - B$.

, the RGB values are normalized between 0 & 1 before the conversation.

Conversation of HIS coordinates:

The 'HIS' color model stands for Hue (H), Intensity (I) & saturation (S). It is useful for separating color from brightness. The ~~RGB~~ ~~to~~ Conversation from RGB to HIS involves the steps ——

① Intensity is the avg of three RGB components.

$I = (R + G + B) / 3$.

② saturation measures how pure the color is, calculate how different the maximum & minimum values R, G, B.

$S = 1 - (\min(R, G, B) / I)$.

③ H represented the type of color red, green, blue & calculated using a more complex formula,

If $G \geq B$, then:

$$H = \cos^{-1}\left[\left[0.5 * \left[(R-G)+(R-B)\right]\right] / \left[\sqrt{(R-G)^2 + (R-B)*(G-B)}\right]\right]$$

If $G < B$, then,

$$H = 360^\circ - H$$

The resulting H is in degrees (0° to 360°), where 0° is red, 120° is green & 240° is blue.

This Process helps in transforming a color image from the RGB space, which is based on light, into the CMY or HIS spaces, which can be more useful for Printing or image Processing applications.

3(c)? A 4x4 original image is given with 3 bits/pixel

0	-1	0
-1	5	-1
0	-1	0

3x3

2	3	2	0
1	1	5	2
2	7	1	5
2	5	3	1

i) Perform laplacian operator on the image (use padding, use any kernel)
ii) Analyze diff of both images.

(1)

kernal + (+)

6	10	2	-4
-5	-11	19	0
0	26	-15	21
3	13	-2	-3

(ii) After Perform the laplacian operation, Compare the original image to the resulting image. The laplacian operator emphasizes edges, so the differences between both images will likely highlight edge areas on transitions in intensity, between neighboring pixels.

A 4×4 original image is given with 3 bits/pixel.

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

$4 \times \frac{1}{9}$

① Perform Lowpass & High-Pass filter on the image separately (using Padding).

② Analyze the statement "Lowpass + Highpass = Original".

for LowPass

$f(x,y) =$

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

Low ⇒ 1
max = 6
Intensity = (0-7)
3 bits = $2^3 = 8$.

Avg kernel = mask

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

$\Rightarrow \frac{1}{9}$

1	1	1
1	1	1
1	1	1

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

$*$

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

Then pixel Replication, এর এ এমন এমন নিয়ে হিসাব

3×3

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

×

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

⇒

2.09	2.31	2.09	0.22
2.2	3.19	3.3	2.31
2.09	3.19	3.52	2.75
2.09	2.86	2.53	2.42

⇒

2	2	2	0
2	3	3	2
2	3	4	3
2	2	3	2

এখন
0 padding

After

0	0	0	0	0	0	0
0	2	2	2	0	0	
0	2	3	3	2	0	
0	2	3	4	3	0	
0	2	2	3	2	0	
0	0	0	0	0	0	

×

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

0.99	1.1	0.77	0.22
1.54	2.53	2.64	1.54
1.54	2.64	2.53	1.87
0.99	1.76	1.87	1.32

⇒ (Low pass)

1	1	1	0
2	3	3	2
2	3	3	2
1	2	2	1

for High Pass:

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

$\times \frac{1}{9}$

-1	-1	-1
-1	8	-1
-1	-1	-1

$\Rightarrow$

-1/9	-1/9	-1/9
-1/9	8/9	-1/9
-1/9	-1/9	-1/9

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

$\times$

-1/9	-1/9	-1/9
-1/9	8/9	-1/9
-1/9	-1/9	-1/9

$\Downarrow$

0	0	0	0
0	1.80	0	0
0	2.75	2.42	0
0	0	0	0