1) Explain Ideal low pass filter and effect of different cutoff frequencies. **CO3 L2 6M**

Ans

In the field of Image Processing, **Ideal Lowpass Filter (ILPF)** is used for image smoothing in the frequency domain. It removes high-frequency noise from a digital image and preserves low-frequency components.

It can be specified by the function-

$$H(u, v)=\begin{cases} 1 & D(u,v) \le D_0 \\ 0 & D(u,v) > D_0 \end{cases}$$

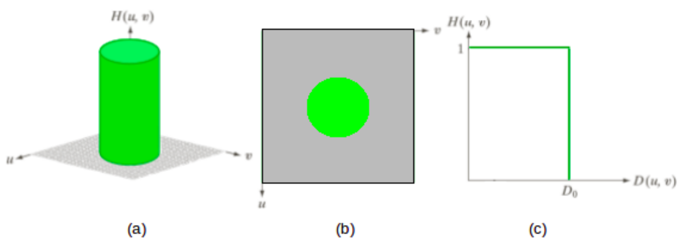
*Where, D_0 is a positive constant. ILPF passes all the frequencies within a circle of radius D_0 from the origin without attenuation and cuts off all the frequencies outside the circle. This D_0 is the transition point between H(u, v) = 1 and H(u, v) = 0, so this is termed as **cutoff frequency**.*

is the Euclidean Distance from any point (u, v) to the origin of the frequency plane, i.e,

$D(u,v)$

is the Euclidean Distance from any point (u, v) to the origin of the frequency plane, i.e,

$$D(u, v)=\sqrt{(u^2 + v^2)}$$



(a): Perspective plot of an ideal lowpass filter transfer function, (b): Filter displayed as an image, (c): Filter radial cross-section

Effects of Different Cutoff Frequencies:

1. **Low Cutoff Frequency**:
   - **Effect**: When the cutoff frequency is low, the filter significantly smooths the image, removing most of the high-frequency details.
   - **Result**: The image appears blurred, and fine details (like edges and textures) are lost. This can be useful for noise reduction but may lead to a loss of important structural information.
2. **Medium Cutoff Frequency**:
   - **Effect**: A moderate cutoff frequency allows some high-frequency components to pass while still filtering out higher frequencies.
   - **Result**: This strikes a balance, preserving some detail while reducing noise. The image may appear clearer than with a low cutoff frequency, maintaining a more realistic appearance.
3. **High Cutoff Frequency**:
   - **Effect**: A high cutoff frequency retains most of the high-frequency components.
   - **Result**: The image remains sharp, and details are preserved, but less noise reduction occurs. This can be useful when details are more important than noise in the image.

(Or)

2) Explain Image sharpening filtering **CO3 L2 6M**

Ans

Image sharpening is an effect applied to digital images to give them a sharper appearance. Sharpening enhances the definition of edges in an image. The dull images are those which are poor at the edges. There is not much difference in background and edges. On the contrary, the sharpened image is that in which the edges are clearly distinguishable by the viewer. We know that intensity and contrast change at the edge. If this change is significant then the image is said to be sharp. The viewer can clearly see the background and foreground parts.

Image sharpening using the smoothing technique

Laplacian Filter

- It is a second-order derivative operator/filter/mask.
- It detects the image along with horizontal and vertical directions collectively.
- There is no need to apply it separately to detect the edges along with horizontal and vertical directions.
- The sum of the values of this filter is 0.
- .

Using the sharpening mask: High Boost Filtering

High Boost Filtering

It is a sharpening technique that emphasizes the high-frequency components representing the image details without eliminating low-frequency components.

Formula:

HPF = Original image - Low frequency components

LPF = Original image - High frequency components

HBF = A * Original image - Low frequency components

= (A - 1) * Original image + [Original image - Low frequency components]

= (A - 1) * Original image + HPF

Here,

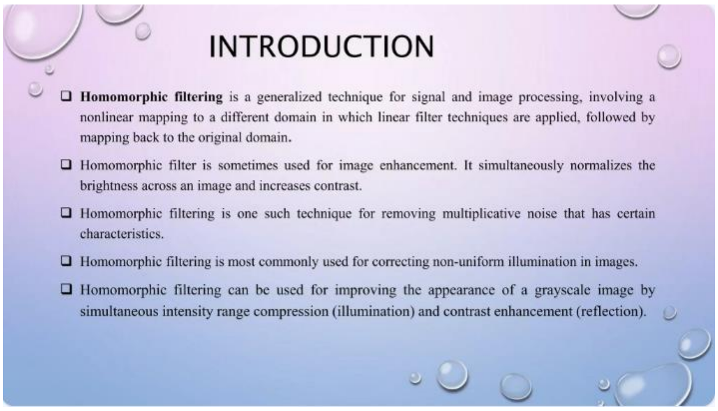
- HPF = High pass filtering, which means the higher frequency components are allowed to pass while low-frequency components are discarded from the original image.
- LPF = Low pass filtering, which means the lower frequency components are allowed to pass while high-frequency components are discarded from the original image.

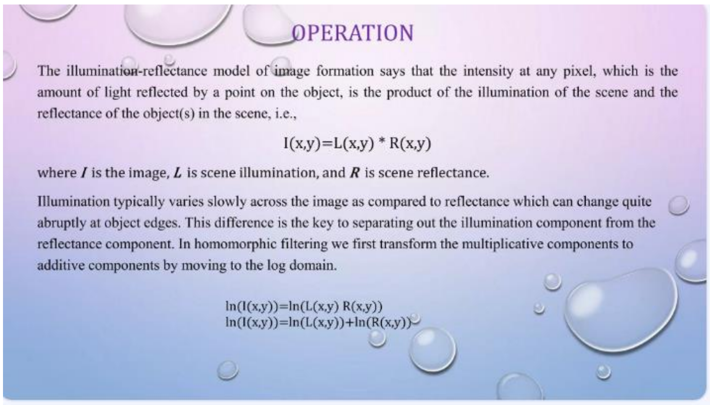
Advantage of HPF over Laplacian Filter:

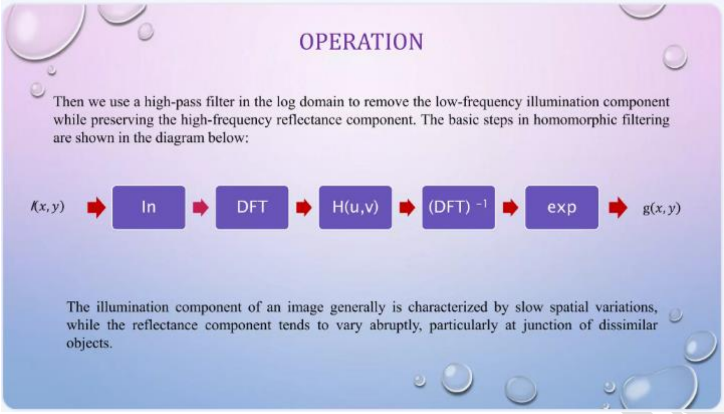
When using the Laplacian filter, we need to subtract the edge-detected image from the original image if the central pixel value of the Laplacian filter used is negative, otherwise, we add the edge-detected image to the original image. Hence two operations were used to carry out while choosing the Laplacian filter.

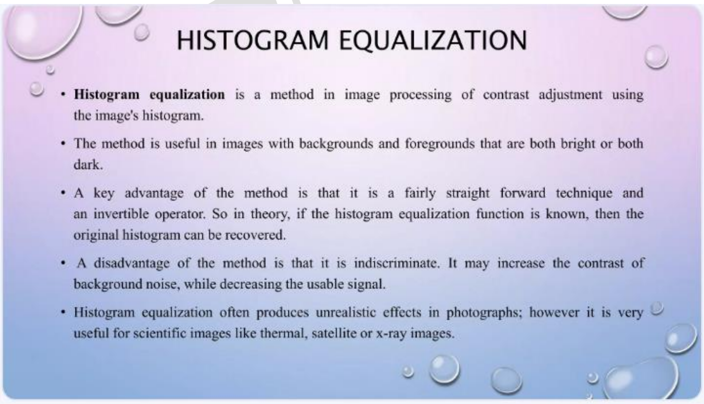
In high boost filtering, we need to use one convolution operation only one time. It will give us a sharpened image.

3) Explain homomorphic filters in frequency domain. **CO4L2 12M**









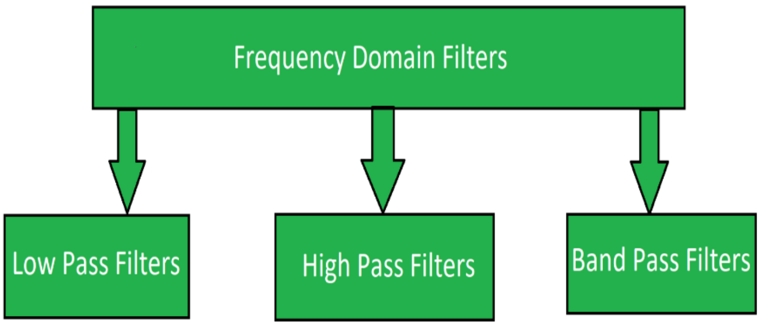
(Or)

4) Explain sharpening frequency domain filters **CO4L2 12M**

Frequency Domain Filters and its Types

Last Updated : 05 Dec, 2019

Frequency Domain Filters are used for smoothing and sharpening of image by removal of high or low frequency components. Sometimes it is possible of removal of very high and very low frequency. Frequency domain filters are different from spatial domain filters as it basically focuses on the frequency of the images. It is basically done for two basic operation i.e., Smoothing and Sharpening.
These are of 3 types:



Classification of Frequency Domain Filters

1. Low pass filter:
Low pass filter removes the high frequency components that means it keeps low frequency components. It is used for smoothing the image. It is used to smoothen the image by attenuating high frequency components

and preserving low frequency components.
Mechanism of low pass filtering in frequency domain is given by:

G(u, v) = H(u, v) . F(u, v)

where F(u, v) is the Fourier Transform of original image

and H(u, v) is the Fourier Transform of filtering mask

2. High pass filter:
High pass filter removes the low frequency components that means it keeps high frequency components. It is used for sharpening the image. It is used to sharpen the image by attenuating low frequency components and preserving high frequency components.
Mechanism of high pass filtering in frequency domain is given by:

H(u, v) = 1 - H'(u, v)

where H(u, v) is the Fourier Transform of high pass filtering

and H'(u, v) is the Fourier Transform of low pass filtering

3. Band pass filter:
Band pass filter removes the very low frequency and very high frequency components that means it keeps the moderate range band of frequencies. Band pass filtering is used to enhance edges while reducing the noise at the same time.

5) a) Explain how a point can be detected in an image **CO5** **L2** **4M**

Ans

3.1. Point Detection [8] [16]

A point is the most basic type of discontinuity in a digital image. The most common approach to finding discontinuities is to run an (n × n) mask over each point in the image. The mask is as shown in figure 2.

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

Figure 2. A mask for point detection

The point is detected at a location (x, y) in an image where the mask is centered. If the corresponding value of R such that

$$\|R\| > T \quad (2)$$

Where R is the response of the mask at any point in the image and T is non-negative threshold value. It means that isola ted point is detected at the corresponding value (x, y). This formulation serves to measures the weighted differences between the center point and its neighbors since the gray level of an isolated point will be very different from that of its neighbors [ ]. The result of point detection mask is as shown in figure 3.

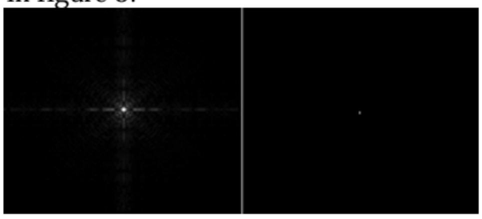


Figure 3. (a) Gray-scale image with a nearly invisible isolated black point (b) Image showing the detected point

b) Define image gradient and explain how it is useful for edge detection. **CO5** **L2** **6M**

Ans

Image gradients have been used as a measure of image sharpness [22]. The gradient at any pixel is the derivative of the DN values of neighbouring pixels. Generally sharper images have higher gradient values. Thus, any image fusion method should result in increased gradient values because this process makes the images sharper compared to the low resolution image. The mean gradient defines the contrast between the details variation of pattern on the image and the clarity of the image [23]. The mean gradient G¯ of an image *X* is given by

(16.39)G¯=1N2∑i=1N∑j=1NΔIx2+ΔIy22

(16.40)ΔIx=X(i+1,j)−X(i,j)

(16.41)ΔIy=X(i,j+1)−X(i,j)

In the above equations ΔI_X and ΔI_y are the horizontal and vertical gradients per pixel.

The main disadvantage of gradient approach is time consuming and didn't detect edge clearly, so we are move on Deeplearning approach

So that I was trying to compare deep learning based holistical-nested edge detection (VGG network) vs gradient edge detection (canny)

☆First Method — Gradient edge detection☆

- **Gradient :** Directional change in intensity of image(Using filter and find feature)

Basic idea of edge detection:

1. look for a neighborhood with strong sign of change
2. Issues of considered (size of neighborhood & what matters represent to changes)

- **Image gradient:** Gradient of an image = measure of change in image function f(x,y) in x(across/columns) and y(across/row)
- **Computing of discrete gradient:**

x = df(x,y)/dx = f(x+1,y)-f(x,y) = equivalent kernel = Hx = ([0,-1,0],[0,1,0]) (Hx(3*2 matrix))

y = df(x,y)/dy = f(x,y+1)-f(x,y) = equivalent kernel = Hx = ([0,-1,0],[0,1,0]) (Hy(2*3 matrix))

Then,

- Output = Derivation(Kernel of compute derivation (input(F)) * kernel smoothing (H))

Steps of Gradient edge deteciton:

1. *Smoothing — suppress noise*

2. Compute gradient

3. Apply edge enhancement

4. Edge localization

5. Thershold thin

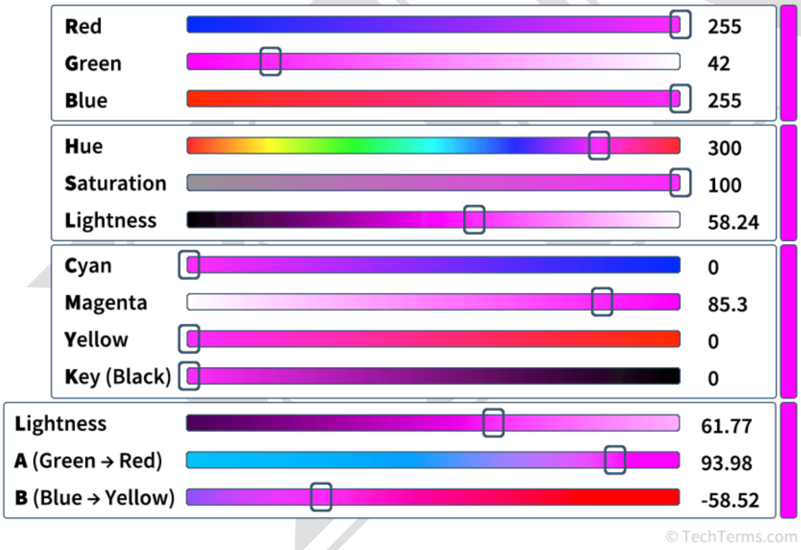
(Or)

6) a) What is the purpose of color model? Explain **CO5** **L2** **4M**

Ans

A color model is a way to represent colors mathematically using sets of numbers. A color model defines several measurable attributes of color (such as hue, saturation, and brightness) and represents each attribute as a number within a range. Most color models use sets of three values to define a color, while some use four.

Each color model measures a different set of attributes and the relationship between those attributes. The most common color model for displaying digital images on a computer is the RGB model, which separates color into red, green, and blue light. The most common model for printing images, CMYK, instead represents colors as a mix of cyan, magenta, yellow, and black inks. Other models measure other properties of color like hue, luminance, saturation, or the deviation from a specified middle color.



The same color represented numerically by 4 color models

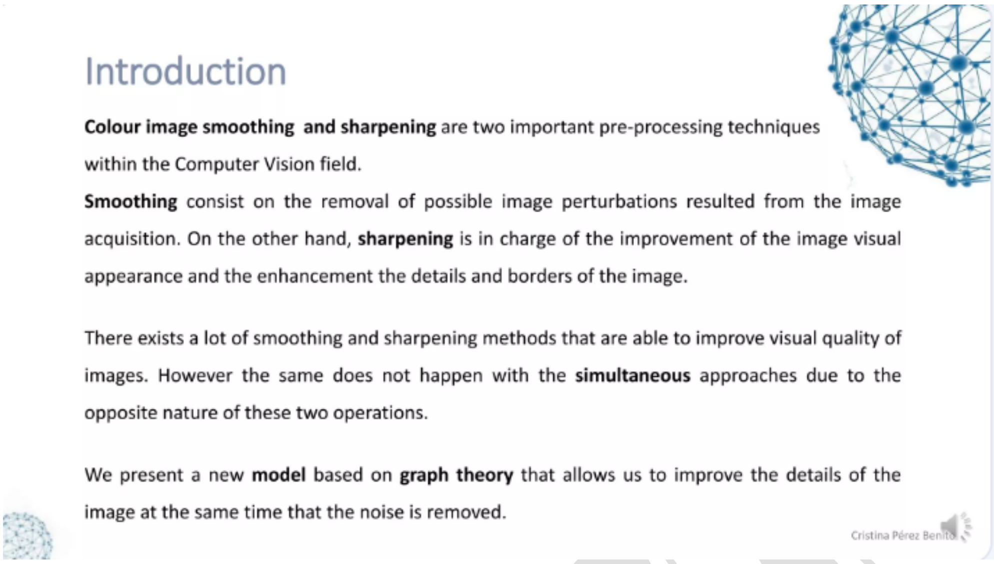
Software applications can convert color information from one model to another. For example, an image editing application that supports multiple color models allows a graphic designer to primarily use the HSL color model, which makes subtle color adjustments more intuitive. Meanwhile, the computer automatically converts it to the RGB model when it sends the image to the monitor.

While color models define how colors are measured numerically, they do not necessarily represent the limited range of colors a device can display. In most cases, it isn't useful to specify a color that cannot be shown. Software and hardware makers split many color models, particularly RGB, into smaller color spaces that use a limited subset of colors.

b) What is color image smoothing? Explain how smoothing will done by neighborhood averaging

CO5 L2 8M

Ans Color image smoothing is a pre-processing technique that averages out the background color of an image to enhance its quality:



Color image smoothing is a technique used to reduce noise and enhance the visual quality of color images. It involves averaging pixel values across a defined neighborhood to create a more uniform appearance. This process helps eliminate small variations in color and intensity, resulting in a cleaner image.

How Smoothing is Done by Neighborhood Averaging

Neighborhood Averaging involves calculating the average color value of pixels within a specified area (or kernel) surrounding each pixel in the image. This technique can be applied to each color channel (red, green, and blue) separately in a color image. Here's how it works:

1. **Select a Kernel**:
   - A kernel (or filter) is a small matrix that defines the neighborhood around each pixel. Common kernel sizes include 3×33 \times 33×3, 5×55 \times 55×5, or larger depending on the desired level of smoothing.
2. **Iterate Over Each Pixel**:
   - For each pixel in the image, consider the pixels within the kernel's area. The center pixel will be replaced with the average of the pixel values in this neighborhood.
3. **Calculate the Average**:
   - For a pixel at position (x,y)(x, y)(x,y) in a color image III:

$$I'(x,y) = \frac{1}{N} \sum_{(i,j)\in \text{kernel}} I(x+i, y+j)$$

   - Here, I′(x,y)I'(x, y)I′(x,y) is the new value for the pixel, NNN is the total number of pixels in the kernel, and (i,j)(i, j)(i,j) represent the offsets of the pixels included in the kernel.
4. **Apply to Each Color Channel**:
   - The averaging is performed separately for each color channel (R, G, B). This means that the new values for the red, green, and blue components of the pixel are computed independently using the same kernel.
5. **Boundary Handling**:
   - For pixels near the edges of the image, special handling may be required since the neighborhood may extend beyond the image boundaries. Common approaches include zero-padding, replicating edge values, or cropping the kernel.

Example

Consider a 3×33 \times 33×3 kernel applied to a pixel in the image:

mathematica
Copy code
[I(x-1, y-1) I(x-1, y) I(x-1, y+1)]
[I(x, y-1)   I(x, y)   I(x, y+1)   ]
[I(x+1, y-1) I(x+1, y) I(x+1, y+1)]

- Each pixel in the kernel will contribute to the average color value for the center pixel at (x,y)(x, y)(x,y).

SET-2

1) Explain mean, median and mode smoothing filters **CO3 L2 6M**

Ans

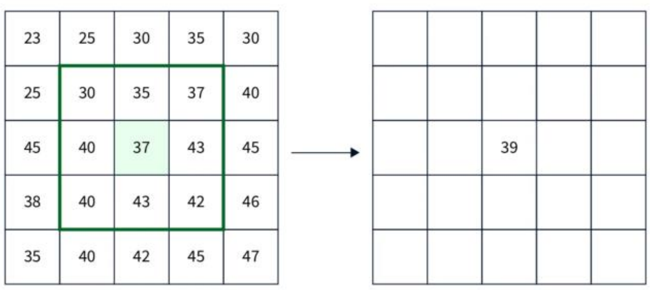
Smoothing in image processing refers to the process of reducing noise or other unwanted artifacts in an image while preserving important features and structures. The goal of smoothing is to create a visually appealing image that is easy to interpret and analyze. Smoothing techniques use various algorithms, such as filters or convolutions, to remove noise or other distortions in the image. Effective smoothing requires striking a balance between removing unwanted artifacts and preserving important image details, and is an essential step in many image processing applications, including **image segmentation, object recognition, and computer vision**.

Types of Smoothing Filters

Smoothing filters, also known as **blurring filters**, are a type of image filter that are commonly used in image processing to reduce noise and remove small details from an image. There are several types of smoothing filters, including mean filter, median filter, Gaussian filter, and bilateral filter.

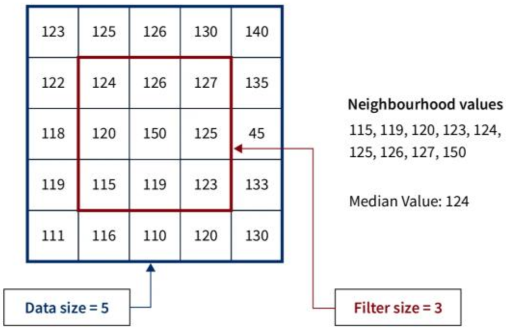
Mean Filter

The mean filter is a type of **linear smoothing filter** that replaces each pixel in the image with the average of its neighboring pixels. The size of the neighboring pixels is defined by the filter kernel or mask. The larger the kernel, the stronger the smoothing effect. Mean filters are easy to implement and are commonly used in low-level image processing tasks such as noise reduction and edge detection. However, they tend to blur edges and details in the image, leading to loss of image quality.



Median Filter

The median filter is a type of **nonlinear smoothing filter** that replaces each pixel in the image with the median value of its neighboring pixels. The size of the neighborhood is also defined by the filter kernel. Unlike the mean filter, the median filter does not blur edges and details in the image. Instead, it preserves them while removing the noise. Median filters are commonly used in image processing tasks that involve removing salt and pepper noise from the image.



3. Mode Filter

Description:

- The mode filter replaces each pixel's value with the most frequently occurring pixel value in its neighborhood.

How it Works:

- For each pixel, the filter counts the occurrence of each pixel value in the neighborhood and selects the mode (the value that appears most frequently).

Effect:

- The mode filter is effective for removing certain types of noise, particularly where the noise has a specific value that appears frequently (like salt-and-pepper noise). It can preserve edges while reducing the intensity of noise.

(Or)

2) What is meant by image enhancement? Why it is needed? CO3 L2 6M
Ans

Image enhancement refers to a set of techniques used to improve the visual appearance of an image or to make certain features more discernible. The goal is to accentuate important details, increase contrast, or reduce noise, thereby making the image more suitable for a specific application or for better human interpretation.

Why Image Enhancement is Needed:

1. **Improving Visual Quality**:
   - Many images captured under poor lighting conditions or with low contrast may look dull. Enhancement techniques can improve brightness, contrast, and color balance to make images more visually appealing.
2. **Highlighting Features**:

    - In applications like medical imaging (e.g., X-rays, MRIs), enhancing specific structures or anomalies (like tumors) can aid in diagnosis and analysis.
3. **Preparing for Analysis**:
    - Image enhancement can be a crucial preprocessing step before further analysis, such as edge detection or object recognition. Enhancing edges or removing noise can lead to more accurate results in these subsequent processes.
4. **Facilitating Interpretation**:
    - Enhanced images can make it easier for humans to interpret the content. This is particularly important in fields such as remote sensing, where enhanced images can help in land use classification or change detection.
5. **Visualizing Data**:
    - In scientific research, enhanced images can help visualize data that might be too subtle to detect in the original image. This is often seen in microscopy or satellite imaging.

Techniques Used in Image Enhancement:

1. **Contrast Enhancement**: Adjusting the contrast to make dark areas darker and light areas lighter. Techniques include histogram equalization and contrast stretching.
2. **Noise Reduction**: Using filters (like mean, median, or Gaussian filters) to reduce noise while trying to preserve important details.
3. **Sharpening**: Enhancing the edges and fine details of an image using techniques like unsharp masking or high-pass filtering.
4. **Color Adjustment**: Modifying the color balance or saturation to make colors more vivid or to correct color casts.
5. **Transformations**: Applying mathematical transformations (like Fourier or wavelet transforms) to manipulate image data for enhancement purposes.

3) a) Explain image edge enhancement in frequency domain. CO4 L2 6M
b) Explain smoothing filters in frequency domain. CO4 L2 6M
Ans https://www.scaler.com/topics/smoothing-in-image-processing/

(Or)

4) Explain Butter worth filter and Gausian filter in frequency domain. CO4 L2 12M
Ans
https://www.slideshare.net/slideshow/frequency-domain-image-enhancement-techniques/14648770

5) a) What is the role of noise in image thresholding? CO5 L2 4M
Ans

Noise plays a significant role in image thresholding, which is a technique used to segment an image into foreground and background by converting a grayscale image into a binary image. The presence of noise can greatly affect the effectiveness of thresholding methods. Here's how noise impacts this process:

1. Degradation of Image Quality:

- Noise introduces random variations in pixel values, making it difficult to distinguish between relevant features (like objects) and irrelevant variations. This can lead to inaccuracies in the thresholding process.

2. Choosing the Threshold:

- In noisy images, the optimal threshold value becomes less clear. Noise can cause pixel intensities to fluctuate around the true object boundaries, leading to misclassification of pixels as foreground or background.

3. Types of Noise:

- Different types of noise (e.g., Gaussian, salt-and-pepper, speckle) have distinct characteristics:
    - **Gaussian Noise**: This type of noise can introduce subtle variations in pixel values, making it difficult to determine a clear threshold.
    - **Salt-and-Pepper Noise**: This noise presents as random white and black pixels. It can create false edges in the image, complicating thresholding.

4. Effects on Segmentation:

- Noise can lead to:
    - **False Positives**: Pixels that are actually part of the background might be incorrectly classified as foreground.
    - **False Negatives**: Important foreground features may be overlooked due to noise interference.

5. Thresholding Techniques:

- Various techniques attempt to mitigate the effects of noise:
    - **Global Thresholding**: Using a single threshold for the entire image can be problematic in the presence of noise.
    - **Adaptive Thresholding**: This method computes thresholds based on local neighborhoods, helping to account for variations caused by noise.
    - **Preprocessing**: Applying smoothing filters (like median or Gaussian filters) before thresholding can help reduce noise and enhance segmentation results.

6. Performance Evaluation:

- The impact of noise on thresholding can be evaluated using metrics such as precision, recall, and the F1 score. A robust thresholding method should maintain high performance even in the presence of noise.

b) Write the applications of segmentation and explain threshold-based segmentation

CO5 L2 8M

Ans

Image segmentation breaks a digital image into multiple segments. It simplifies or changes its representation into something more meaningful and accessible to analyze. In other words, segmentation means assigning labels to pixels. This means all the pixels in the same category have a standard label assigned to them.

Image segmentation and image processing are different terms. Image processing involves changing an image into a digital form. Then, certain operations are done on it to get valuable data.

Applications of Image Segmentation

Image segmentation is a crucial process in computer vision and image processing that involves partitioning an image into distinct regions or segments. These segments can be based on characteristics such as color, intensity, or texture. Here are some key applications of image segmentation:

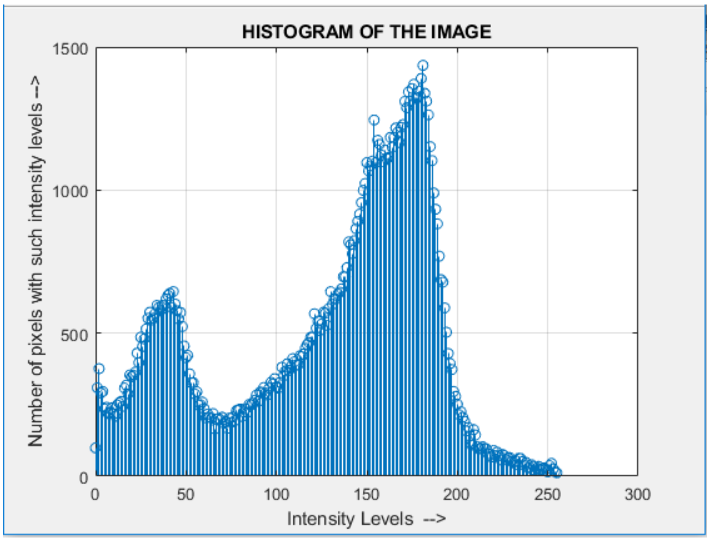
1. **Medical Imaging**:
    - **Tumor Detection**: Segmentation helps identify and delineate tumors in MRI or CT scans, aiding in diagnosis and treatment planning.
    - **Organ Segmentation**: Helps in visualizing and analyzing different organs in medical images for better assessment and surgical planning.
2. **Object Detection and Recognition**:

- Used in autonomous vehicles for identifying and classifying objects like pedestrians, vehicles, and road signs.
- Facilitates object tracking in video surveillance systems.

3. **Image Editing and Enhancement**:
   - Enables selective editing of image regions, such as background removal or applying effects to specific areas.
   - Used in graphic design and photography to enhance images.
4. **Remote Sensing**:
   - Segmenting satellite images for land cover classification (e.g., forests, urban areas, water bodies).
   - Monitoring environmental changes over time.
5. **Face Recognition**:
   - Identifying and isolating facial features for recognition and analysis in security systems and social media applications.
6. **Industrial Inspection**:
   - Automated quality control in manufacturing by detecting defects in products through image analysis.
7. **Agriculture**:
   - Analyzing crop health and monitoring growth stages through segmentation of aerial or satellite images.

Thresholding

Thresholding is one of the segmentation techniques that generates a binary image (a binary image is one whose pixels have only two values – 0 and 1 and thus requires only one bit to store pixel intensity) from a given grayscale image by separating it into two regions based on a threshold value. Hence pixels having intensity values greater than the said threshold will be treated as white or 1 in the output image and the others will be black or 0.



Suppose the above is the histogram of an image f(x,y). We can see one peak near level 40 and another at 180. So there are two major groups of pixels – one group consisting of pixels having a darker shade and the others having a lighter shade. So there can be an object of interest set in the background. If we use an appropriate threshold value, say 90, will divide the entire image into two distinct regions.

In other words, if we have a threshold T, then the segmented image g(x,y) is computed as shown below:

$$g(x,y) = 1 iff(x,y) > T and g(x,y) = 0 iff(x,y) \leq T.$$

So the output segmented image has only two classes of pixels – one having a value of 1 and others having a value of 0.

If the threshold T is constant in processing over the entire image region, it is said to be global thresholding. If T varies over the image region, we say it is variable thresholding.

Multiple-thresholding classifies the image into three regions – like two distinct objects on a background. The histogram in such cases shows three peaks and two valleys between them. The segmented image can be completed using two appropriate thresholds T_1 and T_2.

$$g(x,y) = aiff(x,y) > T2andg(x,y) = bifT1 < f(x,y) \leq T2andg(x,y) = ciff(x,y) \leq T1$$

where a, b and c are three distinct intensity values.

From the above discussion, we may intuitively infer that the success of intensity thresholding is directly related to the width and depth of the valleys separating the histogram modes. In turn, the key factors affecting the properties of the valleys are the separation between peaks, the noise content in the image, and the relative sizes of objects and backgrounds. The more widely the two peaks in the histogram are separated, the better thresholding and hence image segmenting algorithms will work. Noise in an image often degrades this widely-separated two-peak histogram distribution and leads to difficulties in adequate thresholding and segmenting. When noise is present, it is appropriate to use some filter to clean the image and then apply segmentation. The relative object sizes play a role in determining the accuracy of segmentation.

Global Thresholding

Original Image

Thresholded and segmented Image

When the intensity distribution of objects and background are sufficiently distinct, it is possible to use a single or global threshold applicable over the entire image. The basic global thresholding algorithm iteratively finds the best threshold value so segmenting.

(Or)

6) a) Write the applications of RGB color model **CO5** **L1** **4M**

Ans

The RGB color model, which represents colors using the combination of Red, Green, and Blue light, is widely used across various applications due to its versatility and alignment with human vision. Here are some key applications of the RGB color model:

1. Digital Imaging and Photography

- **Image Capture**: Cameras and smartphones use the RGB model to capture images, where each pixel's color is represented by the intensity of red, green, and blue channels.
- **Photo Editing**: Software like Adobe Photoshop utilizes the RGB model for color correction, enhancement, and manipulation.

2. Computer Graphics

- **Rendering**: Graphics applications and video games use the RGB model to create and display images and animations, allowing for realistic representation of colors and lighting.
- **User Interfaces**: RGB is commonly used in designing graphical user interfaces (GUIs) to specify colors for elements like buttons, backgrounds, and text.

3. Web Design

- **HTML/CSS Color Specification**: Web developers use the RGB color model to define colors in websites, using values like rgb(255, 0, 0) for bright red.
- **Web Graphics**: The RGB model is essential for creating web images, icons, and graphics that display correctly across devices.

4. Television and Displays

- **Screen Technology**: RGB is the primary color model used in CRT, LCD, and OLED displays to produce a wide range of colors by varying the intensity of red, green, and blue pixels.
- **Video Broadcasting**: Television and video content use RGB for color representation during transmission and display.

5. Medical Imaging

- **Imaging Techniques**: RGB is used in medical imaging systems like ultrasound and endoscopy to represent different tissues and structures through color coding.
- **Visualization**: In fields like radiology, RGB images help visualize complex data, aiding in diagnosis and analysis.

6. Machine Vision and Image Processing

- **Color Detection**: Algorithms that utilize the RGB model are used for object detection and recognition based on color.
- **Image Segmentation**: RGB is employed in segmentation tasks to distinguish between different objects or regions based on their color properties.

7. 3D Modeling and Animation

- **Texturing**: In 3D modeling software, textures are often defined using the RGB color model to achieve realistic surface appearances.
- **Lighting Calculations**: RGB values are used in simulations to calculate how light interacts with surfaces, impacting shading and rendering.

8. Color Printing

- **Printing Process**: While printing commonly uses the CMYK model, RGB is often used in the design phase before converting to CMYK for printing. RGB colors are initially created and then converted for accurate printing.

9. Art and Design

- **Digital Art Creation**: Artists use the RGB model in software to create and manipulate colors in digital paintings, illustrations, and designs.
- **Color Theory Education**: The RGB model is used to teach color mixing and theory in art and design courses.

b) Discuss about histogram processing of color images **CO5** **L2** **8M**

The histogram of a digital image with gray levels in the range *[0, L-1]* is a discrete function.

Histogram Function:

$$H(r_k) = n_k$$

Points about Histogram:

- Histogram of an image provides a global description of the appearance of an image.
- Information obtained from histogram is very large in quality.
- Histogram of an image represents the relative frequency of occurrence of various gray levels in an image.

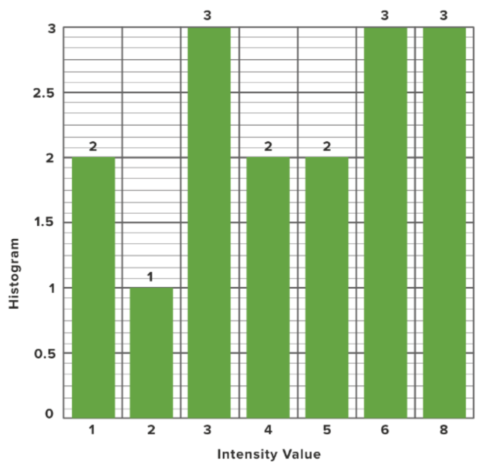
Let's assume that an Image matrix is given as:

$$\begin{bmatrix} 3 & 6 & 6 & 8 \\ 5 & 3 & 1 & 4 \\ 8 & 6 & 5 & 1 \\ 4 & 8 & 2 & 3 \end{bmatrix}$$

This image matrix contains the pixel values at *(i, j)* position in the given x-y plane which is the 2D image with gray levels.

There are two ways to plot a Histogram of an image:

Method 1: In this method, the x-axis has grey levels/ Intensity values and the y-axis has the number of pixels in each grey level. The Histogram value representation of the above image is:



Explanation: The above image has 1, 2, 3, 4, 5, 6, and 8 as the intensity values and the occurrence of each intensity value in the image matrix is 2, 1, 3, 2, 2, 3 and 3 respectively so according to intensity value and occurrence of that particular intensity we mapped them into a Graph.

Method 2: In this method, the x-axis represents the grey level, while the y-axis represents the probability of occurrence of that grey level.

Probability Function:

$$P(r_k) = \frac{n_k}{n}$$

Below table shows the **probability of each intensity level** of an pixel

Intensity Value/ Gray Level	#/Occurrence of intensity value/ number of pixels	Probability
1	2	0.125
2	1	0.0625
3	3	0.1875
4	2	0.125
5	2	0.125
6	3	0.1875
8	3	0.1875

Now we can create a histogram graph for each pixel and corresponding occurrence probability.