1. Spatial Domain Filtering

Spatial domain filtering refers to image processing operations that are performed directly on the pixel values of an image. This involves manipulating the intensity values of pixels in an image based on some local neighborhood of each pixel. Common operations include convolution with a mask or kernel to achieve effects such as blurring, sharpening, and edge detection.

2. Smoothing and Sharpening Filters

- **Smoothing Filters**: These filters are used to reduce noise and smooth out rapid changes in pixel values. Common

examples include the mean filter, median filter, and Gaussian filter.

- **Sharpening Filters**: These filters enhance the edges and fine details in an image. They work by emphasizing high-frequency components and include filters like the Laplacian filter and the unsharp mask.

3. Discrete Fourier Transform (DFT)

The Discrete Fourier Transform converts a finite sequence of equally-spaced samples of a function into a sequence of coefficients of a finite combination of complex sinusoids. In image processing, DFT is used to transform an image from the spatial domain to the frequency

domain, where it can be more easily manipulated for filtering, compression, and other purposes.

4. Fast Fourier Transform (FFT)

The Fast Fourier Transform is an algorithm that computes the Discrete Fourier Transform (DFT) and its inverse more efficiently. FFT reduces the complexity of computing the DFT from $O(N2)O(N2)$ to $O(N\log N)O(N\log N)$, making it feasible to process large images quickly.

5. Discrete Cosine Transform (DCT)

The Discrete Cosine Transform is a technique similar to the DFT but uses only

cosine functions. It is widely used in image and video compression standards such as JPEG and MPEG because it has strong energy compaction properties, meaning most of the signal information tends to be concentrated in a few low-frequency components.

6. MATLAB Tool in Digital Image Processing

MATLAB provides a powerful platform for digital image processing with its Image Processing Toolbox. It includes a wide range of functions and tools for performing image processing tasks such as filtering, transformation, analysis, segmentation, and visualization. MATLAB's built-in functions and user-friendly interface make it a popular choice

for researchers and engineers in the field.

7. Image Segmentation and Image Restoration

- **Image Segmentation**: This process involves dividing an image into meaningful regions or objects. Techniques include thresholding, clustering, edge detection, and region growing.

- **Image Restoration**: This refers to the process of recovering an image that has been degraded by factors such as noise, blur, or distortion. Techniques include deblurring, denoising, and using inverse filtering or Wiener filtering.

8. Edge Detection

Edge detection is a technique used to identify the boundaries of objects within an image. It works by detecting discontinuities in intensity. Common methods include the Sobel, Prewitt, and Canny edge detectors, each with its own approach to highlighting significant changes in gradient.

9. Hough Line Method or Hough Transform

The Hough Transform is a feature extraction technique used to detect simple shapes, such as lines, circles, and ellipses, in an image. For line detection, the method transforms points in the Cartesian coordinate system to a parameter space where lines are represented as

intersections. This allows for robust detection even in the presence of noise or gaps.

10. Thresholding and Its Techniques

Thresholding is a simple, yet effective, method for image segmentation. It converts a grayscale image into a binary image based on a threshold value. Techniques include:

- **Global Thresholding**: Using a single threshold value for the entire image.

- **Adaptive Thresholding**: Using different threshold values for different regions based on local image characteristics.

- **Otsu's Method**: Automatically determining the threshold value by minimizing intra-class variance.

11. Image Data Compression

Image data compression reduces the amount of data required to represent an image. Techniques are classified into:

- **Lossless Compression**: No information is lost during compression (e.g., PNG, GIF).

- **Lossy Compression**: Some information is discarded to achieve higher compression ratios (e.g., JPEG).

12. Quantization

Quantization refers to the process of mapping a large set of input values to a smaller set, such as rounding off values to a limited number of levels. In image processing, quantization is used in compression techniques to reduce the number of bits needed to represent an image.

13. Morphological Operations

Morphological operations are a set of image processing techniques that process images based on shapes. They are particularly useful for binary images. Common operations include:

- **Erosion**: Removes pixels on object boundaries.

- **Dilation**: Adds pixels to object boundaries.

- **Opening**: Erosion followed by dilation, useful for removing small objects.

- **Closing**: Dilation followed by erosion, useful for closing small holes.