**Briefly describe image, digital image, intensity/gray level and pixel. (4 marks)**

* **Image**: An image is a visual representation or depiction of an object, scene, or concept.
* **Digital Image:** A digital image is a representation of an image in a digital form, composed of discrete elements called pixels
* **Intensity/Gray Level:** Intensity or gray level refers to the brightness or darkness of a pixel in a digital image.
* **Pixel:** A pixel (short for picture element) is the smallest unit of information in a digital image. It is a square or rectangular area that represents a single point in the image. Pixels are arranged in a grid pattern, and each pixel contains numerical data that represents its color or intensity value.

**List three (3) fundamental processes in digital image processing for each of the following:**

**a. The outputs of the processes generally are images.**

**- Image Enhancement:** Histogram equalization, Sharpening, and Noise reduction.

**-** **Image Restoration.**

**- Image Segmentation:** Thresholding, and edge detection.

**b. The outputs of the processes generally are image attributes.**

**- Image Feature Extraction.**

**- Image Transformations.**

**- Image Classification.**

**List three (3) types of frequency domain filters and their purposes.**

**Low-pass Filter:** reduces high-frequency components in an image while preserving the low-frequency information. It is used to smooth or blur an image, reducing noise or fine details and preserving larger structures or overall image content.

**High-pass Filter**: allows high-frequency components to pass through while attenuating or removing low-frequency information. It emphasizes or enhances edges, details, or fine structures in an image by suppressing the background or smoother regions. It is commonly used in edge detection or image sharpening applications.

**Band-pass Filter:** allows a specific range of frequencies to pass through while reducing both low and high frequencies outside the selected range.

**Describe the following items in the context of digital image processing and its use. You may use diagram or sketch to illustrate the meaning of each item.**

**a. 4-neighbor of pixel, p**

In digital image processing, the 4-neighbor of a pixel refers to the four adjacent pixels surrounding a given pixel, typically in a 2D grid arrangement. The 4-neighbors of pixel p are the pixels directly above, below, to the left, and to the right of p.

X

X p X

X

**b. Resolution of image, I**

In digital image processing, the resolution of an image refers to the level of detail or clarity in the visual representation of the image. It is determined by the number of pixels (picture elements) that form the image and the physical dimensions of the image.

**c. Thresholding method in an image segmentation.**

It is a widely used method in image segmentation, where an image is divided into distinct regions based on pixel intensity values. It involves selecting a threshold value and classifying each pixel in the image as either foreground or background based on its intensity compared to the threshold.

Example Thresholding at a value of 100:

0 0 0 0

255 255 0 0

0 0 255 0

0 0 0 0

70 90 80 60

120 150 100 40

75 90 110 30

100 80 70 20

**Describe the objectives of image segmentation?**

* Object Extraction: The primary objective of image segmentation is to extract meaningful objects or regions of interest from an image.
* Boundary Detection: Image segmentation aims to identify and delineate the boundaries or contours of objects within an image.
* Image Understanding and Interpretation: Image segmentation facilitates higher-level image understanding and interpretation.
* Image Compression and Coding: Image segmentation plays a role in image compression and coding algorithms.

**Digital Image Processing is the technology of applying a computer algorithms to process a digital image. The outcome of this process can be either images or a set of representative properties of the original images. Briefly explain:**

**The concept of an image:** an image refers to a two-dimensional representation of visual information. It is a collection of pixels (picture elements) arranged in a grid pattern, where each pixel represents a specific color or intensity value.

**The main purpose of digital image processing:** The main purpose of digital image processing is to manipulate and analyze images using computer algorithms.

**Application area that use digital image processing:** Medical Imaging, Remote Sensing, Computer Vision and Digital Photography and Entertainment.

**A Laplacian filter** is an edge detector used to compute the second derivatives of an image, measuring the rate at which the first derivatives change.

**Use**: It highlights areas in which intensity changes rapidly producing a picture of all the edges in an image.

Example of combining spatial enhancement methods:

1. Laplacian to highlight fine details.
2. Gradient to sharpen the edges.
3. Gray-level transformation to increase the dynamic range of Gray levels.

**Fourier Transformation:** function, expressed in either a Fourier series or transform, can be reconstructed (recovered) completely via an inverse process, with no information loss.

**Basic filtering in the frequency domain:**

1. Multiply the input image by (-1) x+y to center the transform to u= M/2 and v = N/2.
2. Compute F(u,v), DFT of the 1
3. Multiply F(u,v) by the filter function H(u,v).
4. Compute the inverse DFT from 3
5. Obtain the real part of the result in 4
6. Multiply the result in 5 by (-1)x+y to cancel the multiplication of the input image.

**Smoothing Frequency Domain Filters**

Ideal, butterworth, Gaussian.