① A 5×5 image patch is given below. Compute the value of marked pixel if it is smoothened by a 3×3 average filter and median filter

$$\begin{bmatrix} 0 & 1 & 2 & 3 & 2 \\ 5 & 6 & 7 & 8 & 4 \\ 4 & 3 & (2) & 1 & 2 \\ 8 & 7 & 6 & 5 & 3 \\ 1 & 5 & 3 & 7 & 6 \end{bmatrix}$$

Average filter

average of the pixels contained in the neighborhood $= (6+7+8+3+2+1+7+6+5)/9 = 5$

So value of the marked pixel becomes 5 after applying average filter.

Median filter

The gray levels are 6, 7, 8, 3, 2, 1, 7, 6, 5

After sorting 1, 2, 3, 5, 6, 6, 7, 7, 8

So the value of the marked pixel after applying Median filter becomes 6

② A 3bit image of size 4×5 is shown below. Compute the histogram equalized image.

$$\begin{bmatrix} 0 & 1 & 1 & 3 & 4 \\ 7 & 2 & 5 & 5 & 7 \\ 6 & 3 & 2 & 1 & 1 \\ 1 & 4 & 4 & 2 & 1 \end{bmatrix}$$

max value = 7, so we need 3 bits to represent, $L = 2^k = 2^3 = 8$ gray levels

Gray level	0	1	2	3	4	5	6	7
no of pixels	1	6	3	2	3	2	1	2
CFD	1	7	10	12	15	17	18	20
CFD/total no pixels	1/20	7/20	10/20	12/20	15/20	17/20	18/20	20/20
multiply by 7	7/20	49/20	70/20	84/20	105/20	119/20	126/20	7
round off	0	2	4	4	5	6	6	7

Equalised image = $\begin{bmatrix} 0 & 2 & 2 & 4 & 5 \\ 7 & 4 & 6 & 6 & 7 \\ 6 & 4 & 4 & 2 & 2 \\ 2 & 5 & 5 & 4 & 2 \end{bmatrix}$

(3) A skilled medical technician is charged with the job of inspecting a certain class of monochrome images generated by electronic microscope. To facilitate the inspection, the technician uses image processing aids. However when he examines the image, he finds the following problems

(a) Presence of bright isolated dots that are not of interest

(b) Lack of sharpness

(c) Poor contrast

Identify the sequence of preprocessing steps that the technician may use to overcome the above mentioned problems and explain it.

a) Noise Reduction

a) ⇒ The presence of bright isolated dots indicates the presence of noise in the image.

⇒ Techniques like Median filter can be used

Median filter

* It replaces the value at the center by the median pixel value in the neighborhood (i.e the middle element after they are sorted)
* It is particularly used in removing impulse noise.
* In a 3×3 neighborhood, the median is 5th largest value, in a 5×5 neighborhood, the 13th largest value and so on

b) Lack of Sharpness

* In order to increase the sharpness, Laplacian filter can be used
* Laplacian operator of an image $f(x,y)$ is

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

* Laplacian operator is applied to enhance the edges and details in an image.

* By accentuating the high frequency components (ie edges), the Laplacian operation effectively sharpens the image, making edges appear more defined.

(c) Poor Contrast

* In order to increase the contrast, histogram equalization can be used.
* Histogram Equalization
  - ⇒ Technique used in image processing to adjust the contrast of an image by modifying the intensity distribution of its pixels
  - ⇒ It works by redistributing the pixel intensities in such a way that the histogram of the resulting image becomes more evenly distributed across the intensity range.
  - ⇒ This redistribution helps to spread out the intensity values, making both dark and bright regions more distinguishable, hence enhancing the overall contrast of the image.

A) You have sobel operator and Laplacian operator for edge detection. Which operator will you select for edge detection in the case of noisy image? Explain

In case of Noisy Image, Sobel operator can be choosen over Laplacian operator because

1) The sobel operator calculates gradients in both the horizontal and vertical directions separately and then combines them. This process helps to reduce the impact of noise because noise is often random and doesn't exhibit consistent patterns in both directions

2) Additionally the Sobel operator implicitly performs some level of smoothing during the gradient calculation process, which helps to supress noise.

3) Sobel operator tends to provide more accurate localization of edges compared to the Laplacian operator, especially in the presence of noise.