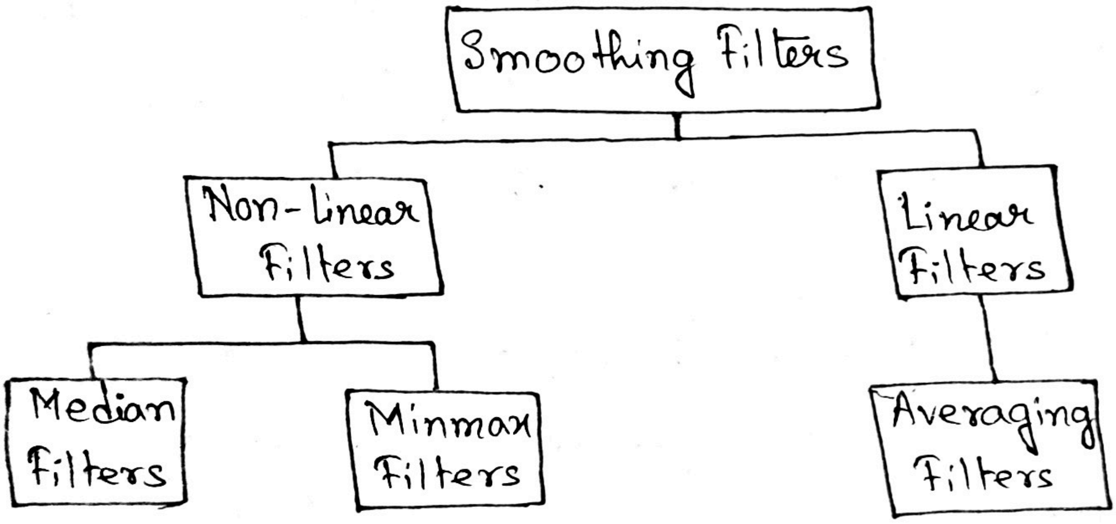
Smoothing Spatial Filters:

- Smoothing filters are used for blurring and for noise reduction

- Noise reduction can be accomplished by blurring with a linear filter and also by non-linear filtering.

- Blurring is used in preprocessing tasks, such as removal of small details from an image prior to object extraction and bridging of small gaps in lines or curves.



Smoothing linear Filters:

- The output of a smoothing linear filter is simply the average of the pixels contained in the neighborhood of the filter mask.

- These filters are sometimes called averaging filters or a lowpass filters.

Order-Statistic (Nonlinear) Filters:

Order-statistic filters are non-linear spatial filters whose response is based on ordering the pixels contained in the image area encompassed by the filter and then replacing the value of the center pixel with the value determined by the ranking result.

i) Median filter:

- Median filters are one of the best known filter among non-linear filters.
- The median filter replaces the value of a pixel by the median of the intensity values in the neighborhood of that pixel.
- Median filter provide excellent noise reduction capabilities, with considerably less blurring.
- Median filters are particularly effective in the presence of impulse noise, also called salt and pepper noise.

ii) Max filter:

- The max filter is a type of non-linear spatial filtering.
- The max filter is used for finding the brightest points of an image.
- The response of a 3x3 max filter is given by,

$$R = \max\{z_k \mid k = 1, 2, \ldots, 9\}$$

iii) Min filter:

- The min filter is a type of non-linear spatial filtering.
- The min filter is used to find the dull points of an image.
- The response of a 3x3 min filter is given by,

$$R = \min \{ z_K \mid K = 1, 2, 3, \ldots, 9 \}$$

Using the second order derivative for image sharpening:

- This approach uses the laplacian for image sharpening.
- The laplacian for a function $f(x,y)$ of two variables is defined as,

$$\nabla^2 f = \frac{d^2 f}{dx^2} + \frac{d^2 f}{dy^2}$$

- In x-direction we have,

$$\frac{d^2 f}{dx^2} = f(x+1, y) + f(x-1, y) - 2f(x,y)$$

- In y-direction we have,

$$\frac{d^2 f}{dy^2} = f(x, y+1) + f(x, y-1) - 2f(x,y)$$

- By combining the above three equations we have,

$$\nabla^2 f = [f(x+1,y) + f(x-1,y) + f(x,y+1) + f(x,y-1)] - 4f(x,y)$$