Spatial Filtering :

The use of spatial masks for image processing usually is called Spatial filtering and the masks are called spatial filters.

The following figure shows a general 3×3 mask. Denoting the gray levels of pixels under the mask at any location by $z_1, z_2, \ldots, z_9$, the response of a linear mask is

$$R = w_1 z_1 + w_2 z_2 + \cdots + w_9 z_9$$

w_1	w_2	w_3
w_4	w_5	w_6
w_7	w_8	w_9

A 3×3 mask with arbitrary co-efficients (weights)

If the center of the mask is at location (x, y) in the image, the gray level of the pixel located at (x, y) is replaced by R. the mask is then moved to the next pixel location in the image and the process is repeated. This continues until all pixel locations have been covered.

Nonlinear spatial filters also operate on neighborhoods. Their operation is based directly on the values of the pixels in the neighborhood under consideration.

median filtering.

One of the principal difficulties of the smoothing method is that it blurs edges and other sharp details. If the objective is to achieve noise reduction rather than blurring, median filters are used. That is, the gray level of each pixel is replaced by the median of the gray levels in a neighborhood of that pixel, instead of by the average. This method is particularly effective when the noise pattern consists of strong, spike like components and the characteristic to be preserved is edge sharpness. Median filters are non linear.

In order to perform median filtering in a neighborhood of a pixel, sort the values of the pixels in ascending order and select the center value which is the median value in its neighborhood. Suppose that a 3×3 neighborhood has the values (10, 20, 20, 20, 15, 20, 20, 25, 100). The values are sorted as (10, 15, 20, 20, 20, 20, 20, 25, 100), results in a median of 20.

sharpening filters:

Smoothing filters

Smoothing filters are used for blurring and for noise reduction. Blurring is used in preprocessing steps, such as removal of small details from an image prior to object extraction, and bridging of small gaps in lines or curves. Noise reduction can be accomplished by blurring with a linear filter and also by non linear filtering.

Lowpass Spatial filtering :

For a 3x3 spatial filter, the simplest arrangement would be a mask in which all the coefficients have a value of 1. while the sum of grayleels for nine pixels be divided by 9. The response R would simply be the average of all the pixels in the area of the mask. The use of masks of this form shown in figure is often referred to as neighborhood averaging.

$\frac{1}{9} \times$ | 1 | 1 | 1 |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 1 | 1 |

(a)

$\frac{1}{25} \times$ | 1 | 1 | 1 | 1 | 1 |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 |

(b)

$\frac{1}{49} \times$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |

(c)

Spatial lowpass filters of various sizes.

Figure shows the classic implementation of a 3x3 sharpening filter. Choosing a positive value in the center location with negative coefficients in the rest of the mask meets this condition.

$$\frac{1}{9} \times \begin{array}{|c|c|c|} \hline -1 & -1 & -1 \\ \hline -1 & 8 & -1 \\ \hline -1 & -1 & -1 \\ \hline \end{array}$$

A basic highpass spatial filter

When the mask is over an area of constant or slowly varying gray level, the output of the mask is zero or very small. Reducing the averaging value of an image to zero implies that the image must have some negative gray levels. As the results of high pass filtering involve some form of scaling so that the gray levels of the final result span the range $[0, L-1]$.

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