NON-LINEAR FILTERS

Rank filter

Convolution is not the only way of carrying out spatial filtering. There also exist nonlinear techniques some of which are referred to as order statistics filters or rank filters. The idea is to compile an ordered (ascending) list of the gray values in a neighborhood of a pixel and then select a value from a particular position in this list to be used as output value for the new pixel.

Median filter

Selects the median value in a (mostly square shaped) neighborhood. As compared to the mean filter, the median is good at removing impulse noise (salt-and-pepper or shot noise) while still preserving edges. However, a drawback is that the median erodes the corners of rectangular objects.

Minimum filter

Selects the minimum value in a neighborhood. Causes darker regions in an image to swell. Contributes to non-linear blurring.

Maximum filter

Selects the minimum value in a neighborhood. Causes brighter regions in an image to swell. Contributes to non-linear blurring.

Range filter

Computes the difference between the maximum and minimum gray levels in a neighborhood. Also, acts as a omni-directional, non-linear edge detector.

Adaptive filter

Many common filters are isotropic, that is they perform in the same way regardless of where in the image they operate. The idea with adaptive (or non-isotropic) filtering is to change the behavior of the filter in response to local image intensity variations. One example is the minimal mean square error filter. This filter computes the output as:

$$g(x,y) = f(x,y) - \frac{\sigma_n^2}{\sigma^2(x,y)} \Big[f(x,y) - \overline{f}(x,y) \Big]$$

where σ_n^2 is an estimate of noise variance, $\sigma^2(x,y)$ is the gray-level variance computed for the neighborhood centered on (x,y,) and $\overline{f}(x,y)$ is the mean gray-level in that neighborhood.

In image regions, which are supposed to be homogeneous, noise will be the sole cause of variations in gray-levels. Thus, $\sigma^2(x,y) = \sigma_n^2$ and equ. (1) reduces to: $g(x,y) = \overline{f}(x,y)$ In the vinicity of edges, we expect $\sigma^2(x,y)$ to dominate local noise variance, resulting in a small ratio of variances and a value for g(x,y) that is close to the original value at that pixel, f(x,y).