

Smoothing and Noise Removal Filters

TNTmips provides several sets of image filters that can be applied to grayscale or color images temporarily as a Display option (using the Filter tabbed panel on the Raster Layer Display Controls window) or permanently using the Spatial Filters process (Image / Filter / Spatial Filter). For ease of selection these spatial filters are organized into groups based on their purpose. To select a filter, choose the filter group from the Type menu and the specific filter from the Filter menu (see the Technical Guide entitled *Spatial Filter Process*).

Filters in the Smoothing and Noise Removal group are designed to reduce detail and remove “noise” from an image. Image noise occurs as local extreme (outlier) cell values that are very different from the majority of the surrounding cell values. Distinguishing noise from desired image detail is difficult, however, so loss of valid image detail (blurring) also occurs when smoothing / noise reduction filters are applied. You can blend the source image and the filter result in any proportion using the Blending slider to vary the amount of smoothing in the final blended result. Smoothing filters (especially the Gaussian Blur filter) are also commonly used prior to applying edge-detection filters, which are sensitive to image noise.



Sample Grayscale Image

The Low Pass / Average and Gaussian filters are simple convolution filters that use a set of kernel coefficients (weights) to process values in the filter window. In the Spatial Filters process the weights for these filters can be viewed and edited on the Kernel tabbed panel. The remaining filters in this group do not use kernel coefficients, so the Kernel panel is inactive when they are selected. Many of these filters are designed to preserve valid image detail while removing random noise. Some of the filters in this group have a user-defined parameter (its name varies depending on the filter) that can be adjusted using a slider control.

Low Pass / Average

The Low Pass/Average filter computes the simple average (mean) of the cells in the filter window. All of the weights in the filter kernel have a default value of 1.0. This filter can be used to remove noise and emphasize general brightness trends, but results in some blurring of edges, general loss of detail, and reduction in image contrast.



Low Pass / Average, 5 x 5

These effects increase as the size of the filter window increases. Because the value of the local mean is influenced by extreme values of noise cells, the Low Pass / Average filter is less successful at removing noise than the other filters in the Smoothing group.

Gaussian Blur

The Gaussian filter is a convolution filter in which the filter weight values vary across the filter kernel according to the shape of a Gaussian distribution (a normal-frequency bell-shaped curve) in two dimensions. The highest weight value is in the center of the kernel (corresponding to the value of the cell being filtered) and the weight values decrease with distance from the center pixel. The resulting weighted average is thus heavily biased toward the center cell and its immediate neighbors, which means that the Gaussian Blur filter preserves edges better than the simpler Low Pass / Average filter.

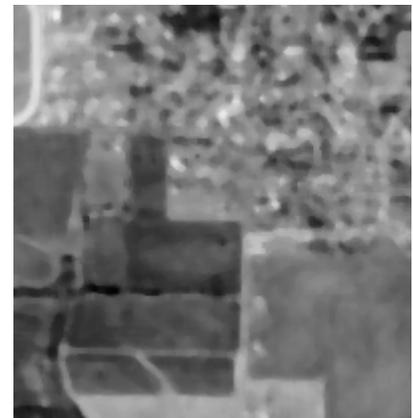
The shape of the Gaussian kernel function is set by the Sigma parameter with a value expressed in decimal numbers of standard deviations. A larger value of Sigma results in a broader, less peaked Gaussian kernel function, more weight given to more distant cells in the filter window, greater smoothing, and less preservation of edges.



Gaussian Blur, 5 x 5, Sigma = 1.0

Median

The Median filter ranks the input cell values in the filter window in numerical order and assigns the median value (middle value in the rank order) as the output. Because the output value is not affected by the actual value of outlier cells within the filter window, the Median filter is particularly good



Median, 5 x 5

at removing isolated random noise. The Median filter preserves (over)

edges better than the Low Pass / Average filter, but thin lines (narrower than the filter window dimensions) can be removed.

Modal

The Modal filter evaluates the raster values in the filter window and assigns the mode (most frequent value) as the filter result. If no image value occurs more than once in the filter window, the input cell value is used. The Modal filter produces considerable smoothing, but can produce irregular shifts in edges, which make them appear ragged. Since no averaging is performed, this filter is appropriate to use to simplify a categorical (class) raster in which the cell values serve only as labels and have no numerical significance.



Modal, 3 x 3

Olympic

The Olympic filter is a variant of a low pass (averaging) filter. It is named for the system of scoring used in certain Olympic events, in which the highest and lowest scores are dropped and the remaining ones averaged. The Olympic filter ranks the values within the filter window and discards a range of high and low values before calculating the mean of those remaining. Because extreme values are excluded, the averaged result is less influenced by outlier values than the simple Low Pass / Average filter, but it can still blur edges and remove fine detail. The Clip setting for this filter is an integer value that sets the number of values discarded at each end of the distribution. Increasing the Clip value reduces the number of image values used in the averaged result, which tends to reduce the blurring of discrete sharp edges but makes areas of fine-scale variability appear more uniform.



Olympic, 5 x 5, Clip = 8

Multi Level Median (MLM)

The MLM filter is designed to reduce image noise (outlier values) while preserving edges, corners, and thin line detail in the image. The filter calculates separate median values for horizontal, vertical, and two diagonal transects through the central cell in the filter window. The minimum and maximum of these four values are then found. The minimum, maximum, and original center raster value are then ranked, and the median of these three values is assigned as the filter output value. The MLM

filter preserves edges better than the simple median filter, but does not smooth small-scale noise as well.

P-Median (PM)

The P-Median filter is designed to suppress noise while preserving edge and line detail. The filter calculates median values for two subsets of the values in the filter window: 1) combined horizontal and vertical transects through the center cell, and 2) two diagonal transects through the center cell. These two median values are then averaged. The PM filter preserves edges better than the simple median filter, but provides less noise suppression in uniform regions.



Multi Level Median, 7 x 7



P-Median, 5 x 5

Adaptive Mean P-Median (AMPM)

The Adaptive Mean P-Median filter is a variant of the P-Median filter that is designed to provide better smoothing in uniform regions while still preserving edges and line detail. The filter first classifies the center cell in the filter window as belonging to either a uniform region or an edge region. The AMPM filter then applies the P-Median filter in windows containing edges, but uses a simple averaging filter in windows with relatively uniform values. The Speckle Smoothing parameter value controls the initial classification or uniform or edge by setting a threshold value expressed as the fractional number of standard deviations from the mean. If the center cell value exceeds the threshold, the window is designated as an edge and the P-Median filter is applied. Increasing values of the Speckle Smoothing setting increase the proportion of the image designated as uniform and subject to the averaging procedure, producing a smoother image with less preservation of edges and fine detail.



Adaptive Mean P-Median, 3 x 3,
Speckle Smoothing = 3.0