# Sharpening 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 Filter 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*). You can blend the source image and the filter result in any proportion using the Blending slider.

Sample Grayscale Image

Filters in the Sharpening group are designed to enhance the appearance of images, primarily by sharpening edges, corners, and line detail. Two of these filters (High Pass and High Boost) are simple convolution filters that use a set of filter kernel coefficients to compute a weighted average of the image cells in the filter window. In the Spatial Filter process the filter 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. Some of the filters in the latter subset also suppress image noise so that the the main image content is preferentially accentuated.

## High Pass

The High Pass filter is a linear convolution filter that selectively enhances local features (high spatial-frequency components) of an image while maintaining the larger-scale features. This filter subtracts an averaged (smoothed) version of the image surroundings from each image cell, accentuating local features.

High Pass 3 x 3

The default filter kernel has filter weight values of –0.5 for all cells except the center cell, which is assigned a high positive weight whose value depends on the filter window size (5.5 for a 3 by 3 filter window). The filter calculation slightly amplifies the value of the center cell, then subtracts from it half of the average value of the surrounding cells. This calculation has little effect in areas of uniform brightness, but if the center cell differs significantly from its surroundings, this difference is accentuated in the filtered image. The result is enhanced contrast for edges and other small-scale features in the image.

## High Boost

The High Boost filter is a milder form of the High Pass filter. The default weighting coefficient for non-central cells is –1.00, while the center cell is assigned a much higher positive value (20.0 for a 3 by 3 kernel) than for a High Pass filter of the same size. Because of the greater difference in weights between the center and non-center cell positions in the kernel, the High Boost filter emphasizes the raw image values much more than the local average being subtracted, so the result is a more subdued enhancement of edge and line detail in comparison to the High Pass filter.

High Boost 3 x 3

## Volterra Unsharp

The Volterra / Unsharp filter is an edge-enhancement filter in which the amount of enhancement is proportional to the local image brightness. The varying edge-enhancement is meant to account for a significant property of the human visual system: image details involving a given brightness contrast are more easily recognized in dark areas than in bright image areas. Edge details in bright areas therefore require more enhancement than those in dark areas of the image, and image noise that is amplified by a filter is more noticeable in dark areas.

Volterra Unsharp 3 x 3
Sharpen = 0.007

The output of the Volterra filter is approximately equivalent to the scaled product of the local mean and a high-pass filter. The scaling is controlled by the Sharpening slider, which varies from 0.001 to 1.0. Sharpening values close to the minimum produce significant sharpening in the pure filtered result, while higher values produce very high-contrast images dominated by edges.

(over)

## Comparison and Selection (CS)

The Comparison and Selection (CS) filter is a simple nonlinear edge-enhancement filter that also suppresses image noise (outlier values). The filter enhances edges by converting raster values that are close to the local mean to new, locally defined values that are farther from the mean.

The CS filter ranks the values within the filter window in numerical order and calculates the mean raster value for the current filter window. The Sharpening parameter value specifies a pair of rank numbers symmetrical about the mean. The raster values corresponding to these rank numbers for the current filter window provide the two possible choices for the filter output value. If the input value is less than the mean, the lower raster value is used for the filter output. If the filter input value is greater than the mean, the higher value is used. The units for the Sharpening parameter are rank numbers measured outward from the mean. Increasing the Sharpening value moves the pair of possible output values farther from the mean, increasing the edge-enhancement effect but producing more smoothing of uniform areas. These effects also increase with increasing filter window size. The CS filter is capable of transforming blurred edges to ideal step edges, but it can distort or eliminate features that are significantly smaller than the size of the filter window.

**Comparison and Selection 3 x 3**
**Sharpen = 8**

## Lower-Upper-Middle (LUM)

The Lower-Upper-Middle (LUM) filter is a nonlinear sharpening filter that simultaneously suppresses image noise. The filter first ranks the values within the filter window in numerical order and determines the median value. Two user-adjustable parameters are used to partition the resulting list of values, and the filter output is determined by the partition in which the window's center cell value falls.

The Sharpening parameter is an integer value that sets symmetrical upper and lower rank limits for values near the median value. If the input cell value is within these limits, the filter result is set to the lower or upper limit depending on whether the input value is below or above the median (respectively). This filter property provides a mild edge-enhancement effect. Increasing the value for the Sharpening parameter moves the central value limits toward the extremes of the window range, increasing this effect.

The Smoothing parameter sets another pair of rank limits outside of (closer to the extremes than) the central limits. This parameter value is an integer that counts rank levels inward from the extremes. If the input value is less than the lower rank limit, the filter outputs the lower limit value. If the input cell value is greater than the upper rank limit, the filter outputs the upper limit value. Extreme high and low values are thus adjusted to be closer to the median value, providing a mild smoothing effect. A Smoothing setting of 1 corresponds to no smoothing, and increasing the value increases the smoothing effect.

**Lower-Upper-Middle 3 x 3**
**Sharpen = 8, Smoothing = 2**

If the input cell value falls outside the central limits (set by the Sharpening value) but closer to the median than the Smoothing limits, the filter simply outputs the input cell value. Thus sharpening effects are targeted to "average" values and smoothing effects targeted to extreme values. The combination of edge-enhancement and noise suppression provided by the LUM filter makes it a good choice for prefiltering a noisy image prior to running a gradient-based edge-detection filter.

## WMMR-MED

The WMMR-MED (weighted majority with minimum range - median) filter is a nonlinear edge-enhancement filter that also suppresses image noise (outlier values). The filter ranks the cell values in the filter window in numerical order, then finds a fixed-size subset in which the values are most closely spaced. The median value of that subset is the filter output. The WMMR-MED filter produces a subtle sharpening of edges (that may be evident only when you display a magnified subarea of the raster), while achieving considerable smoothing of intervening areas. It can distort or eliminate features that are significantly smaller than the size of the filter window. This filter has no user-adjustable parameters except for the filter window size.

**WMMR-MED 3 x 3**