Edge Detection 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*).

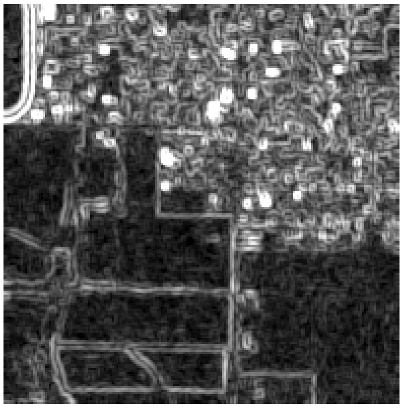
Filters in the Edge Detection class are designed to detect boundaries between image areas that have distinctly different brightness and to reveal other aspects of image texture. For many of these filters the unblended result emphasizes image edges in high contrast. Edge Detection filters are commonly used as a first step in procedures to define discrete objects (such as buildings or agricultural fields) within images.

The Gradient and Laplacian filters are convolution filters that use sets of kernel coefficients (weights) to process values in the filter window. In the Spatial Filter 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.

Sample Image

Std Deviation

The Std Deviation filter computes the statistical standard deviation of the cell values within the filter window, a measure of the spread of values around the mean. Smooth, uniform areas produce low standard deviation values (dark tones in the filter result) whereas edges and rough areas produce higher standard deviation values and bright tones.



Std Deviation 3 x 3

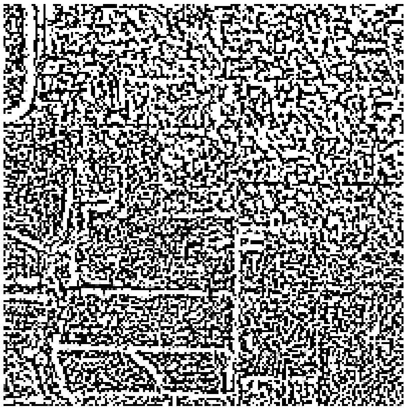
Range

The Range filter emphasizes edges and areas of differing image texture. The filter result is the difference between local minimum and maximum values in the filter window multiplied by an adjustable Gain Factor that modulates the brightness and contrast of the result. The Range filter emphasizes local differences in brightness independent of the average brightness of the area. Increasing the Gain Factor increases the brightness and contrast of the filter result.

Range 3 x 3, Gain Factor = 2

Teager

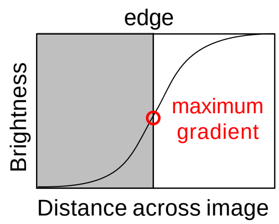
The Teager filter result is approximately equivalent to the result of a high-pass filter weighted by the local mean. It produces a very high-contrast result, greatly boosting the brightness of lighter areas and reducing the brightness of darker areas to emphasize edges.

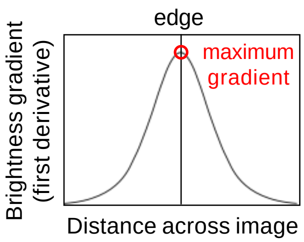


Teager 3 x 3

Gradient Filters

Image edges are defined by a large change in brightness. Therefore in a plot of brightness versus horizontal position along any line across an image, the plot line will have its steepest slopes (gradients) at edges. More uniform areas show little horizontal change in brightness and thus have lower slopes in a brightness profile. In a plot of the gradient (first derivative) versus distance, image edges are peaks and more uniform areas are valleys (see illustrations above right).





(over)

Several filters designed to measure brightness gradients are provided. Each filter uses a pair of filter kernels of fixed size. The two kernels measure brightness gradients in two perpendicular directions. Their output is combined to produce a measure of the overall magnitude of the local gradient at each cell location. These edge-detecting filters produce very similar results, so only one sample filter result is illustrated here.

Gradient-Sobel

The Gradient-Sobel filter uses two 3 by 3 kernels to detect gradients in the horizontal and vertical directions.

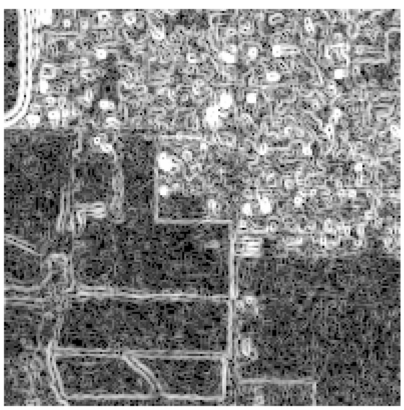
1	2	1		-1	0	1
0	0	0		-2	0	2
-1	-2	-1		-1	0	1

Gradient-Roberts

The Gradient-Roberts filter uses two 2 by 2 kernels to measure gradients in opposing diagonal directions.

0	-1		-1	0
1	0		0	1

The upper left cell in each kernel is centered on the raster cell currently being evaluated. Because the kernels do not process neighboring cells on all sides of the current cell, the edge image produced is shifted by one-half cell in the lower-right direction compared to the input image. However, the Gradient-Roberts filter produces a sharper edge image than the filters using centered 3 by 3 kernels.



Gradient-Roberts (logarithmic contrast)

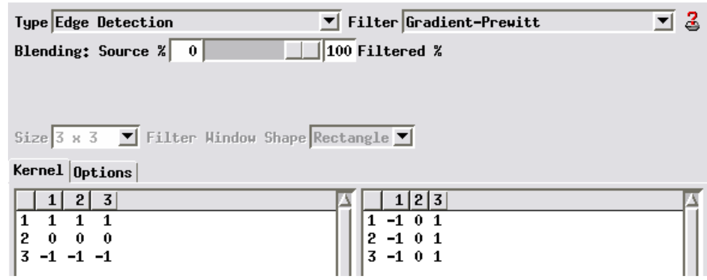
Gradient-Prewitt

The Gradient-Prewitt filter uses two 3 by 3 kernels to measure horizontal and vertical gradients.

1	1	1		-1	0	1
0	0	0		-1	0	1
-1	-1	-1		-1	0	1

Gradient-User Defined

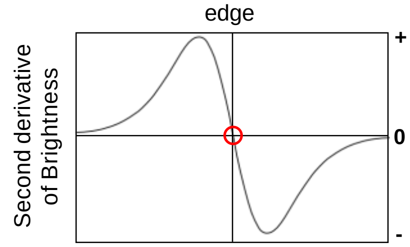
In the Spatial Filter process, the filter coefficients for the Gradient filters are shown on the Kernel tabbed panel. You can edit any of the coefficient values to create custom gradient filters. Editing any coefficient in the pair of kernels automatically changes the Filter menu selection to Gradient-User Defined.



In the Spatial Filter process the Kernel tabbed panel shows a pair of filter kernels for each of the Gradient filters in the Edge Detection group. You can edit these kernel coefficients to produce a custom edge-detection filter; the Filter menu automatically switches to the Gradient-User Defined option when you edit any of the coefficients.

Laplacian and Laplacian with Diagonals

The gradient filters just described measure the spatial first derivatives (rates of change) of image brightness to detect edges. The Laplacian filter is a convolution filter that uses filter weights to compute the spatial *second* derivatives of an image (the rate at which changes in brightness change). The second derivative (slope of the first derivative line) is zero at the maxima (peaks) in the first derivative plot, which correspond to image edges. Thus image edges are marked by 0 values of the second derivative, where the second derivative changes sign (see illustration to the right).



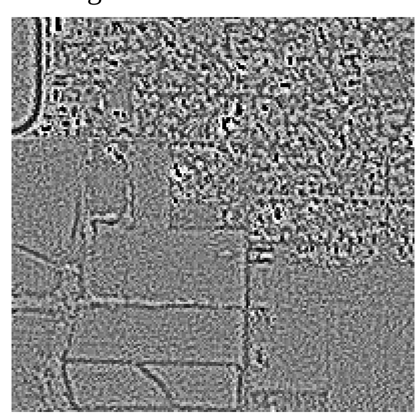
The Laplacian filter has a fixed 3 by 3 filter window size and has 0 values at the corners. This kernel computes an approximation of the second derivative in the horizontal and vertical directions. The Laplacian with Diagonals filter has small non-zero values at the corners, adding a measure of the second derivatives in the diagonal directions.

0	1	0
1	-4	1
0	1	0

Laplacian kernel

0.5	1.0	0.5
1.0	-6.0	1.0
0.5	1.0	0.5

Laplacian with diagonals kernel



Laplacian 3 x 3