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# *Sharpening Images*

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## *How Sharpening Works*

Sharpening is one of the most impressive transformations you can apply to an image since it seems to bring out image detail that was not there before. What it actually does, however, is to emphasize edges in the image and make them easier for the eye to pick out -- while the visual effect is to make the image seem sharper, no new details are actually created.

Paradoxically, the first step in sharpening an image is to blur it slightly. Next, the original image and the blurred version are compared one pixel at a time. If a pixel is brighter than the blurred version it is lightened further; if a pixel is darker than the blurred version, it is darkened. The result is to increase the contrast between each pixel and its neighbors. The nature of the sharpening is influenced by the blurring radius used and the extent to which the differences between each pixel and its neighbor are exaggerated.

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### *Sharpening Methods*

Picture Window offers four sharpening techniques: Sharpen, Heavy Sharpen, Unsharp Mask, and Bilateral Sharpening. Sharpen and Heavy Sharpen are the most straightforward methods. They are computed similarly, but Sharpen blurs the pixels in the image based on only its four closest neighbors and exaggerates the differences moderately while Heavy Sharpen blurs by using the eight nearest neighbors and exaggerates the differences more. In either case, you can moderate the effect by setting the Amount slider back from its 100% maximum value. The effects of Sharpen and Heavy Sharpen are illustrated below:



Sharpen



Heavy Sharpen

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### *Oversharpening*

If you continue to sharpen an image, several things happen:

1. Edges become unnaturally pronounced—dark objects are outlined with light halos and light objects are outlined with dark halos.
2. Normally invisible noise in the image is amplified and starts to show up as texture in areas that looked smooth in the original images. This can create an undesirable graininess in parts of photographs that should be smooth like clouds and clear skies.
3. Extreme sharpening causes the image to break up as each individual pixel stands out more and more from its neighbors.

Thus as you progressively sharpen a slightly blurry image, it first starts to look better, but then as you begin to oversharpen it, it starts to look worse again. Once you know what oversharpening looks like, you will be able to spot it on the screen and back off a little.



Heavy Sharpen Twice



Heavy Sharpen Three Times

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### *Limiting Halos*

One of the common artifacts of sharpening is light halos around dark objects or dark halos around light objects.

All of Picture Window's sharpening methods provide a dual slider for limiting light and dark halos. If you notice any halos, reduce it by moving the appropriate slider to the far left until the halo is no longer noticeable. Limit settings of 5 -10% are typical.

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### *Using the Sharpen transformation*

The best way to set up Picture Window's Sharpen Transformation is to zoom the input image in to a magnification factor of 1:1 or even 2:1 and then zoom the Preview window in to the same magnification factor and scroll the two windows as necessary to display the same part of the image. Resize and reposition the two windows so they are next to each other across the top of the screen. This lets you see

every detail at the individual pixel level in both the original image and the sharpened version. As you preview the results of various settings, you will then be able to compare the original and sharpened versions easily. If necessary, you can scroll both windows to see the effect of the transformation on other parts of the image.

For slightly blurred images, the Sharpen or Heavy Sharpen options often work well. If the effect is too strong, you can always move the Amount slider to the left to reduce the amount of sharpening. If you want to sharpen just part of an image, leaving the rest alone, you will need to create a mask that isolates the region of interest and then select this mask into the Amount control. Making and using masks is covered in the Picture Window manual and help file.

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### *Unsharp Masking*

Unsharp masking is more powerful than Sharpen or Heavy Sharpen, however it is a little more complicated to use. When you select Unsharp Masking, the Sharpen dialog box expands to add two additional sliders for Radius and Threshold.

The Radius slider lets you control the amount of blurring. Generally you should set the radius to correspond to the degree to which the original image is blurred. The blurrier the image, the higher the radius you need to select. Choosing too large a radius creates a sort of ghosting effect around the edges of objects; if the radius is too small, the sharpening effect is minimized.

The Threshold setting lets you restrict to sharpening action to only those pixels whose difference from their neighbors exceeds a specified threshold value. The idea behind setting the threshold value is to select a value that still brings out edge detail without creating unwanted texture in smooth areas like clouds or clear blue skies. In the image detail below, you can see how Unsharp Mask with a threshold of zero sharpens the tree silhouette, but also brings out noise in the sky area. Increas-

ing the threshold to 20 leaves the sky mostly untouched but still makes the tree stand out against its background.



Unsharp Mask -- Threshold 0

Unsharp Mask -- Threshold 20

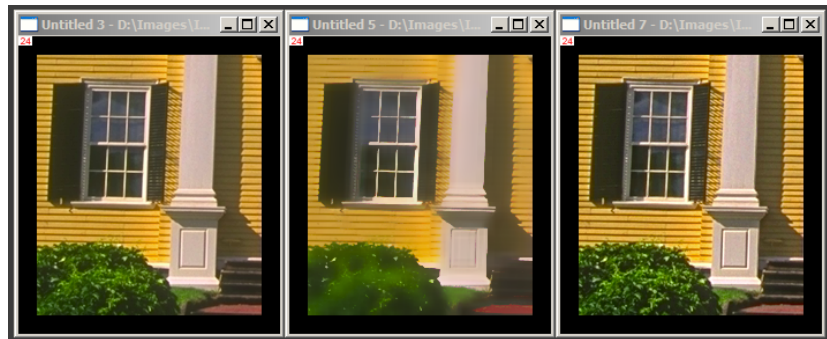
Note: this example has been deliberately oversharpened to emphasize the effects of the threshold setting.

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## *Bilateral Sharpening*

Bilateral sharpening works by first computing a *mean image* from the input image using a technique known as *bilateral filtering*. The idea behind bilateral filtering is to average each pixel with just those pixels in its surrounding neighborhood of approximately the same color. This prevents pixels on one side of a sharp edge from being averaged with those on the other side of the edge and preserves fine detail such as isolated light or dark pixels. The size of the neighborhood and the threshold for inclusion in the average are adjustable by sliders. The resulting mean image is then combined with the original image to produce the enhanced result image.

Each pixel in the result image is computed by multiplying the difference between pixels in the input image and pixels in the mean image by a sharpen factor. This has the effect of lightening pixels that are lighter than the surrounding background and darkening pixels that are darker than the background. The degree to which pixels are changed from the mean image (i.e. the scale factor) determines the amount of enhancement. The net result, like sharpening, is to bring out fine details in the image, but because the bilateral filtering prevents image data from bleeding across edges, halos are reduced.



Input Image

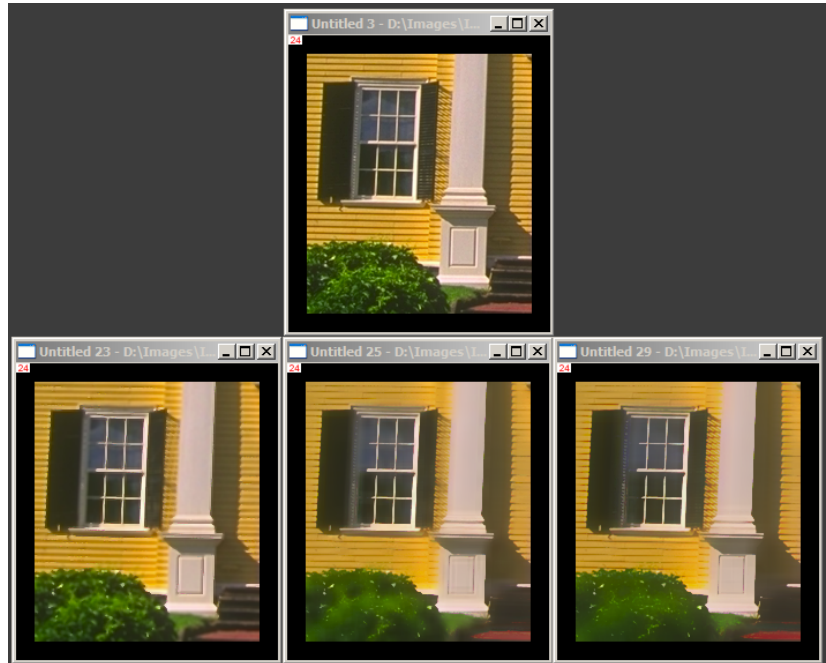
Mean Image

Sharpened Image

The following sections describe the bilateral sharpening controls and how to use them.

## Blur Radius

The *Blur Radius* slider determines the radius of the neighborhood around each pixel that is averaged. The larger the radius, the smoother the mean image. This setting should normally be adjusted just large enough to smooth out variations in areas that are fairly uniform.



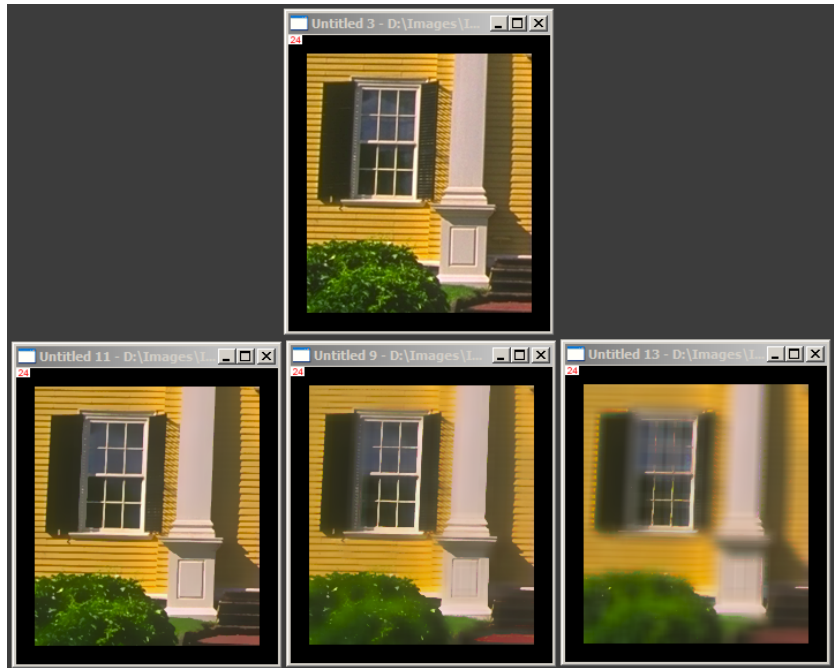
Radius 1  
(too small)

Radius 5  
(about right)

Radius 10  
(too large)

### Blur Threshold

The *Blur Threshold* slider determines how much pixels can differ from the central pixel and still be included in the neighborhood average. Setting too small a threshold reduces or eliminates the sharpening effect. Setting too large a threshold generates halos. The ideal threshold setting is best determined by displaying the mean image in the Preview window and adjusting the slider to as large a value as possible without blurring out important image detail.



10% Threshold  
(too low)

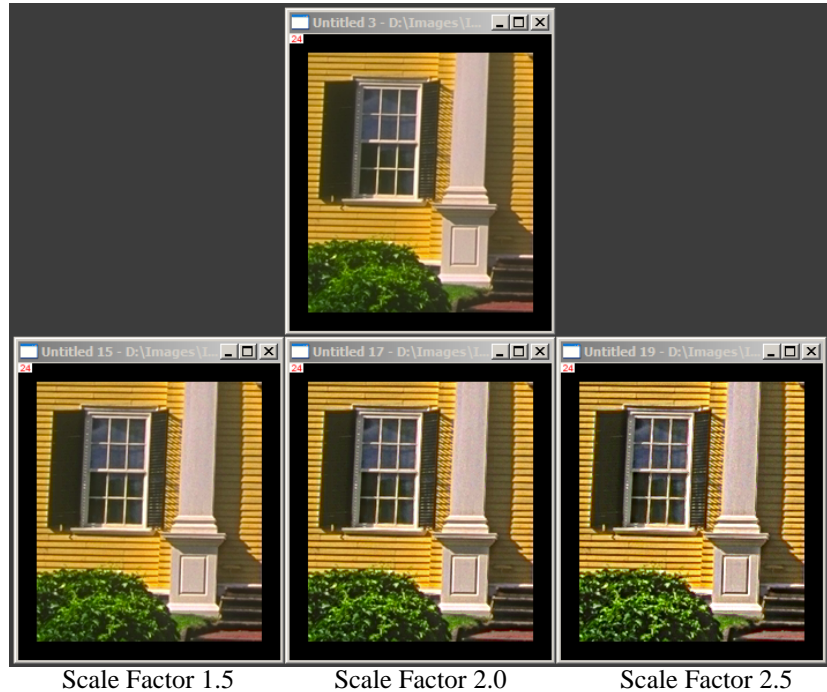
25% Threshold  
(about right)

50% Threshold  
(too high)



## Sharpen Factor

The *Sharpen Factor* slider determines how much each pixel will be moved away from the corresponding pixel in the mean image. The larger the sharpen factor, the more sharpening.

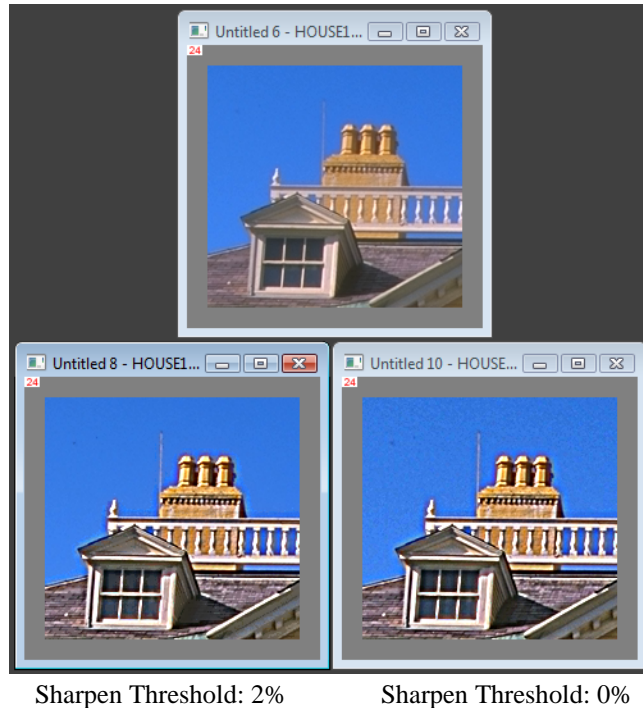


Setting the sharpen factor to a value between 0.0 and 1.0 produces a smoothing effect, while values greater than 1.0 produce sharpening.

Setting the sharpen factor to 0.0 causes the transformation to produce the mean image as its result. This can be very useful for visualizing the effects of the radius and threshold sliders.

### Sharpen Threshold

The *Sharpen Threshold* slider is similar to the unsharp mask threshold slider. The purpose of this slider is to help prevent sharpening noise in smooth areas of the image such as clear skies. Only those pixels that differ from the mean image by more than the sharpen threshold are sharpened.



### *Adjusting Halo Limit Sliders*

The Halo Limit slider can be used with any of the sharpening methods. The slider has two independently adjustable parts - a white slider and a black slider. Moving the white slider to the left limits light halos and moving the black slider to the left limits dark halos.

Moving both sliders all the way to the left eliminates all sharpening. As you move the sliders to the right, increasing amounts of lightening or darkening are allowed. Moving both sliders all the way to the right causes full sharpening to be in effect.



Note how the white halos around the dark branches in the middle image are greatly reduced in the right hand image while still sharpening the bark and leaves.

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## *Advanced Sharpen*

Additional sharpening features as well as noise reduction and speck removal are available in the Advanced Sharpen transformation. For more information on this new transformation, see the separate white paper: *Advanced Sharpen.pdf*.