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# *Using the Advanced Sharpen Transformation*

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## *Introduction*

Picture Window Pro's *Advanced Sharpen* transformation is a powerful tool for enhancing digital images, whether captured by scanning film or from digital cameras. It works in three stages: noise reduction, speck removal and sharpening. These three operations are applied sequentially to the input image to produce the output image.

### **Noise Reduction**

In this phase, the image is blurred in such a way as to reduce noise without softening edges. This feature is very useful for reducing film grain artifacts in scanned images or noise in digital camera images, especially in smooth regions such as clouds or clear skies. The blurring algorithms incorporate special thresholding techniques to prevent softening sharp edges and other high contrast detail.

### **Speck Removal**

Isolated pixels or small clusters of pixels significantly lighter or darker than the surrounding area are called *specks*. Specks can be caused by dust or imper-

fections in the film, camera or scanner. While the noise reduction phase does not remove specks, it does make them easier to detect by smoothing the area around them. Several parameters can be adjusted to control the speck removal process so you can eliminate specks without losing significant image detail.

### **Sharpening**

Once the preceding two phases are complete, the image is ready to be sharpened. Since sharpening amplifies noise and exaggerates specks, the preceding two phases make it possible to sharpen images that might otherwise break up when sharpened. The sharpening phase can be controlled using selectable thresholds to sharpen high contrast detail without amplifying low contrast detail.

The Advanced Sharpen transformation is designed to do a much more precise and thorough job of image enhancement and sharpening than Picture Window's main blurring, speck removal and sharpening tools. Consequently Advanced Sharpen has a somewhat more complicated interface and executes quite a bit slower. When properly used, however, the results make the extra time and effort worthwhile. Once optimal settings have been determined for a given film or camera configuration, they can be saved to later re-use on other images.

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## *User Interface*

The Advanced Sharpen dialog box consists of a fixed upper panel and a variable bottom panel. At the bottom of the dialog box are three tabs that let you select the three phases—*Noise Reduction*, *Speck Removal* and *Sharpening*. Clicking the corresponding tab switches the variable part of the dialog box to show the relevant controls for the phase you have selected. The preview image always displays the results of the current phase and its preceding phases only, so you are only seeing the final preview when you select the *Sharpening* tab.

If you wish to bypass a phase, just click one of the other tabs leaving the settings for the phase you want to skip defaulted to take no action.

The fixed portion of the dialog box consists of the standard Picture Window Amount Slider and a tool bar that lets you control what is displayed in the preview window. The three options are: the result image from the previous phase (or the input image if you are in the Noise Reduction phase), the result image from the current phase, or the difference between the two. This tool bar lets you quickly flip back and forth between the before and after images for the current phase or to view just the changes.

Just to the right of the tool bar is an eyedropper icon which can be either raised or depressed. When depressed, the probe is active and clicking and dragging on the input image window displays a red, vertical marker in the histogram display (see below) for the current phase. The position of the marker corresponds to the histogram value for the part of the image at the current cursor location. If you hold down either Shift key while clicking and dragging on the input image, a red marker is displayed just below the histogram showing the range of values in the input image. To clear the range display, simply click on the input image without the Shift key depressed.

There is also an options menu available by clicking the *Opt* button in the upper right corner of the dialog box. This menu lets you select various advanced options:

### **Reset**

Selecting *Reset* returns all parameter to their original values.

### **Save As.../Load...**

These options let you save or restore a set of settings in a file. On startup, if a file named *default.as* is found in the folder in which Picture Window is installed, this file is automatically loaded.

### **No/Moderate/High Histogram Expansion**

These settings let you control how much expansion is applied to the histogram display. The default setting of no expansion displays histograms normally. The more expansion you select, the more lower histogram values are boosted. Expansion can make it easier to see small variations that would otherwise be swamped by large peaks.

### **Blur All/Chrominance Only**

This setting applies only to the Noise Reduction Phase—it determines how blurring is performed. Normally, the red, green and blue channels are all blurred equally. Optionally, the image can be split into two parts: a brightness component and a pair of color components collectively referred to as *chrominance*. By blurring just the chrominance, its brightness variation remains untouched while just the color information is blurred. This type of blurring can be helpful for reducing color noise in digital camera images.

### **Sharpen All/Luminance Only**

This setting applies only to the Sharpening phase—it determines how sharpening is performed. Normally, the red, green and blue channels are all sharpened equally. Optionally, the image can be split into two parts: a brightness or *luminance* component and a pair of color components. By sharpening just the luminance, its color variations remain untouched while just the brightness information is sharpened. This can prevent certain subtle false coloring effects from occurring at sharp edges.

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## *How Advanced Sharpen Works*

This section describes how each phase of the Advanced Sharpen transformation works:

### **Noise Reduction**

Noise reduction is performed one pixel at a time using modified Gaussian blurring. Gaussian blurring works by replacing each pixel with a weighted sum of the pixels in a roughly circular region surrounding it. Nearby pixels are assigned greater weights than distant pixels following a Gaussian distribution curve.

There are several noise reduction parameters you can control.

#### **Blur Radius**

The larger the radius, the broader the distribution, and the more surrounding pixels are included in the neighborhood, resulting in a blurrier image. Using a larger radius also increases the amount of computation and consequently runs slower.

#### **Blur Amount**

This setting controls how much of the selected blur is applied to the image. When set to zero, no blurring is performed—as the amount increases, blurring is also increased. This is done by computing a weighted average between the original image and the fully blurred image.

#### **Histogram**

The histogram display just below the *Blur Amount* slider lets you perform selective blurring by including only those neighboring pixels in the computations that differ by less than a given threshold amount from the pixel you are sharpening.

Unlike histograms used in the Brightness Curve transformation, the Noise Reduction histogram reflects not the tonality of the image, but rather the roughness of its texture. Bars at the left end of the histogram correspond to pixels in very smooth areas of the image, i.e. areas of nearly solid color.

Bars further to the right in the histogram indicate the presence of pixels whose neighbors exhibit more variation. Pixels that are near prominent edges or in areas that have a lot of fine detail will thus contribute to histogram bars to the right of pixels that are in the middle of a smooth textured feature such as a cloud or clear sky. By distinguishing between these two types of pixels, Advanced Sharpen can smooth areas of low detail while leaving edges and image details intact.

Traditional Gaussian blurring does a very good job of smoothing out noise, but also softens edges and smooths out fine detail. To prevent this, Picture Window excludes all pixels from the blurring computation that differ by more than a specified threshold from the central pixel. Consider for example two areas of more or less solid color that meet at a sharp edge. When blurring pixels on one side of the edge, if the threshold is set properly, only similar neighbors are included in the weighted sum, thus preventing pixels from the other side of the edge from being included in the computation (and thus blurring) the edge.

Actually, rather than implementing a sharp cutoff, Picture Window lets you set two thresholds—one below which all pixels are included and one above which all pixels are excluded. Between the two thresholds, pixels make a partial contribution to the blurring computations. This method helps reduce artifacts from the sudden switchover.

In order to let you make an intelligent decision about how to set the thresholds, Picture Window computes and displays a histogram of the differences between nearby pairs of pixels in the image. Markers are displayed below the histogram to indicate the current threshold settings, and you can adjust these by dragging the markers. Also, when you click and drag on the input image, the corresponding location in the histogram is highlighted so you can see what difference values are present in each part of your image.

For best results, try to apply just enough blurring to remove noise while preserving as much image detail as possible—this usually means setting the radius and thresholds to the minimum values that still eliminate noise in smooth areas of the image.

## **Speck Removal**

Isolated single pixels or small groups of pixels that are either darker or lighter than the surrounding pixels are called *specks*. Since they represent a large local variation from their neighbors, specks are not removed by the noise reduction phase.

Speck removal operates by first detecting and then removing specks from the results of the preceding noise reduction phase. There are several settings to help you control the process.

### **Speck Size**

This setting controls how large a speck will be removed. Try to use the smallest value that removes the specks you want to eliminate. Setting this value too large may cause a loss of image detail. Speck detection works by looking at a region twice the diameter of the speck size. It first computes the average value in the ring of pixels surrounding the speck and then compares this to the pixels in the center.

### **Remove Light/Remove Dark**

These settings tell the speck detector to search for specks that are lighter and/or darker than the background. If neither checkbox is checked, no action is taken. If your specks are primarily black (as is the case with dust on scanned positives), select *Remove Dark*. If your specks are primarily white (as for dust on scanned color negatives), select *Remove White*. If you have both kinds of specks, select both.

### **Speck Difference Threshold**

This slider tells the speck detector to ignore specks that are lighter or darker than the surrounding area by less than a given threshold amount. Set this slider as high as possible to remove specks without removing too much image detail.

## **Sharpening**

Once blurring and speck removal are completed, you may find that relatively little sharpening is needed. In any case, there are several settings you can use

to control how much and what parts of the image is sharpened. Sharpening is performed by first blurring the image and then comparing the original image to the blurred version and exaggerating the differences between them. Thus pixels that stand out from their neighbors will stand out even more in the result image while pixels that are close to the average of their neighbors will be changed relatively little.

### **Sharpen Radius**

This setting controls how much the image will be blurred in preparation for sharpening. For best results, this setting should be smaller for images that are already relatively sharp and larger for images that are softer.

### **Sharpen Amount**

This setting controls how much the differences between pixels in the original image and the blurred image are exaggerated. Higher settings increase the sharpening effect, but if you oversharpen you will start to see light halos around dark objects and dark halos around light objects. These halos can be reduced however by setting the light and dark Halo Limit sliders (see below).

### **Light and Dark Halo Limit**

These settings are useful for controlling light or dark halos that occur around distinct edges. The white slider limits the maximum amount a pixel can be lightened when sharpening and the black slider limits how much it can be darkened. Setting the light or dark halo limit to zero suppresses all sharpening while setting them to 100% performs no halo suppression. Use the highest value that produces acceptable halosing.

### **Histogram**

The histogram display just below the Sharpen Amount slider lets you perform selective sharpening by including only those neighbor pixels in the computations that differ by more or less than a given threshold amount from the pixel you are sharpening. Raising the lower limits helps prevent amplifying fine texture or noise. Lowering the upper limits helps reduce halos.



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## *Advanced Sharpen in Action*

This section illustrates how the Advanced Sharpen transformation can be used to enhance a particular sample image.

### **The Original Image**

Here is the starting point—a small cropped region of an unsharpened raw file from a digital camera.



There are several things you might notice about this image. First it is a little soft as is common with digital camera images viewed at the level of individual pixels. Also there is some low level noise and a few specks at the bottom showing on the surface of the water.

## Sharpening without Noise Reduction and Speck Removal

Here is what happens if we try to sharpen the image without first doing noise reduction and speck removal:



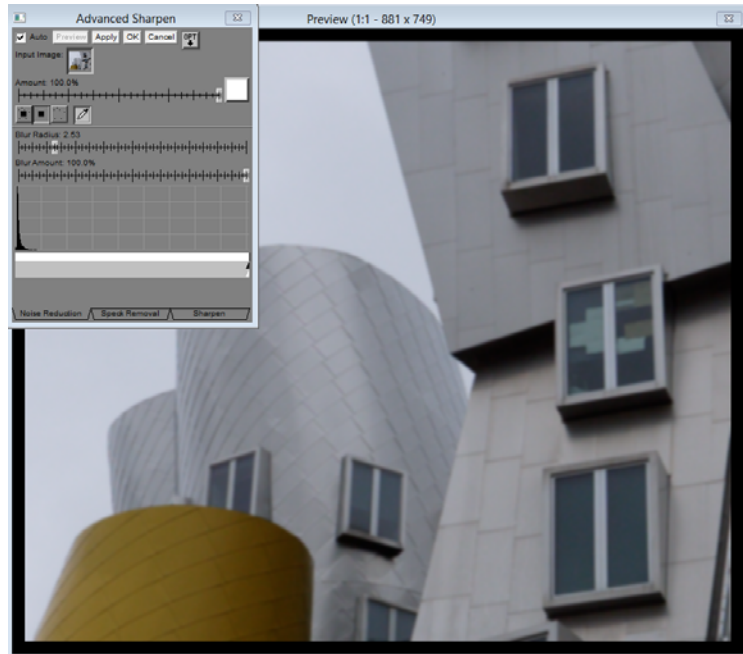
As you can see, while this improves the sharpness of the image, it also exaggerates the camera noise, makes specks more prominent and produces easily visible edge halos.

## Noise Reduction

Now let's return to the original image and see how noise reduction works. The goal of the noise reduction is to remove most of the noise from the image without losing too much fine detail.

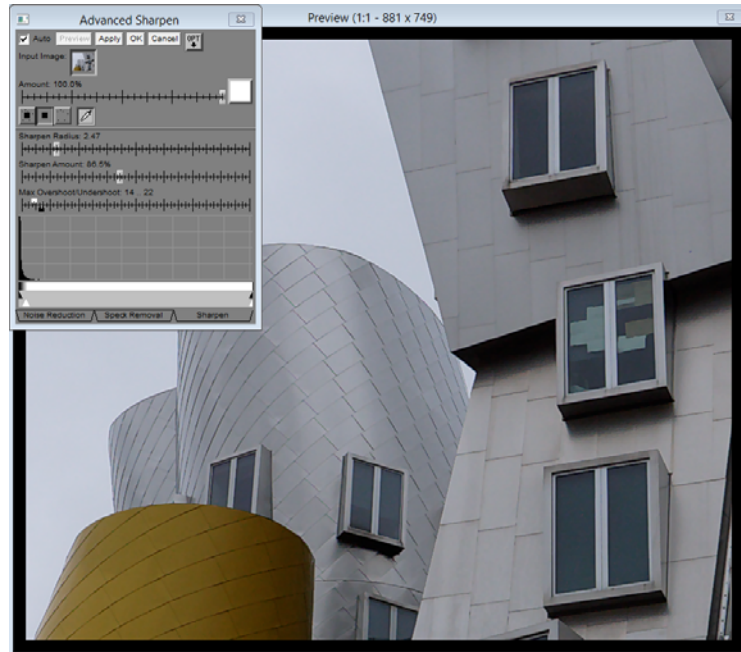
The first step is to set the *Blur Amount* to 100% and adjust the *Blur Radius* slider until the texture of the noise disappears in the preview. In this exam-

ple, this happens at a radius of about 2.5 pixels. At this stage, the building will also get very soft, but we will deal with that next.



Now, if you look at the histogram at the bottom of the dialog box, you will see a big spike at the bottom that falls off to the right. The spike corresponds to the fine texture of the image and this is the part we need to blur. You can confirm this by clicking and dragging over the sky in the input image window as this will display a red marker at the corresponding location in the histogram (assuming the eyedropper button is depressed).

To do this, we need to drag the black and white markers to the left as shown below:



In this case, the black and white markers have been positioned so that the white part of the bar spans the histogram peak and it fades to black along the steep part of the histogram just to the right of the peak. If you don't cover the peak with the white part of the bar, fine texture will not be blurred; if you cover too much beyond the peak, you will start to lose detail in the building. In any case, noise reduction neither sharpens the building nor removes specks—these tasks will be performed by the next two phases.

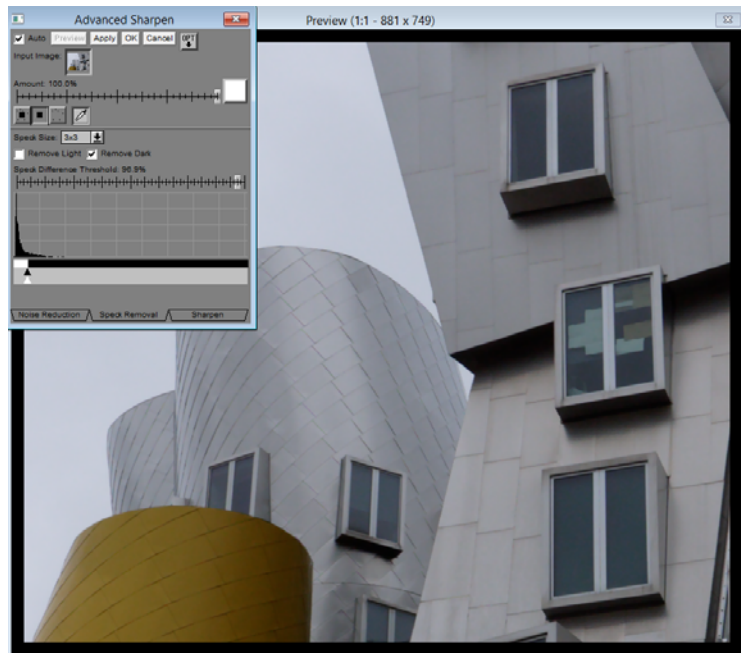
### Speck Removal

The next step is to click on the *Speck Removal* tab. This performs noise removal on the entire input image and switches the dialog box to display the speck removal parameters.

Since this image has black specks only, we first check the Remove Dark checkbox.

Next we need to set the speck size large enough to remove most of the specks. Often it is better to keep this parameter small as this increases the probability of removing image detail instead of specks, and a few large specks are not much trouble to remove manually.

Finally, we need to adjust first the *Speck Difference Threshold* slider and then the markers below the histogram so that we are removing as many specks as possible without removing image detail. To set the *Speck Difference Threshold* slider, slowly move it to the left until specks start to reappear and then back off a bit. Then set the markers (the black and white markers are permanently locked in this phase), so the white area under the histogram spans the area from which we want to remove specks. Again, move the slider to the right until specks start to reappear in the preview. Here is the result of setting the speck removal settings:

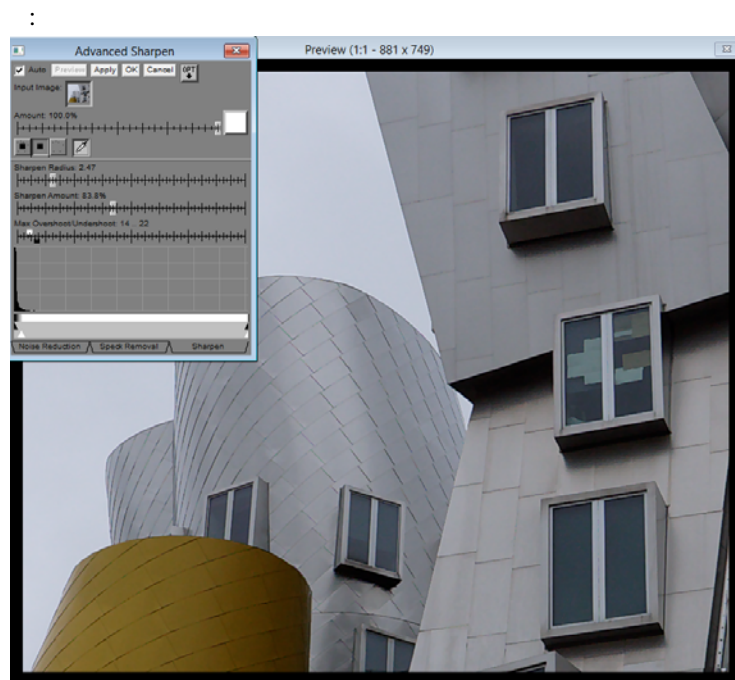


### Sharpening

To advance to the final sharpening phase, you click on the *Sharpening* tab at the bottom of the dialog box. This causes speck removal to be run on the entire image and displays the sharpening controls.

First set the *Sharpen Radius* and *Sharpen Amount* to achieve the desired sharpening effect on the area you want to sharpen. At this stage you can ignore undesired halo effects and amplified noise. The softer the original image, the larger the radius you should select. For a given radius, the amount slider lets you control how much sharpening you want. Over-sharpening produces an unnatural effect and can cause blocking of high-lights and shadows and should be avoided in most cases.

Next, move the *Light/Dark Halo Limit* sliders to the left to remove unwanted light and dark halos. Going too far will also reduce the sharpening effect, so only move the sliders as far left as necessary.



Finally adjust the markers below the histogram so the white area of the bar is under the part of the histogram you want to sharpen. In this case it will be everything except where the large spike is. If you watch what is happening in the preview image as you move the markers you can see where to set them for the most sharpening of the building with the least amplification of noise.

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## *Tips*

Trying to remove too much noise from an image usually results in a loss of detail as well. Usually it is better to undercorrect noise as it is often invisible when the image is viewed at a normal scale rather than zoomed in to 1:1.

If your image has significant chroma noise, it may be helpful to run Advanced Sharpen twice. The first time, set speck removal and sharpening to default (i.e. have no effect) and then use the Opt button to select *Blur chrominance only* and apply noise reduction with a fairly large radius. Use the histogram markers to keep the noise reduction from bleeding colors across strong edges. The result of this operation will be an image with reduced chroma noise but it will still have some luminance noise. Running Advanced Sharpen a second time to make all the remaining corrections should then produce a better effect because you won't have to worry as much about chroma noise.

In some cases, you can get better results by restricting your noise reduction and sharpening to just the lighter or the darker parts of an image. To do this you need to create a density mask for the input image just before running the Advanced Sharpen transformation. For more information on density masks, see the Picture Window manual, help file or other white papers.