1. Purpose

The purpose of this document is to explain how to use the Digital Camera Noise Removal filter to the best effect. In addition to explaining the various controls of the filter, the document provides an introduction to the nature of image noise and describes what to do with troublesome images.

2. Introduction to Image Noise

Readers familiar with image noise and its nature may want to skip this introduction and jump to the next section about the capabilities of the filter. The rest of us are used to thinking about noise in connection with sound, so let us start with an analogy. Imagine a lively international party on a warm summer day in an apartment overlooking a big city. The windows are open for air, letting in noise from the street below. The rumble of traffic outside accompanies the sound of voices in the apartment – those of the women with a generally higher pitch than those of the men. The words of the foreigners are distinctly more difficult to make out than those of the other party-goers, at least for the linguistically challenged. The regular pounding of a jack-hammer wafts up from the street, periodically punctuated by shrieks of laughter or the sound of a breaking glass in the apartment. Over at the bar, the noise of the blender making Daiquiris drowns out the sound of conversation. Now and again, the rhythmic pumping of bass is audible from outside as 4,000 watts of rap music blasts from a car at the traffic lights below, and a squeal of tires accompanies the take-off of some extrovert as the lights change. Among the dense crowd in the kitchen the noise level reaches a peak, while those out on the balcony find it easier to hear each other despite the street noise. All in all, a lot is happening, just as in an image. Let us, therefore, try to pin down the analogy further.

The different pitch of noise from men’s and women’s voices, or the rumble of traffic, appears in an image as spatial frequency, which represents the scale or size of the noise in the image. An image, just like our party, will contain a variation in the spatial frequency or scale of the noise, dependent on the imaging conditions (or on who has
been invited to the party). A noise filter has to deal with this. Just as the noise level of the party is different in the kitchen, the apartment itself, or out on the balcony, the noise in an image is not the same everywhere and will vary with the lightness level in the image, something a noise filter has to take into account. We found it was harder to make out what the foreigners were saying amid the noise and so it is with images too – detail is easier to make out in lightness information than in color information, suggesting we need to treat lightness noise and color noise differently. The noise of the blender drowned out the conversational noise, which is something that happens in images as well, where the presence of fine texture such as grass, gravel or carpet can serve to hide noise by a phenomenon called texture masking. This can affect our judgment of noise. A given level of noise may be excessive for a face or sky, which we know to be smooth in real life. However, if the same amount of noise is removed from vegetation, we may judge the removal to be excessive even though nothing but noise (rather than authentic image information) has been removed from these areas, simply because we expect texture to be present there in real life. A noise filter has to allow us to cope with this situation. The noise we have discussed so far was a steady accompaniment to the sound of the party – on average constant and unchanging throughout its course. This type of overall image noise corresponds to sensor noise or film grain in the image and is the type of noise the Digital Camera Noise Removal filter is designed to suppress.

In the background of the party we heard regular rhythmic noises, such as the jackhammer and the rap music. These have counterparts in images too in the form of regular periodic patterns, such as those formed by moiré patterns or by dots of ink from scanning of printed matter. These are quite distinct from the kind of quasi-random noise we have been discussing and the removal of this type periodic noise may call for a distinctly different kind of noise filter than one designed for quasi-random noise. Our party was also punctuated by sudden noises such as the shrieks of laughter, the breaking glass, or the squeal of tires. In imaging terms this is called impulse noise and occurs suddenly in specific parts of the image rather than everywhere, much as is the case of our party. Examples of this might be stuck sensor pixels, hot pixels visible at very long exposures, or specks of dust on a print or slide. Impulse noise is also distinct from the quasi-random noise that we have been discussing and is best handled by filters designed specifically for this type of noise.

There is one other thing to consider. Our party analogy was a prototype of a noisy event but even in seeming silence the world is seldom really noise-free. Perhaps we can hear the wind in the trees or distant traffic or the hum of the refrigerator or a footfall or just the sound of our breathing. These are sounds of which we are seldom conscious but whose absence makes for a strange, even disconcerting, sensation. So it is with images too. An image completely devoid of noise strikes us as unnatural and, for instance, skin and other materials in such an image acquire an inappropriate “plastic” look. Accordingly a noise filter should remove objectionable noise but retain a natural low level of noise.

### 3. What kind of noise does the filter remove?

The Digital Camera Noise filter is designed to remove quasi-random noise in an image. This is noise such as sensor noise or film grain that is present throughout the image. Rather than verbally describing such noise it is simpler to show some examples.
The first example (left) is typical of noise encountered in sky areas and the Digital Camera noise filter makes short work of the noise (right) leaving a natural result, which maintains the original ragged edges and interior detail of the clouds. In this image, the noise was primarily caused by lightness variation, as shown below.

The airplane below is a much more challenging example since it contains very much larger amounts of noise and a great deal of large scale color noise. Nonetheless, the Digital Camera Noise filter can dispose of even this noise while retaining image detail, even that which is scarcely discernable in the image at left.
The presence of color noise at various scales is clearly visible by comparing the three color channels of the original noisy image. The green channel contains less noise since the sensor of a Bayer pattern digital camera contains twice as many green detectors as red or blue. In the red and blue channels the scale of the noise is much larger than the size of authentic image features. Look, for instance, how something as large as the shadow beneath the airplane is broken up into disconnected chunks in these channels.

In addition to removing noise the Digital Camera Noise Removal filter will preserve fine detail in the image. The image below contains fine facial hair along with noise that is spatially larger than the hair. The granularity in the dark shirt and the trees is clearly larger than the width of individual hairs.
The denoised image (below) is free of granularity but the detail in the facial hair is preserved and the skin looks natural rather than over-smoothed. The noise has been removed from the skin but a natural level of detail, such as fine wrinkles, is retained. The filter offers considerable control over which regions of the image are denoised to what degree.
These images illustrate the kind of challenges that the Digital Camera Noise Removal filter can address.

4. What kind of noise does the filter not remove?

The Digital Camera Noise Removal filter is designed to remove quasi-random noise and will not, in general, be useful for other types of noise. In particular it will not remove impulse noise. This is illustrated by the night-time shot below showing the sky and the roof of a building taken at an ISO setting of 320 and an exposure time of 1 second. The green arrow shows a stuck pixel (permanently on) while the red arrows show hot pixels (more noisy or sensitive than their neighbors).
The image below was denoised with the Digital Camera Noise Removal filter and the noise in the lighter sky area and the darker roof of the building is indeed reduced, while the structure in the roof is retained. However, the stuck pixel and the hot pixels remain since they are interpreted by the filter as authentic image detail. Indeed, it is only from the context of the image that we know these pixels are what they are and are not, for instance, distant stars in the sky.

The proper way to address impulse noise is to use a filter designed for it. The Salt and Pepper filter is one that offers a lot of control but filters such as Median and Despeckle may also be used. Below is an example applying the Salt and Pepper filter to the original noisy image. Impulse noise is removed while the grainy noise remains.
The Salt and Pepper filter settings are worth noting. Even though formally only single pixels are involved in the impulse noise, the interpolation required to derive the image from the sensor response results in a larger number of pixels being affected. Additionally, the camera itself is unaware that the pixels in question are defective so that effects like sharpening are applied to these pixels as to authentic image data, further extending the region of the image that is affected. Consequently, the Speck Size has to be chosen as something on the order of 5 to 7 pixels. The Sensitivity to Specks should be chosen as low as possible consistent with removing the defects so as to not affect other image detail. When only a few pixels in the image are affected it is worth making a rough selection around them before processing, since this makes the filter faster and further restricts any possible damage to the image.

The Digital Camera Noise Removal filter is not designed to remove JPEG artifacts. For low levels of artifacts Edge Preserving Smooth at a setting of 2 to 4 should be used, while for more severe artifacts the JPEG Artifact Removal filter should be used. The examples below provide an illustration.
At top left is the original image, with artifacts in the form of checkerboard patterns on the nose and under the eye as well as a distinct pattern on the lips. Application of the Digital Camera Noise Removal filter gives the image at top right. The non-random artifacts are not removed since they are interpreted as authentic image features. However, when the image is treated with the JPEG Artifact Removal filter as shown at left, the unpleasant artifacts are successfully removed. Accordingly, the Digital Camera Noise Removal filter is not recommended for suppression of JPEG artifacts. There are, nonetheless rare cases in which the filter can be effective.

The image below (left) represents one of these rare cases, where block artifacts are severe and there is very little small scale detail. The result of noise removal (right) is fairly satisfactory, though some uncorrected areas and blockiness remain near the edges of the cloud.
The Digital Camera Noise Removal filter is not recommended for images with periodic noise, such as moiré patterns. Not only is filter unlikely to effectively remove the periodic pattern but it may also create a kind of cross-hatching artifact that is subsequently even harder to remove than the original moire pattern. This is an example image with moiré.
After processing with the Digital Camera Noise Removal filter the cross-hatching artifact is easy to see in the result. Usually, it is very hard to determine filter settings that will remove the periodic pattern and not leave artifacts.

In contrast, when the image is processed with Moiré Pattern Removal filter, the moiré pattern is suppressed and there are no artifacts, as shown below. In fact, it is sometimes possible to improve on the Moiré Pattern Removal filter’s results with a two-step process. Applying the Moiré Pattern Removal filter at the minimum setting to remove the periodic noise can be followed by applying the Digital Camera Noise Removal filter in a subsequent step to eliminate any residual granularity in the image. This can give a superior result in terms of retained image detail than applying the Moiré Pattern Removal filter at a sufficiently high setting to suppress all traces of noise. The image below was obtained by first applying the Moiré Pattern Removal filter at a Fine Details setting of 2 to the original and then applying the Digital Camera Noise Removal filter to only the highlights of the result image by means of the Protect Image option, which will be described later.
Despite the fact that the Digital Camera Noise Removal filter is not recommended for moiré and similar periodic or quasi-periodic patterns, there can be situations where this filter can be used to suppress moiré. Usually, this arises when the moiré pattern is very much larger than the image features. While there is no guarantee of success, it is worth trying the Digital Camera Noise Removal filter if no other means can be found of eradicating the pattern. The image below represents an example from which it was not possible to remove the pattern by any simple means but which proved amenable to the Digital Camera Noise Removal filter. Treated and untreated regions are separated by a blue line. The filter does an extraordinarily good job of removing the large scale pink dots while maintaining the detail in the much smaller faces.
5. How does the filter work?

In interactive use, the overall behavior of the Digital Camera Noise Removal filter is as follows. When the filter starts, the image is automatically analyzed to determine uniform areas in shadow, midtone and highlight regions. These sampling areas are marked in the image and are used to characterize image noise. In each of these regions a separate analysis is made of small scale, medium scale and large scale noise. The analysis is done separately for lightness and color information in the image. The result is a multi-dimensional description of how image noise of different scales is distributed over lightness and color information as a function of image lightness. In other words, a rather complete picture of the image noise characteristics is created.

Once the noise analysis is complete, the denoised image is created. The environment of each pixel is examined and compared to what is expected for a noise-free image having that particular color and lightness. This is done for every scale of image noise taking image texture into account. Using sophisticated mathematics, a result pixel is computed as a combination of the original image along with different proportions of luminance and chrominance images smoothed at different scales. During this process edges in the image are smoothed in a special way designed to preserve the edge information and to maintain edge continuity over multiple scales. The result is a denoised image in which each pixel is formed as its own a unique combination of luminance and chrominance images denoised to different degrees at different scales. This can be contrasted with a conventional smoothing filter such as Gaussian Blur, which applies exactly the same degree of smoothing to each pixel irrespective of color or location in the image. Because the Digital Camera Noise Removal filter constructs each result pixel in a unique way, it
involves considerably more calculation and is significantly slower than a simple filter such as Gaussian Blur. However, in exchange for this, it is capable of removing noise while preserving detail smaller than the noise itself.

The filter provides a range of settings to control the quality of the result. The available settings are a compromise between keeping the filter simple enough for anyone to use and providing enough control to achieve a desired result. The main controls are as follows:

1. Noise sampling regions in the image
2. Noise reduction controls on the Remove Noise tab
3. Color-based tuning of noise reduction on the Protect Image tab
4. Presets, both conventional and a Camera Preset unique to this filter.

These controls are explained in detail in the following sections.

6. Noise sampling regions

When the filter is run interactively three noise sampling boxes are automatically placed in the image in uniform areas of the shadows, midtones and highlights respectively. These regions are shown with annotations in the left preview window. The image itself is initially centered in the left and right preview windows and is shown at 100% zoom. Consequently, the noise sampling regions will probably lie outside the preview and so will not be visible at the outset. To aid in locating the sample regions the filter dialog contains a small proxy image marked with crosses at the locations of the samples within the image. You can set the preview to the position of a sample by using the normal filter navigation button. However, it is much more convenient to just left-click on the cross for the sample of interest in the proxy image. As soon as you click on the sample cross, the preview will jump to show you that sample’s annotation.

The filter makes a best estimate of where to place the samples. The automatically created samples are always square. However, because of some specific image content coupled with the internal rules used for creating samples, it may be possible to improve on the sample shapes and positions. This is because you understand the content of the image and its meaning in a way that an algorithm analyzing only pixel colors cannot. For these reasons, the samples are adjustable. You can move them by placing the cursor inside the sample. Samples can also be moved by dragging their crosses in the proxy image with the right mouse button. The left preview will simultaneously show the new sample position as you do this so you can place the sample accurately.
You can change the size and shape of samples by dragging on their sides or corners. Samples can be removed by dragging sides or corners to make them smaller. Once the sample has become too small to be useful, its sides are shown dashed. At this point you can release the mouse and the sample will be removed. Alternatively, you can drag the sample larger until the sides become solid in order to retain the sample. New samples can be created by dragging them out in the left preview in a place where a sample does not already exist. The figure below summarizes the parts of the dialog that concern noise samples.

When adjusting or creating noise samples, certain guidelines should be followed:

1. Never place a sample straddling the edge of an object in the image. If you do, the edge will be interpreted as noise and the image will undergo excessive smoothing.
2. Never place a sample in exactly black or exactly white areas of the image. Such areas may have had their brightness levels clipped with the result that noise will be underestimated.
3. The default samples created automatically have a size somewhat larger than the minimum permissible size. This makes estimates of noise more accurate. If you
can, try and maintain the original sample area, even if you have to change the shape to avoid object edges. Only reduce the sample to a minimum size if you are forced to do so in order to avoid crossing object edges. The upper bound on the size of the sample is determined by the size of the image.

4. Pay careful attention to what is inside a noise sample region. If there is any authentic texture inside the sample region then either move the sample to a completely uniform area of the image or, if this is impossible, remove the sample.

5. You should have at least one noise sample in the image, even though nothing prevents you removing all the sample regions. If you do not have any samples, the filter will still try to remove noise but the results will be very far from optimal so you should avoid this. Very rarely you may encounter images in which every part of the image contains texture so that it is impossible to place even one sample in the image. This situation can be addressed using Camera Presets, which are described later.

6. It is preferred to have three noise samples in the image – one for shadows, one for midtones and one for highlights. Don’t be too fussy about exact definitions of these brightness regions – just make sure there is a sample somewhere dark, somewhere light and somewhere in between. In a pinch you can use one or two samples when there are insufficient uniform areas.

7. You can have up to 10 noise samples in the image. However, resist the temptation to create a lot of such samples. When a lot of samples are present it is very easy to have samples that contradict each other or simply duplicate each other’s information. In this case, the filter will ignore some samples but you won’t know which ones, something that can only lead to confusion. Three samples are typically quite sufficient.

8. More than three samples can be helpful for very noisy images with distinct brightness levels. You should position a sample at each brightness level, very carefully ensuring that the brightness is uniform (or supposed to be uniform) in each region where you place the sample. It is very unlikely that you will need to use more than 6 samples.

9. When an image contains large distinct regions of different hue, such as red, green, blue or yellow, it may be helpful to place a sample in each hue region even though these regions may have similar brightness values.

10. When you have placed a sample in a uniform region but some noise feature is not removed in this overall region, try moving the sample so that it is exactly over the piece of noise you would like to remove.

11. The filter does not pay any attention to image transparency and will sample whatever colors are present irrespective of the transparency or otherwise of the pixels. It is up to you to ensure there is valid color data in the sampling region. However, the filter will not place samples outside the bounding box of the opaque layer data; nor will it allow you to place samples outside this bounding box. Consequently, samples will typically be placed in sensible locations even for images with transparency.
7. Noise reduction controls (Remove Noise tab)

The important controls on the Remove Noise tab are:

1. The Noise Correction group for adjusting the amount of small, medium and large scale noise that is removed,
2. The Correction Blend control for combining the denoised image with the original,
3. The Sharpening control, which adjusts the sharpness of the image.

We will ignore the Camera Preset checkbox for now and discuss it in the section on presets.

Perhaps the most difficult aspect to understand is the idea of the scale or size of objects in an image and this is best addressed with an example.
At top left is an original image showing some dry cracked mud along with an artificially created strip comprising a combination of patterns repeating at different spatial frequencies or, equivalently, with different repeat intervals. The image at top right is representative of what the Digital Camera Noise Removal filter considers to be small detail. The image shows primarily the fine texture of the surface of the mud along with a rapidly varying pattern extracted from the bottom strip. At bottom left is shown the medium scale image. It contains only the coarsest surface features of the mud along with the cracks splitting the mud. The strip contains a much more slowly varying pattern extracted from the original bottom strip. The large details are shown at bottom right. Only the general outlines of the pieces of mud are visible and the strip contains a pattern that repeats with a very low spatial frequency. The original image can be considered to be a combination of the small, medium and large scale detail images along with a residual image containing features larger still, which is not shown. This is how the Digital Camera Noise Removal filter sees the image, except that instead of simply seeing it as greyscale it decomposes luminance and chrominance information in a similar way.

Each of the Small, Medium and Large detail sliders in the Noise Correction group controls how much noise is removed at each of the scales. The higher the setting of each slider, the more noise of that scale is removed. At the same time, the higher the setting of each slider, the more likely it is that authentic image detail will be destroyed. The position of each control is, therefore, a compromise between removing noise and retaining detail. For normal noisy images the default settings of 50 provide an excellent starting point. Indeed, with well-selected noise samples, it is very often unnecessary to change these settings at all. If changes are needed, it is usually best to keep the sliders locked together with the Link Detail Sizes checkbox and move them in unison with each other. This is because the filter has already automatically determined the best relative description of small, medium and large scale noise so that your joint adjustment simply determines how much noise reduction you prefer. To get a proper sense of exactly how much noise is being removed, investigate the Small, Medium and Large settings while the Correction Blend control is set to 100. (More about this a little later.)

There are some exceptions to the rule that the detail sliders should be operated in concert. For example, some images with very low levels of noise overall do not have any significant large-scale noise at all. In this case the result may look better if the Large scale correction is switched off. The effect is usually rather subtle and may appear as a reduction in scattered light in the image, rather as if a slight soft-focus effect were being removed. If you find it necessary to also switch off the Medium scale noise, then your image probably does not required the Digital Camera Noise Reduction filter and is better given a touch of Edge Preserving Smooth (say at a setting of 2 to 4). Another situation where independent adjustment is warranted may arise when you are having difficulty preserving the finest details. In this case, reducing the Small slider relative to the other two may be helpful. However, if you are having problems of this type they may be better handled using the Protect Image tab, about which more later. The table below shows a portion of a noisy image in which various combinations of small, medium and large details have been suppressed. This should give you a sense of what to expect when you adjust the Noise Correction sliders.
The Correction Blend control blends the denoised image with the original image. By this method a small amount of noise can be left in the result image, preventing it from appearing over-smoothed or “plastic”. A setting of zero shows only the original image, while a setting of 100 shows solely the denoised image. For this reason, if you are trying to make subtle adjustments with the Noise Correction sliders, you should keep the control at 100 while making the adjustments so you can see the full effect of the noise adjustment. After that the Correction Blend control can be backed off for a more natural-looking result. Generally, the default setting of 70 is a good starting point for setting this control. For subtle control of the amount of denoising it is often sufficient to leave the Noise Correction sliders at their default values of 50 and to make small changes in the amount of smoothing by choosing a Correction Blend setting in the interval 70 to 90.

The Sharpening control, not surprisingly, controls the sharpness of the result image. Generally, this control is best left at around 10, though you may want to experiment with other settings depending on your taste for image sharpness. The control does not, however, function like a conventional sharpening filter for two reasons. First, the filter itself makes some decisions during the noise removal process about what are and are not edges. Consequently, what is available to be sharpened depends to some degree on the setting of the Noise Correction controls. Second, the filter weights the edge information so that sharpening is predominantly applied to intermediate and weak edges, so preventing oversharpening of strong edges that were well preserved during noise removal.
8. Color-based tuning of noise reduction (Protect Image tab)

Despite the control options available on the Noise Removal tab there is frequently a need for more subtle and detailed control of noise removal. This is provided by the controls on the Protect Image tab. The central idea behind this tab is the following: regions of color space can be defined and the noise removal effect can be limited to a lower value within these defined color regions in order to preserve detail. For example, a range of colors corresponding to hair can be defined and the noise removal effect can be reduced for this range of colors in order to preserve more detail in the hair whilst simultaneously strongly smoothing noise elsewhere in the image. This approach can be useful when very a noisy image contains texture. In such a case, the color and brightness variation in the textured regions can be comparable in magnitude to the noise in smooth image regions. Since, based on our understanding of the scene, we expect textured regions to be busier than smooth regions, the filter may appear to smooth texture excessively. In this case, texture regions may be selected by color and smoothed less to create a more appropriate and natural image.

Selecting color ranges with the Color Wheel

Color ranges may be defined in two ways – either by means of the Color Wheel control or by sampling from the image. We will start with the Color Wheel method. The initial state of the Color Wheel (or the state after a filter reset) is shown below.

The color space can be thought of as a cylinder around whose circumference are different hues. The Color Wheel represents a section through this cylinder by means of which hue ranges can be selected. The central axis of the cylinder represents lightness and points out of the screen perpendicular to the color wheel. This axis is also shown in the pane on the right and runs from dark colors on the left to light colors on the right as shown by the density wedge at the bottom of the pane.
A color range may be specified by dragging the control knob into the color wheel. The closer the knob is brought towards the center of the wheel, the broader is the range in question. The range is shown as a highlighted segment in the Color Wheel. The mean hue of the color range can be set by dragging the control knob clockwise or anticlockwise around the color wheel. Alternatively, the mean hue and the color range can be set with the Hue and Range numeric edit controls. The image below shows a range of magenta hues.

The range is visible as a highlighted segment of the Color Wheel, which is echoed in the Hue and Range controls. The pane on the right corresponds to whatever color range is currently shown in the Color Wheel. The color range is automatically provided with soft boundaries so that the selected hue range gradually tapers away at the edges. This prevents abrupt changes of noise with image color. The pane on the right shows horizontally the range of brightness contained in the defined color interval. The density wedge shows the mean color of the current color range and the limits of the lightness interval corresponding to the range. At the top of the pane are highlighted control nodes allowing the noise reduction to be modulated according to lightness within the color range. When these nodes are at the top of the pane, the full noise reduction is in effect. When the nodes are dragged downwards the noise suppression is progressively diminished. This is shown by the icon on the left of the pane, which shows a schematic of noise increasing from top to bottom.

Achromatic colors such as black, grey and white are set in a special way by using a Range of 360 degrees. This setting can also be made with the Color Wheel by dragging the adjustment knob towards and through the center of the wheel.
An example of a color-based noise adjustment is shown in the figure below for the same magenta color range we have been discussing. The control node corresponding to the middle of the brightness interval of this color range is all the way to the bottom of the pane. This means that the noise removal of midtone magentas is completely suppressed. The nodes adjacent to this center node are each half way between the top and bottom of the pane. This means that for these lightness levels the noise reduction is suppressed to about 50% of its full value. Outside the central lightness interval the control nodes remain at the top of the pane. This implies that very dark and very light magenta tones are subjected to the normal full level of noise suppression.

![Color-based noise adjustment](image)

It is important to think of the process of color-based adjustment in the right way. What is happening is this. Portions of color space are selected by means of a hue interval and, within the chosen interval, the degree of noise suppression is tailored according to the lightness of the color. This essentially permits every portion of color space to have its own defined degree of noise suppression. There are, however, no color samples as such within the filter. Whatever color range happens to be selected – however wide or narrow it may be – always corresponds to the pane on the right and all modifications of the degree of noise suppression in dependence on lightness in this pane affect the whole color interval.

This has the following consequences. Suppose after adjusting the magenta range above, we select a range of green hues and adjust the noise suppression for this hue interval. If we subsequently sweep the hues through the magenta region we will see our previous magenta adjustment. Alternatively, if we select a slightly different magenta range that only partly overlaps the previous one, the amount of noise suppression will be reduced in the new range to a degree dependent on the amount of overlap between the ranges. The image below shows how the previous adjustment made for a color range centered on a hue angle of 308 degrees appears when we use a second magenta hue interval of the same range but centered on a hue angle of 297. For mid brightness levels the suppression is no longer complete because the new hue interval only partly overlaps the old.
In order to make management of the color-based noise modification easier the Protect Image tab has two reset buttons. Reset All completely removes all color adjustments, no matter to what hue or lightness they correspond. This restores the filter to a state without any color based adjustment. The filter’s Reset button will also achieve this goal but will also reset the control settings on the Remove Noise tab, which Reset All will not do. The Reset Current button removes color-based adjustments for whatever range is currently active. The same effect can be achieved by dragging all the control nodes to the top of the pane but the button is quicker and simpler.

Note that Reset Current will have an affect on any overlapping color ranges. For instance, if we use the Reset Current button on the magenta range centered on the 297 degrees, the previous magenta range centered on 308 degrees no longer looks the same (see below).
Because the overlapping range was reset, the original magenta range no longer has the full amount of suppression that we set originally.

Superficially, the adjustment of color ranges seems complicated. However, since the filter handles color range overlap and lightness overlap internally by smooth interpolation, there is seldom any need to worry about details. Adjustments are simply a question of selecting a color interval of interest and tailoring the noise reduction as a function of lightness by watching the effect in the right preview.

### Selecting color ranges by sampling the image

The function of the Protect Image tab has been explained in terms of setting different degrees of noise reduction in different portions of the image color space. However, we are not usually thinking about colors within the image but about specific areas of the image in which we want to manage or limit the amount of noise suppression. Accordingly, the filter provides a second method of defining color by sampling it from the image. Sampling a region of the image allows us to define the portion of color space corresponding to the content of that image region. Then we can adjust the noise suppression for just that portion of the color space.

Color is sampled by Ctrl-dragging a color region in the left preview window. This is similar to using Ctrl with painting tools to sample color from an image. When Ctrl is depressed the cursor changes into an eye dropper and a region of the image can be dragged out to select a color range. The sample box is shown with a dashed line. When the mouse is released the sample box disappears and the portion of color space corresponding to the sample is displayed on the Protect Image tab. Color samples can be obtained irrespective of the currently active tab but it is more useful to have the Protect Image tab active.
The color sample is shown according to the hue interval and lightness interval it
occupies. The color range is highlighted on the Color Wheel and this is echoed in the
values of the Hue and Range controls. At the same time, the lightness range of the
sample is shown by highlighting in the right hand pane and the limits of the lightness
range of the sample are shown on the density wedge beneath the pane, which is
updated to show the the mean color of the sample. In addition to this, the control nodes
whose adjustment will affect the sampled color are highlighted in red. This is illustrated
in the figure below.

![Color Wheel and Density Wedge](image)

The method of sampling color from an image is a particularly useful way of creating
color-based adjustments to the noise suppression. In order to illustrate how this works
we will use the somewhat artificial example below.

![Example Images](image)
For this example, a noise sample is deliberately placed to catch the edge of a leaf in order to create an incorrect noise estimate and, additionally, very high values are used for Noise Correction. Together these create a very strong blurring of the image. This we will remedy individually and selectively for the red and the yellow flower to show how a color sample is used in conjunction with a lightness-based noise suppression.

The left preview shows the region of the image that was sampled, while the Protect Image tab shows the noise suppression adjustment. This is proves to be very effective, as shown in the right preview. The blurring of the red flower is completely eliminated while the rest of the image remains severely blurred. The next figure shows a similar adjustment after resetting the previous correction with Reset All. This time the adjustment was made by sampling the yellow flower as indicated and applying the correction shown on the Protect Image tab. In this case, the yellow flower is protected against blurring while the red flower and the rest of the image remain strongly blurred. If we were to apply both the red and yellow corrections simultaneously we would obtain both a crisp red and a crisp yellow flower, while the leafy portions of the image remained blurred.
One final point to bear in mind. Just as with other filter settings, the Digital Camera Noise Removal filter remembers across separate runs of the filter any color-based adjustments that you made on the Protect Image tab. Because there is no way to picture the entire volume of color space and all the various tuning of the noise suppression within it, it is easy to forget about previous color-based adjustments. This can lead to frustration when a previously made but forgotten color adjustment interferes with noise suppression in the current image. Accordingly, it is good practice to press the Reset All button on the Protect Image tab (or the filter’s Reset button) before starting any noise removal on a new image.

9. How to use presets

The Digital Camera Noise Removal filter has two kinds of presets. The first type of preset is a conventional one like those in other filters. The second type is known as a Camera Preset and is specific to this filter. Which type of preset is being used depends on the state of the Camera Preset checkbox. When this box is not checked, the presets you save and the presets you can see in the Presets droplist are conventional presets. When the box is checked, you can only save and load the special Camera Presets.
A conventional preset stores the settings of the filter, such as the Noise Correction slider settings, the Correction Blend and Sharpening settings, along with whatever color adjustment settings you have made on the Protect Image tab. When you load a conventional preset, the filters controls are set to the values that were stored in the preset. However, the filter still automatically samples noise from the image, just as if you were running it interactively. Thus conventional presets allow you to have preferred values for the various filter controls but the filter is always adaptive and samples noise from the image on which you are working.

A Camera Preset is different. Whereas it stores filter settings like a conventional preset, it also stores the results of all the noise estimates that were made on the image. Subsequently, when a Camera Preset is loaded, the image is not sampled at all and the stored noise estimates are used instead. This makes it possible to analyze one image carefully to create a Camera Preset representative of image noise under the particular exposure conditions and then apply that preset to other images created under the same conditions.

There are two benefits of this approach. First, it is ideally suited to scripting, where images are processed automatically without invoking the filter dialog. While the automatic placement of noise samples is effective, it cannot be perfect, since perfect placement requires image understanding. Without Camera Presets, samples would be placed invisibly during script processing and any errors would go undetected except for an incorrect final result. When stored noise estimates are used this type of error cannot arise. The second benefit of Camera Presets is that they can be used to process images from which noise cannot be sampled. Examples of images from which noise cannot be sampled are those that contain nothing but texture, such as the one below.
The image contains no uniform areas from which noise can be sampled. However, a Camera Preset derived from a more normal image created under the same conditions can be applied to such an image without problems.

To prepare a Camera Preset by analyzing the noise in an image, select a colorful image that has uniform regions of different lightness value spanning the entire lightness range, such as the one below. Suitable sampling areas are shown along with their greyscale equivalents. Aim for around five samples representative of the lightness variation.
When preparing Camera Presets bear in mind that the noise parameters characterizing the preset are not simply a function of the specific model of camera that you have. They also depend on the imaging conditions, such as the ISO setting and the exposure time, as well as any noise reduction or sharpening settings of the camera. Be sure to take this into account when creating presets and use them only on images that were obtained under the same conditions as those used to prepare the Camera Preset.

10. What to do about problems

This section briefly discusses what to do about problems that may arise while using the filter.

*Not enough noise is removed*

If the filter appears not to be removing any (or enough) noise check for the following problems:

1. Make sure the correct image layer is active when you run the filter.
2. Make sure at least one noise sample is present in the image.
3. Make sure the Noise Correction sliders are at least at 50 and the Correction Blend setting is at least 70.
4. Make sure no color-based noise adjustment is in effect from a previous run of the filter. Press the Reset All button on the Protect Image tab to make certain.
5. If you are using a Camera Preset, make sure it is appropriate for the conditions under which the current image was obtained.

*Too much detail is removed*

If the filter appears to be blurring the image too much and causing loss of details check for the following problems:

1. Make sure none of the noise samples straddle an object edge in the image, zooming in to make sure of the exact position of the sample box.
2. Make sure that noise samples are positioned over portions of the image that were exactly uniform in real life. If any sample includes texture then either move it to a homogeneous region of the image or remove it.
3. Make sure the Noise Correction sliders are set no higher than 50.
4. Try reducing to the Correction Blend control to 50.
5. If you are using a Camera Preset, make sure it was not created for a higher ISO setting than the one at which the current image was obtained.

*Balancing noise removal with detail preservation*

There may arise situations in which overall the noise is well removed but some specific noise feature or features resist removal. In this case, try placing a noise sample exactly over the recalcitrant feature. If this does not remove the noise, first set the Correction Blend to 100 so you can inspect the fully denoised image. In the event this removes the feature, see how much you can back off the Correction Blend setting before the feature reappears. If the problem feature cannot be removed in this way, there is no recourse but to slowly increase the Noise Correction settings. Start by increasing the Small Detail slider by the minimum amount required to suppress the feature.
In some cases you may have removed all the image noise in a very satisfactory way but textured regions such as hair, grass or distant trees look inadequately crisp. Address this situation using the Protect Image tab. Sample the color of the problem region using the Ctrl-drag technique and then reduce the amount of noise removal for the hue and lightness range corresponding to the sample. Use multiple samples if necessary. However, when you do, keep a careful eye out for unexpected changes in other parts of the image that contain comparable colors to the ones you have sampled. Problems may not be apparent unless you inspect the image at close to 100% zoom.

The Digital Camera Noise Removal filter is designed to allow you to quickly and effectively achieve the level of noise reduction you require. If small adjustments of the Noise Correction controls and the Correction Blend control, along with protecting certain colors of the image, do not give you the result you want, take a more direct approach. Extensive fiddling with the filter is likely to provide marginal rather than dramatic improvement so don’t waste time with it. Instead, duplicate the image as a new layer and apply the filter to the new layer to achieve the required degree of noise suppression, ignoring any loss of detail that may result during this process. After applying the filter, erase (or partially erase) any regions of the image where detail has been destroyed, exposing the unmodified image content on the layer below. Using a soft Eraser (e.g. with a Hardness setting of 50) in this way allows you to do this more quickly than trying to use selections to restrict the region of the image that is modified. (The filter does, however, respect selections and only the selected area is modified, though noise samples may be placed outside the selection.) Setting the Eraser’s Opacity to 30 or 50 allows you to progressively build up the erasing effect to taste. The soft edges avoid abrupt and visible transitions in the noise level of the image and are forgiving of any small positioning errors during erasing. Best of all, if you overdo things, the right mouse will unerase things back to their original condition.

Pathological images

Once in a while you may encounter pathological images with which the filter has a hard time coping. Typically, these images are extremely underexposed, representing situations where a flash should have been used but was not, or night-time shots with insufficient exposure. Irrespective of noise, such images are difficult to rescue and typically require drastic changes in image brightness and contrast. Small differences between dark tones become exaggerated after correction and there is considerable quantization of the histogram. These factors together create extreme amounts of noise in the image. Not infrequently, the scale of this extreme noise is much larger than normal and the noise scale can become greater than the largest noise scale built into the Digital Camera Noise Removal filter. Consequently, the filter has a hard time removing all the noise and leaves an unpleasant large-scale color mottling in the image. An example of such a pathological image is shown below on the left, with the exposure corrected on the right. Even at one tenth of the original scale the color noise and mottling is readily seen in the corrected version.
The way to cope with such images is to resize them to half, one-third or even one-quarter of their original size prior to processing with the Digital Camera Noise Removal filter. After denoising the images can be restored to their original size. This is illustrated with the following examples.

Even at 25% zoom, the color noise is readily visible. When the image is processed at its actual size, a very substantial reduction in noise occurs but the colors retain a mottled effect. In contrast, when the image is processed at one-third of the original size and then resampled back to the original size, the mottling is absent, as shown in the following image.
Processing at a reduced size is not something you will do very often. However, for very poor images with pathological noise levels, this technique can allow you to save an otherwise useless image. It is something to think about if the image turns out to be the only one you have of some family memory.