Stacking Images

Written by Jonathan Sachs
Copyright © 2007 Digital Light & Color

Introduction

The Stack Images transformation in Picture Window Pro is a powerful tool for combining multiple images. As its name implies, it lets you arrange the images in a stack of layers and control the transparency and weighting of each image to create a single composite result. While this transformation is a very general tool that can be used in many different ways, its primary intended purpose is to combine bracketed exposures of the same scene into a single image.

Stack Images assumes that all the images to be combined are already registered. Normally this is automatic if you capture images using a digital camera mounted on a good tripod. If you are shooting handheld or scanning film however, you will need to register all of the images before stacking them. For detailed information on registering images, please see the white paper *Register and Distort.pdf*.

The usual goal of stacking bracketed exposures is to extend the dynamic range of the digital camera sensor or film you are using. For example, if the scene you are photographing contains very dark and very bright elements, you will often have to choose between good shadow detail and no highlight detail or good highlight detail and no shadow detail. By taking overexposed and underexposed photographs of the same scene you can overcome this limitation by combining the good highlight detail from the underexposed image with the good shadow detail from the overex-

posed image. The resulting image will generally have lower contrast than an image shot at the correct exposure, but will include more detail at both the high and low ends of the tone reproduction scale. The final effect is similar to using color negative film with its high latitude and low contrast instead of slide film with its narrow latitude and high contrast. For low contrast subjects there is little to be gained by bracketing, but for very high contrast subjects that exceed the dynamic range of the camera sensor or film, stacking bracketed exposures may save the day.

The trick to combining bracketed images properly is to first lighten the underexposed image and darken the overexposed image so as to bring their overlapping tonal ranges to a set of levels consistent with a normal exposure, and then to combine the two adjusted images assigning a higher weight to the lighter parts of the underexposed image and the darker parts of the overexposed image. Determining the right adjustment curves and density masks by trial and error is next to impossible, but fortunately, the Stack Images transformation includes a built-in tool for building the necessary curves automatically from a set of three test exposures. Once you have a good set of curves you can use them over and over again without having to make new test exposures every time.

The User Interface

Here is what the Stack Images transformation looks like:
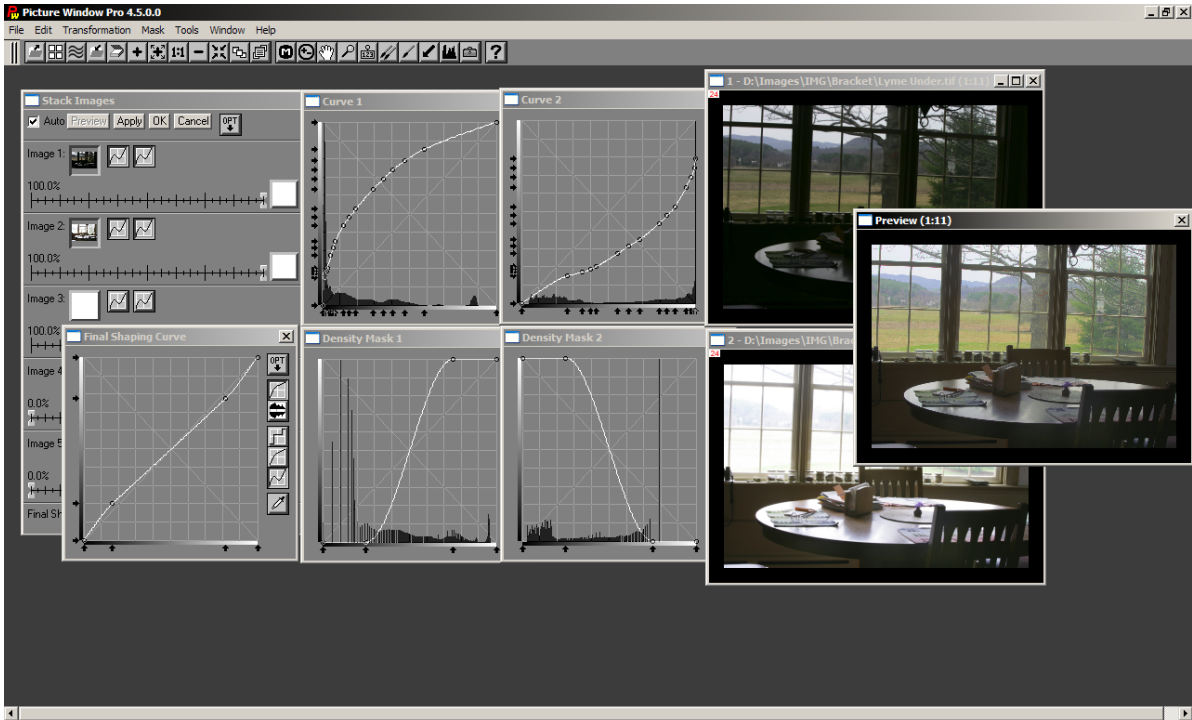
In the main dialog box, there are a series of controls that allow you to stack up to ten images. In this example only the first two are used and an underexposed and an overexposed image have been selected. If no image is selected for a section of the input controls, that section is ignored and does not contribute to the result image.

Next to the image selection controls are two curve buttons - the first one selects an optional brightness curve to be applied to the input image (see the *Curve 1* window) and the second selects a density mask (see the *Density Mask 1* window) that is used to weight the contribution of its associated image to the final result. When the button is depressed, the curve or density mask is used. When the button is raised, the curve or density mask is ignored. The density masks are simple - the one for the underexposed image is set to fully weight the lighter parts of the image and to ignore the darker parts while the one for the overexposed image does the opposite.

The two adjustment curves (*Curve 1* and *Curve 2*) are less obvious and were in fact derived from actual measurements of bracketed exposures of a test target consisting of a series of graduated grays. The curves are precisely constructed so that each gray in the target is adjusted to a consistent level in both images. This step is necessary prior to combining images to prevent problems in the tone curve of the result.

Each image also has an amount control you can use to scale back the overall weight of the image in the result. Setting the amount to zero is a quick way to see what an image is contributing since it effectively turns it off.

Finally, the two input image windows and the preview window are shown on the right of the screen.

Workflow Considerations

Not all subjects are equal.

If you want to be able to combine multiple exposures, your subject needs to be stationary for the length of time it takes to capture all the images. Landscapes are often good candidates, but be careful if it is windy. Sometimes a little motion is OK as long as it is primarily in the darker or lighter parts of the scene since most of the contribution for that part of the tone range will come from a single image.

All the images must be the same type and must have the same dimensions in pixels. There is no provision in Stack Images for registering images—all the input images are assumed to already be registered. You will save yourself a lot of trouble if you use a good tripod when taking pictures you expect to stack.

How much bracketing is enough?

When you photograph a scene, you need to consider how much to bracket. A good starting point is 2 stops overexposure, normal exposure, and 2 stops underexposure. For contrastier scenes you could go to 3 or 4 stops over and under. Unfortunately most cameras will not autobracket by more than 2 stops so in those cases you have to bracket manually. If in doubt, shoot a range of exposures such as -4, -3, -2, 0, +2, +4. Different amounts of bracketing call for different adjustment curves.

Bracketing by two stops either adds four stops of exposure latitude—bracketing by three stops either way adds 6 stops. Since a normally exposed image has around 6 stops of latitude, you can easily achieve a 10 to 12 stop range by combining bracketed images. However, it is important to remember that sooner or later when you view or print your images you will need to reduce them back to the 6 stops or so that printers or monitors can reproduce, so there is a practical limit to how much exposure latitude is really useful.

Consistency is essential

In addition to deciding how much to bracket, you also need to make sure you process your images consistently before combining them. For example, you can use all JPEGs straight from the camera, or all RAW files processed with the same settings,

but not a combination of the two. Different RAW processing also requires different sets of adjustment curves, so it pays to standardize your workflow.

Creating custom curves

Once you have selected bracketing amount and preprocessing workflow, the next step is to create a set of custom adjustment curves and density masks that bring all the bracketed exposures to a consistent set of brightness levels. Doing this requires some test photographs of a target. You can create your own by printing the file: *Gray Wedge 15.tif* that we supply, or you can use either a Kodak Q-13 gray scale or a standard IT8 target of the type used for calibrating scanners. A Kodak Q-13 is available for about $20 from any good photo supply store. If you print your own target, try to get the blacks and dark as possible and to print on very white paper—the wider the contrast range of the target the better. It does not matter if there is a slight color cast to the gray patches as long as all of them can be easily distinguished.

Determine a normal exposure using a gray card or by making sure the range of gray patches in the target is pretty much centered in the image histogram.

Take three test exposures of your target at the same level of bracketing you intend to use for normal subjects and using the same preprocessing workflow. Proper preparation of these reference images is critical (see illustration below):

1. Crop the images so that only the gray scale is showing
2. Make sure the lightest patch is on the left and the darkest on the right.
3. Clean up any specks in your test images by cloning, speck removal, or using the blur transformation with the 5x5 Median option.

Underexposed 2 stops

Normal exposure

Overexposed 2 stops

Cropped Images of Kodak Q-13 Target

It does not matter if the images have a slight color cast, and high resolution is unnecessary—around 1000 pixels in image width is plenty.

To generate custom curves from your test images, start up the Stack Images transformation and select the underexposed test image as *Image 1*, the overexposed test image as *Image 2*, and the normal test image as *Image 3*. Then click on the *Opt* button in the upper right corner of the dialog box and select *Build Curves* from the options menu. This brings up the *Build Curves from Calibration Images* dialog box:
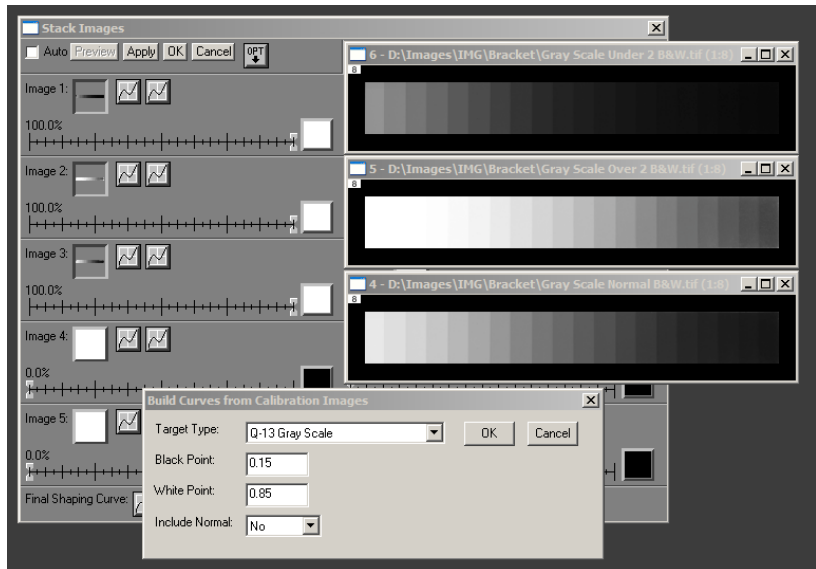
Double check that the three images are set up with white on the left and black on the right and with the underexposed image first, the overexposed image second, and the normal image third exactly as shown above.

In the dialog box, first specify the type of target you are using (*15-Step Gray Wedge*, *Q-13* or *IT8*).

Next you have some decisions to make about overall contrast. The black and white point settings let you determine what level the black and white patches in the normally exposed test target will be assigned in the final image. Setting the black point at zero and the white point at 1.0 will expand the normal image so that its black patch becomes pure black and its white patch becomes pure white, but doing this

does not leave any room to add new tonal information below black or above white which is why we are going to all this trouble in the first place. Setting the black and white points closer together results in a lower contrast final image, but this leaves room to render shadows darker than the black target patch and highlights lighter than the white target patch. The default values of 0.15 and 0.85 are a good starting point, but for very contrasty scenes where you are bracketing by more than two stops you might want to use 0.25 and 0.75 or even 0.30 and 0.70.

Finally you need to specify whether you will be stacking just the underexposed and overexposed images or whether you want to stack the normal image along with the other two. For 2-stop bracketing, the normal image is usually unnecessary, but for wider bracketing it may help fill any gap that opens up between the two exposures. Once you make your selections and click *OK*, you are returned to the Stack Images dialog box with the newly created curves all set up.

At this point you might want to click *Preview* to see how the stacked gray scale will look. It should show a smooth gradation from a dark gray corresponding to your selected black point to a light gray corresponding to your selected white point. To save these curves for future use, click the *Opt* button and select *Save As...* from the options menu.

Applying your custom curves

Armed with a set of custom curves, you are now ready to process bracketed images of something other than test targets.

Load the underexposed image into *Image 1*, the overexposed image into *Image 2*, and, if needed, the normally exposed image into *Image 3*. Then click the *Opt* button and select *Load...* from the options menu and select your saved settings file. Finally click *Preview* or *OK* to check the results.

Remember the order of the images must be the same as when you created the curves—*Image 1* is the underexposed version, *Image 2* is the overexposed version, and if you included the normal exposure, it must be *Image 3*. Also, the images you work with must be processed using the same workflow you used to create the reference images.

Final Shaping Curve

The end result of the Stack Images transformation is an image that includes a much wider dynamic range than any of the input images. Consequently it will usually appear to have reduced contrast since this wider range of information is compressed into the same number of bits. Unless the original subject was extremely contrasty the end result can look somewhat dull and lifeless. To offset this effect, you can apply an S-shaped final shaping curve to the result image to increase its midtone contrast at the expense of some shadow and highlight contrast. This restores the punch of the original images while recovering some of what would otherwise be lost shadow and highlight detail. This is done using the *Final Shaping Curve* button at the bottom of the dialog box. You can also use the final shaping curve to bring out more shadow or highlight detail depending on the effect you are looking for.

Bit Depth

Even if your input images are 8-bit black and white or 24-bit color, the Stack Images transformation treats them internally as though they were 16-bit black and white or 48-bit color. This extra bit depth allows for manipulating a much wider tonal range without loss of information. Consequently, the final result image normally comes out with 16 bits per channel, but if you wish you can force the result back to 8 bits per channel by unchecking *Output 16 bits per channel* in the *Opt* menu. Of course if the input images all have 16 bits per channel, the result will always have 16 bits per channel regardless of the option setting.

Other Uses for Stack Images

Noise Reduction

Stacking multiple images of the same subject is often a good way to reduce noise and bring out very faint detail. Astrophotographers frequently combine multiple exposures of the same part of the sky to produce the equivalent of a single very long exposure, thus making visible objects too faint to be seen otherwise. Or you can stack a series of high ISO images that are noisy and grainy to produce a less noisy composite. Similarly, when using a scanner, stacking multiple scans will usually produce a better result than any single scan—assuming the scans are all perfectly aligned.

Motion Blur Effects

Often it is considered a problem when subjects move while you are trying to photograph them, but sometimes you may want to capture a sense of motion in your images. The following example was created from a series of photographs of a large elm tree during a wind storm. Stacking a number of images, potentially with different weights, can produce interesting effects: