

TACC Sharpening Workshop – An Introduction

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Purpose: To teach Bruce Fraser's Multi-Pass Sharpening Techniques

References: Bruce Fraser, "Real World Image Sharpening..."

Bruce Fraser and Jeff Schewe, "Real World Camera Raw with Adobe Photoshop CS3," contains a great section on the new ACR 4.1 sharpening tools and a lot of info on sharpening in general. I recommend starting here.

Bruce Fraser, <http://www.creativepro.com/story/feature/12189-2.html>

Deke McClelland, "Sharpening an Image with Guile and Gaussian Blur," Photoshop User Magazine, March 2008 pg 064, 065. This article shows how, if ever one really felt he had to, to reproduce the UnSharp Mask functionality with a layered blurring approach within Photoshop. The purpose of including it is to help illuminate the actual UnSharp Mask functionality. Don't ever actually use it!

www.thelightsrightstudio.com, a pdf on multistage sharpening to accompany their sharpening tool. They have an online e-book on the subject of sharpening, and a lot of other tools as well.

<http://photoshopnews.com/2007/05/31/about-camera-raw-41/> This is an article about Camera Raw 4.1 by Jeff Schewe of Pixel Genius that includes a segment about the new sharpening routines found in ACR 4.1+. It also contains much useful info on other aspects in ACR 4.1.

<http://www.bythom.com/sharpening.htm> This is yet another intro to the edge masking Unsharp Mask technique with examples and some guidelines. Very rudimentary but very clear.

Tools: Pixel Genius' PhotoKit Sharpener (PKS) developed by Bruce Fraser is my favorite sharpening tool. It is almost automatic and can be optimized for almost any combination of image type and output process.

Noise Ninja from Picture Code is a favorite noise removal package.

Resizing software, such as Genuine Fractals from On One Software is reputed to be an outstanding resizing package although I have not found it does significantly better than just using the internal Photoshop image resizing options with the appropriate choice of algorithm (bicubic sharper for size reduction and bicubic smoother for size increase).

TLR Sharpening Tool from The Light's Right Studio, found here: www.thelightsrightstudio.com/TLRSharpeningToolkit.htm. The TLR toolkit is basically a set of actions that need to be installed as actions in your Photoshop program. I could not find what version of CS these actions are written for so I cannot vouch for them, however there is also a spreadsheet of USM settings that match to the models that Fraser set up and that PixelGenius sells which may help you if you wish to develop your own actions.

Needless to say, both the PixelGenius and the TLR tools contain many more options than any one person is likely to use.

ACR 4.1 sharpening tool: This includes a masking tool for masking edges to avoid general noise degradation. This sharpening tool is intended for CAPTURE sharpening but there is not much guidance given for how to set it up to just do the capture sharpening bit. See the Schewe article at Photoshop News referenced above, and / or the Fraser / Schewe Camera Raw 4.1 book.

This new ACR 4.1 tool has a live viewer that allows you to look at the effects on masks and detail settings as you make them and to go back and forth between mask views and image views so see the effects. START with this tool if you have CS3 because it will teach you all about what is going on in the sharpening game.

WHY SHARPEN?

1. Sensor – Each sensor element (“pixel”) measures only one color of light: The Bayer array of pixels assigns one red, one blue, and two green pixels for a 2x2 array of elements. Thus, one out of every four pixels on the sensor measures red light, etc.
2. DeMosaicing Sensor Data – The RAW interpreter (Adobe Camera Raw, ...) needs to assign an RGB color value to each pixel position. This is done by a mathematical process known as interpolation. It is done in the camera for JPEGs but in a RAW interpreter for Camera Raw image capture.

Since interpolation is only an approximation process, it essentially smooths the data and softens edges.

3. Lens and film softness compensation – Sharpening techniques (UnSharp Mask) were originally developed to increase the edge contrast on film capture and thereby increase the appearance of sharpness.

4. Creative Sharpening – Attention can be drawn to parts of the image by making those parts sharper than others, or a depth of field introduced, or selective blurring to remove distraction.
5. Output Process Interpolation – All displays and printers use an interpolation process to set the color values of each pixel in the final print or display. That is why we print at 1200 or 1400 dots per inch in a 300 pixels per inch image. This interpolation process again introduces softness and it is dependent on the paper (matte or glossy, the coating, etc.) as well.

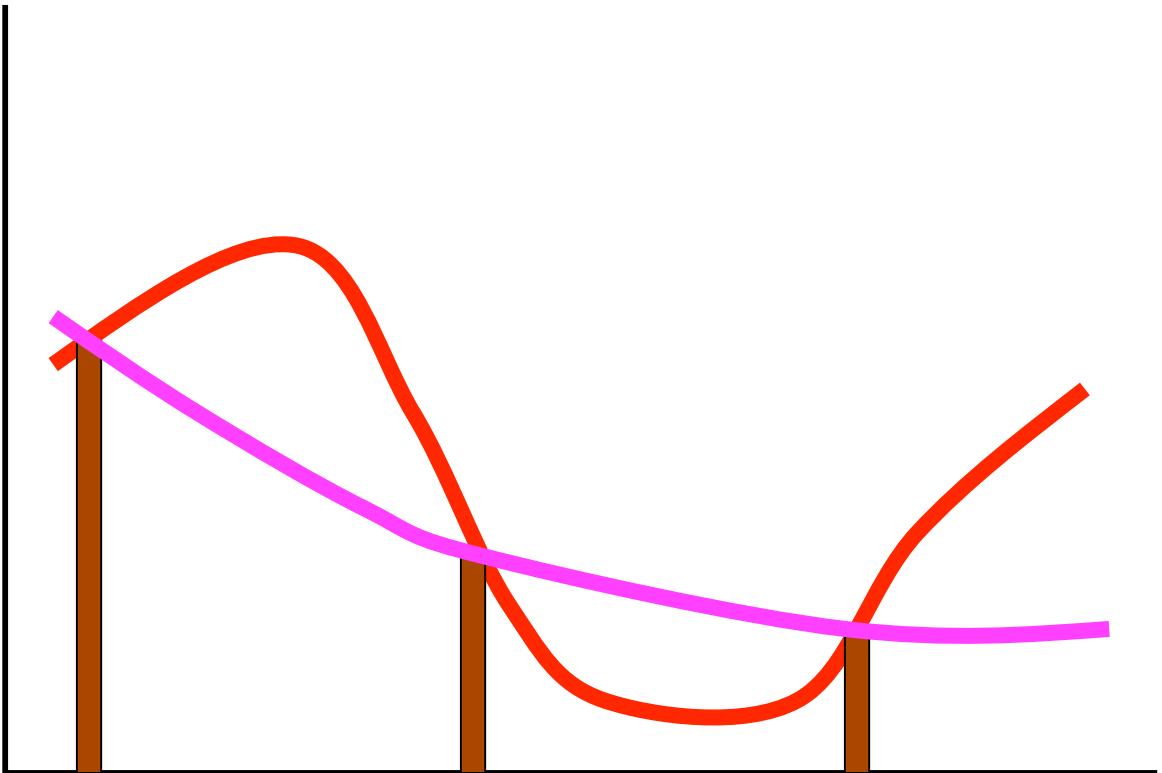
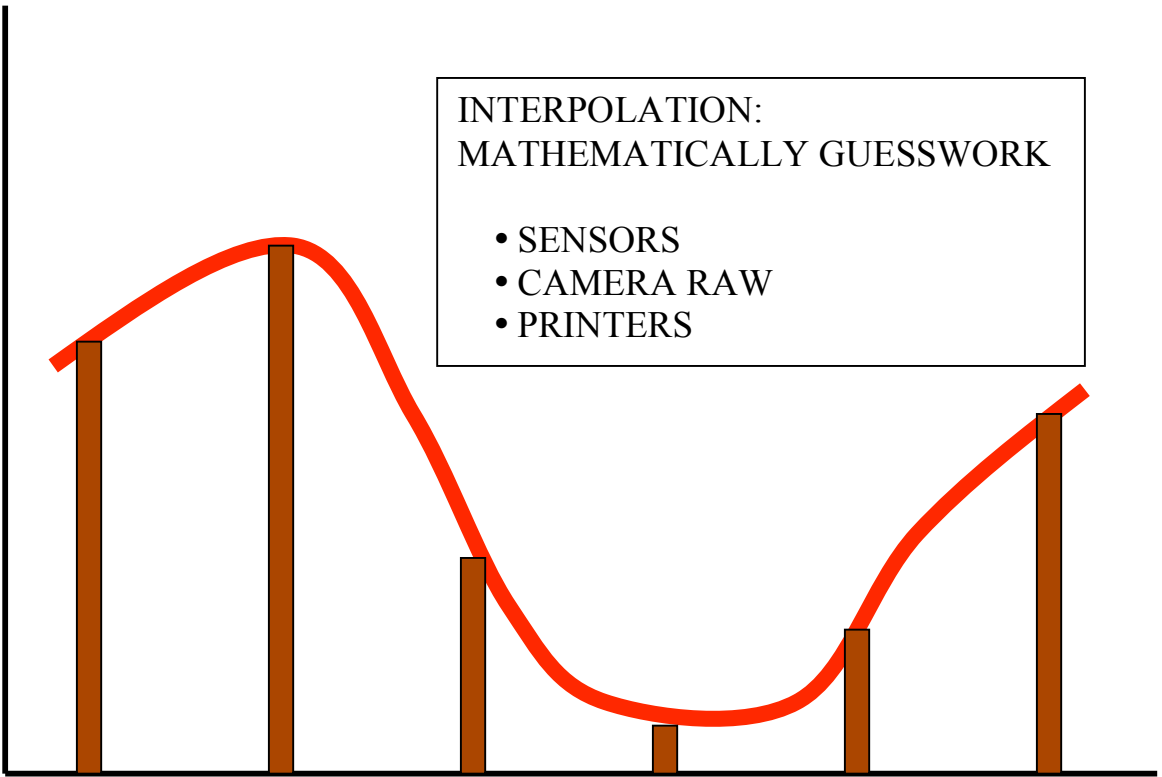
SHARPENING RULES:

1. The first rule is that our eyes ultimately determine the required resolution at the print size and viewing distance required. Resolution no lower than 180 ppi, 240 ppi is fine for matte papers, 300 or 360 ppi on high-resolution glossy papers. 72 ppi is the accepted resolution for web use although most modern monitors are closer to 100 ppi.
2. The Second Rule is that the sharpening haloes should be limited to approximately 0.01 inches to not be offensive. These are the final output print haloes.
3. These first two rules govern the total haloes generated and limit the maximum amount of sharpening that can be applied.
4. The Third Rule is that sharpening accentuates noise as well as subject edges and the accepted way of controlling that is to:
 - a. Filter out the noise to the extent possible before sharpening, and
 - b. To do sharpening through masks that limit the sharpening effects to the edges within the image.
 - c. A corollary to this is that noise removal can also be done with edge masks to avoid softening edges while still filtering noise.

Camera Raw 4.1++ sharpening, Pixel Genius PhotoKit Sharpener, and most other professional sharpening routines use automatically generated edge masks to both sharpen and remove noise.

INTERPOLATION:
MATHEMATICALLY GUESSWORK

- SENSORS
- CAMERA RAW
- PRINTERS



SHARPENING PROCESS

So, this gives at least a Three Step Sharpening process:

1. **CAPTURE SHARPENING** in which the softness of the capture is compensated. The Capture sharpening is a function of the anti-alias filter in the camera mainly and is a pre-sharpening that becomes part of the archival file for the image.
2. **CONTENT SHARPENING**: Sharpening that optimizes the style of the image and is most often characterized by the spatial frequency content of the subject, or which you want to be emphasized. **LOW FREQ** (broad surfaces and diffuse edges, up-close subjects, portraits), **MEDIUM FREQ** (your normal everyday subjects), or **HIGH FREQ** (detail, lots of detail, that you want to retain and sharpen) are the terms Fraser uses. Using a **HIGH FREQ** sharpening on a low frequency image will render it harshly, exaggerate noise and imperfections in skin tone, for example.

Becomes part of the archival file for the image.

3. **CREATIVE SHARPENING (Optional)** which allows the artist to emphasize some areas of the image, or to apply special sharpening effect.

Creative sharpening also becomes part of the archival image file.

4. **OUTPUT SHARPENING** which is used to sharpen for the actual output being used. **DOES NOT BECOME PART OF THE ARCHIVAL IMAGE FILE.**

Output sharpening is output dependent depending on whether output is for the web, for inkjet or laser printer, for offset printing, and depends on the pixels per inch at which the output is being performed.

Key to Output Sharpening is that the image must be at the final size and ppi before output sharpening is applied. It is therefore **NOT** a part of the image archival file but needs to be done just before the printing.

SHARPENING TOOLS

All image sharpening is based on one form or another of the **UNSHARP MASK** filter. Unsharp Mask is a technique for increasing the **EDGE CONTRAST** across perceived edges in the image.

1. **HALOs** – Increasing the edge contrast introduces halos on either side of a light-dark edge in the image. These halos may be one or more pixels in extent and of varying degrees of brightness. If small enough, they are not visible at normal viewing distances while still improving the apparent sharpness.
2. **MASKING** – Advanced tools and techniques use masking techniques to avoid sharpening undesired parts of the image. In particular, **EDGE MASKING** is used

to sharpen only the edges while not sharpening areas of low contrast so as to not add to the noise.

NOISE

Noise is increased by sharpening along with the image edge contrast. Automated tools for avoiding this to all possible extent are available. Noise is in fact the main reason that creates the need for sophisticated sharpening routines. Removing it early before it is enhanced by any sharpening and contrast adjustments is important.

1. **NOISE REDUCTION SOFTWARE:** Noise Ninja is a favorite but the Fraser book outlines how to use the Photoshop noise filters as well. Be aware that Noise Ninja also has a sharpening component in it which should probably be set to zero because it will end up oversharpener using Fraser's sharpening techniques.

Noise reduction filtering should be used on any noisy image as soon in the workflow as possible. Curves and contrast adjustments will all have the potential to increase the noise.

2. **EDGE PROTECTED NOISE REMOVAL:** Noise Ninja as well as Fraser and other systems offer edge protected sharpening routines so that edges are not destroyed or softened in the noise removal process. Especially important for large smooth unpatterned areas like sky.
3. **NOISY images** are likely from dark subjects (night sky, shadow areas, blue areas) and from using high ISOs. Noise is specific to particular cameras as well. The larger the pixel size and the more sophisticated the camera software, the lower the noise can be.

I find noise in my 5D becomes noticeable at large image sizes for ISOs of 800 and above. Noise Ninja does an outstanding job for this camera with its canned profile as long as I set the USM amount to zero.

Noise Ninja has a nice feature of developing a profile for the image and automatically identifying how much noise removal can be done. It also has a well-developed archive of profiles for noise from many cameras that it can use to automatically remove just the right noise.

UNSHARP MASK

UNSHARP MASK is the root of all sharpening techniques. It works by locating the edges where contrast is significant, and then increases the contrast across those edges.

1. USM Example 1:



This shows the effect of USM with an amount of about 75, a radius of about 4px, and a threshold of 0. The right half is filled at 33% gray, the left with 66% gray. Clearly there is a several pixel wide dark halo on the left and light halo on the right, and the individual pixels are visible in the onscreen version of this example.

Increasing the radius makes the aggregate halo wider. Increasing the Amount makes it more pronounced (more contrast, brighter).

2. USM Example 2:



This is a tool that can be used to illustrate or analyze the effects of USM at various contrast edges for particular radius and amount settings. Fraser discusses this at length. Above it is at zero Amount.



This shows the effect of USM with Amount = 500% and Radius = 1.5 px. On the far right the contrast in this wedge is zero and there are no haloes. As the contrast increases (going to the left) the halo gets brighter and broader.

Fraser also introduces into the USM layer a blending style in which he sets the blend mode to Luminescence to avoid color shifts, and a range of blending that excludes the white and black ends of the contrast range so that the extreme tones do not get sharpened. This is shown below for the same Amount – 500% and Radius – 1.5px.



These two figures show how the blending style limits the extent of the sharpening to the middle tones of the image. The Amount and Radius chosen are just for illustration.

One last aspect of Fraser's technique is that although the USM is applied in very large amounts, the actual halo extent is limited by the masking technique. Layer masks are applied to find the edges and limit the sharpening to the breadth of the "REVEAL" part of the masks, which can be made very narrow. This is done largely by blurring the masks with a Gaussian blur by a set amount.

Fraser's technique involves setting goals for the Capture, Content, and Output sharpening that will provide the optimum (maximum) amount of sharpening without introducing objectionable haloes and without exaggerating the noise levels in areas of low detail.

It involves EDGE DETECTION filtering to automatically create a mask that is applied to the UNSHARP Mask layer within Photoshop, limiting the sharpening to the brighter sections of the mask.

Fraser's Source Sharpening Rules:

NOTES from Fraser's Book

The BIG problem with Fraser's approach (book) is that he does not give explicit numbers for many of the options. I have collected here as much as I can find about Radius and Amount settings for USM, and Blur Radius. I have also done some extrapolations that are not indicated in the book, and there is much that I just cannot figure out.

What I do recommend wholeheartedly is to just go and spend the \$100 bucks for the Photokit Sharpener from Pixel Genius.

Page	Comment																					
60-67 OUTPUT Sharpening	<p>Goal of OUTPUT sharpening is to keep the haloes not visually obvious, below the level of visual acuity. This depends on how far you are from the print. For an inkjet print, this is 0.01 inches. Printing at 360 ppi, the sharpening haloes can be as wide as 3.6 pix if image requires it.</p> <p>360 ppi == 3.6 pix 300 ppi == 3.0 pix 240 ppi == 2.4 pix 200 ppi == 2.0 pix 180 ppi == 1.8 pix</p>																					
60 Resolution and the Eye	<p>Viewing Distance and Resolution</p> <table border="1" data-bbox="565 682 1377 947"> <thead> <tr> <th>Viewing distance</th> <th>Limit (inches)</th> <th>PPI</th> </tr> </thead> <tbody> <tr><td>8</td><td>.0023</td><td>428</td></tr> <tr><td>12</td><td>.00349</td><td>286</td></tr> <tr><td>15</td><td>.00436</td><td>229</td></tr> <tr><td>18</td><td>.00524</td><td>191</td></tr> <tr><td>20</td><td>.00582</td><td>172</td></tr> <tr><td>24</td><td>.00698</td><td>143</td></tr> </tbody> </table> <p>This shows why we like to print at about 180 to 300 ppi for high quality images. I typically use 240 ppi for matte and 300 or 360 for glossy. I got this tip from Katrin Eismann.</p>	Viewing distance	Limit (inches)	PPI	8	.0023	428	12	.00349	286	15	.00436	229	18	.00524	191	20	.00582	172	24	.00698	143
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165 SOURCE Sharpening	<p>Source optimization done with single app of USM, tuned to the sensor.</p> <p>Radius is determined by pixel size of sensor Amount is determined by the amount of anti-aliasing in the camera's optics. Most DSLRs have an anti-aliasing filter (a blur filter) in front of the sensor that avoids the extreme interaction between image detail and the sensor discreteness.</p> <table border="1" data-bbox="565 1371 1377 1598"> <thead> <tr> <th>Megapixel Count</th> <th>Sharpening Radius (USM)</th> </tr> </thead> <tbody> <tr><td><= 4 Mpx</td><td>1 pixel</td></tr> <tr><td>6 Mpix</td><td>.6 pixel</td></tr> <tr><td>8 Mpix</td><td>.5 pixel</td></tr> <tr><td>11 Mpix</td><td>0.4 pixel</td></tr> <tr><td>≥ 12.5 Mpix (5D and up)</td><td>0.3 pixels</td></tr> </tbody> </table> <p>Blend-If setting for Source Optimization:</p> <table border="1" data-bbox="565 1671 1377 1822"> <tbody> <tr><td>Blend Mode</td><td>Luminosity</td></tr> <tr><td>Opacity</td><td>66 %</td></tr> <tr><td>This layer</td><td>20, 80, 145, 235</td></tr> <tr><td>Underlying layer</td><td>20, 80, 145, 235</td></tr> </tbody> </table>	Megapixel Count	Sharpening Radius (USM)	<= 4 Mpx	1 pixel	6 Mpix	.6 pixel	8 Mpix	.5 pixel	11 Mpix	0.4 pixel	≥ 12.5 Mpix (5D and up)	0.3 pixels	Blend Mode	Luminosity	Opacity	66 %	This layer	20, 80, 145, 235	Underlying layer	20, 80, 145, 235	
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	The Opacity setting allows decreasing or increasing the resulting source sharpening after it has been done. That is counter-intuitive to me, but it works.
Viewing Results	Requires actual printing at size to get the right answer. Viewing on the screen of the monitor does not give accurate sharpening at any zoom factor. Fraser recommends using a 50% rather than 100% zoom and never 33% or 66% because PS screws it up with more anti-aliasing.
106 Radius and Amount	<p>Low frequency images with wide edges and soft detail require higher Radius settings than high frequency images with narrow edges and sharp tonal transitions. A diffuse boundary or edge, like a soft shadow on smooth facial backgrounds, is a low frequency edge, and requires higher Radius setting to get sharpening. (? Requires for what objective?, to get sharp? It certainly doesn't soften it. Why would one want to sharpen such surfaces anyway? Sharpening for content, matching Radius to the edges in the image is most important.</p> <p>USM increases the width of the halo as the contrast at the edge increases, which is not what is desired. Use edge masks to control that behavior.</p>
125 Luminosity Blending and Edge Masks	Luminosity blending mode eliminates the shifts in color that the unsharp mask can introduce since you end up sharpening only the luminosity of the image. Older methods used to do a L*a*b color mode sharpening to get at just the luminosity channel, but it is now available as a blending mode and no color space translation and back is required.

FRASER'S SOURCE RULES: (page 84)

1. The Sharpening Radius is tuned to the minimum level of detail the camera can resolve. He gives the radius values. For a 5D that means about 0.3 to 0.4 px radius. This means that the extent of the pixels influencing the sharpening are within about or less than one pixel away from the center pixel.

In Practice, blow your image up to 400% and sharpen away until you start obliterating detail, then back off, do it again, and again, and you will soon get to the values for your camera. I use 0.3 px for my 5D, but I could use 0.4 also as there is some leeway. I repeatedly find that an Amount setting of 280 to 320 is about right for the 5D. But watch out that you are not oversharpening in this Source Sharpening phase.

Note that the Amount setting is said to be determined largely by the anti-aliasing filter of the camera and the interpolation in the RAW converter, but that doesn't

help in determining what it should be because no one ever discloses that information. Only experimentation will help. And the key is to blow the image up a huge amount so that no other interpolation is a factor, and then make it just sharp but not crunchy. See page 83 for an image example before and after source sharpening.

2. The sharpening is applied to a layer in the LUMINOSITY mode set at 70% opacity. The luminosity mode is chosen to avoid color shifts in the unsharp mask operation, only sharpen the luminosity information, not the colors.
3. The sharpening is focused on the midtones using the blend-if blending styles so that nothing with luminosity below 25 or above 200 is sharpened.
4. ALWAYS (page 81) reduce noise if needed BEFORE any sharpening is applied!!!
5. Page 86, the Source sharpening phase of the workflow is more about improving the relationship between EDGES and NOISE so that a good mask for content sharpening can be obtained. It isn't just about the edges.