

## Unsharp masking: Digital magic to bring out the best in your digital images.

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In an earlier article I described digital images as being "sampled" in space and in brightness.

"Sampled in space" means that image sensors are composed of a number of light sensitive areas arranged in a fixed, regular pattern, like a checkerboard. The total number of these light sensitive areas – which are called pixels, short for picture elements – is important to image quality.

"Sampled in brightness" means each pixel can have only one value that represents the average of the total light hitting the pixel. Typically, amateur digital cameras use 8 binary digits (called bits) of brightness information per color. 8-bits can represent 256 different decimal numbers. Black is usually represented by 0 and white is represented by 255. All of the brightness information between black and white must be represented by the remaining 254 numbers. Any fine detail that falls on a pixel is averaged with all the other light hitting that pixel.

A consequence of this sampling is a

slight loss of image sharpness. This means the edges of objects in digitized images just aren't as "crisp" as they should be and so just about all digital images need some amount of sharpening to restore the "snap" present in the original scene. Keep in mind that what we call sharpness is really the subjective visual response (the way our eyes and brain work together) to the "punch" of an image. Scientists who measure what we see as sharpness use two terms to describe it: resolving power and acutance.

Resolving power is easy to understand. It's a measure of the ability of an imaging system form separate and distinct images of two objects that are very close together. We usually see it expressed in terms of line pairs per millimeter. Acutance isn't quite so easy to understand because acutance isn't about resolving detail; it's about the transition that occurs across edges. It usually involves looking at the intensity distribution across the image of a knife-edge and is described by something called a modulation transfer curve. In digital imaging it's easy to change the sharpness of an image by altering the transition across edges in the image, but no amount of magic can change the resolving power of the captured image

When sharpening a digital image, lots of newcomers to digital imaging avoid using the unsharp masking (USM) filter because of the "unsharp" part of the name, but USM is actually the most useful of the sharpening filters.

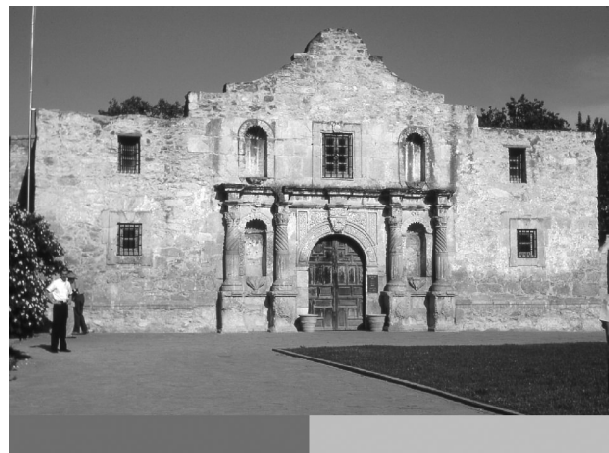
How did the term "unsharp" get in the name of a filter that actually "sharpens" an image? In studies of contrast masking used to prevent contrast increases when printing color transparencies, J. Yule (PHOT. J., 84, 321 (1944)) suggested that masks should be deliberately made unsharp by printing them with a thin spacer between the mask material and the transparency. He found this helped hide the slight lack of registration of the masks, and helped improve the reproduction of fine detail.

By having an unsharp mask, the fine detail of the original is not resolved by the mask and therefore when the negative mask is placed in registration with the original image and printed, it does not reduce the contrast of fine detail, but only large areas. Upon increasing the overall contrast of the image, the contrast of the coarse detail is restored and the contrast of the fine detail is enhanced.

A digital imaging equivalent of this darkroom process can be carried out in Photoshop by adding a nega-

tive, low contrast, unsharp (blurred) version of an image to the original image. Thus the original name from silver halide photography days continues.

My test image of the Alamo in San Antonio, Texas was scanned from a slide without sharpening. The strip at the bottom of the image contains a straight edge and is designed to make the effect of unsharp masking easier to see.



Original image.

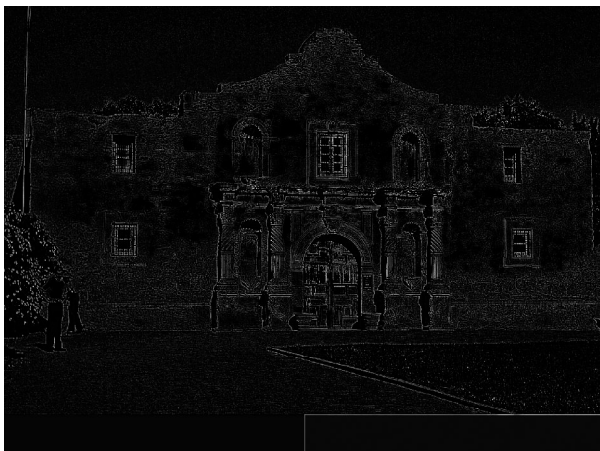


Low contrast, blurred negative of original image.



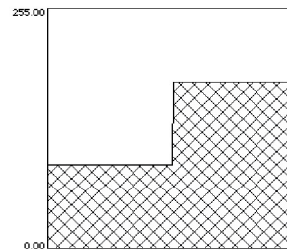
Final Image: Original image + Low contrast blurred image. Contrast adjusted.

It's easy to see the effect of the sharpening by using Photoshop to subtract the Final Sharpened image from the Original image and then using Photoshop's Levels tool to lighten the resulting image to make the changes easier to see. Areas with no change will be dark while areas that have changed will be light. Looking at the "Edges" image we can easily see that it is the edges in the original image that have been changed and sharpened.

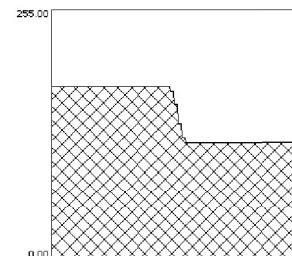


"Edges".

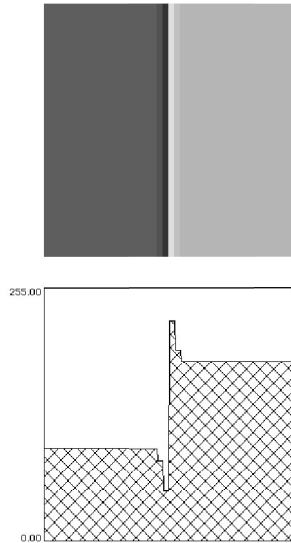
The following images are magnified views (600%) of the edge in the strip at the bottom of the full images. A line profile of the edge is also included at the bottom of each image to show the stages of the unsharp masking process clearly.



Original image.



Low contrast, blurred negative of original image.



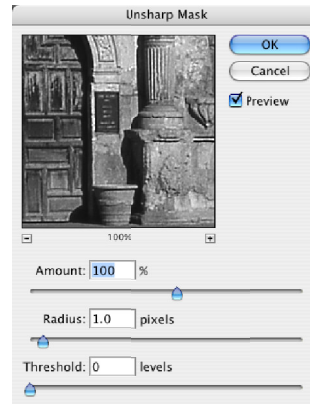
Final Image: Original image + Low contrast blurred image. Contrast adjusted.

The edge change achieved by unsharp masking is similar to a visual optical illusion known as the Mach band effect. In the Mach band effect, when your eye sees an edge corresponding to a brightness change, it enhances the edge beyond its actual appearance so you can more easily see the edge. It does this by making the dark side of the edge appear darker and the light side of the edge appear lighter making the edge easier to see – just like unsharp masking!

Remember that in sharpening, like everything else with computers, GIGO – garbage in means garbage out - applies. Don't expect miracles in trying to sharpen an out of focus image - some fine detail has to be present in the image to start

with.

Note that digital imaging software actually uses more sophisticated mathematical calculations to achieve the same USM effect and requires no further contrast adjustment. Different programs call the adjustments you can make in the sharpening process by different names. Photoshop has three adjustments and two of the three have equivalents in the original darkroom masking process.



Adobe Photoshop's Unsharp Masking Settings.

Photoshop calls the contrast of the mask the Amount and it controls the strength of the sharpening. The higher the Amount, the greater the difference between the peaks on either side of the image.

Photoshop calls the amount of blurring of the mask the Radius and it controls the width of the sharpened area. A larger Radius gives more sharpening.

Photoshop's third adjustment, Threshold, is the one that doesn't have a direct photographic equivalent. The Threshold setting acts to reduce noise in the sharpened image by keeping small brightness differences between adjacent pixels from being sharpened

Software manuals don't do a good job of telling you how to set the terms. You should experiment trying different settings to see what happens.

I always recommend applying USM as the last image enhancement step you use. The amount of USM you need to apply is really a function of what you want to do with the image. In most cases apply just enough USM so that you can just see the effect on your computer monitor. By the way, when evaluating the effect, you must have the monitor screen image set to 1:1 (1 pixel in the image is represented by 1 pixel on the screen) – sometimes this is called 100%. If you are making a large print to be viewed at a distance or preparing an image to be printed in a paper or magazine, you will probably want to apply a bit more sharpening.