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A REVIEW ON IMAGE ENHANCEMENT USING SHARPENING
TECHNIQUES

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Abstract

Image processing is basically the use of computer algorithms to perform image processing on digital images. Digital image processing is a part of digital signal processing. Digital image processing has many significant advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing of images. In this paper, a new filtering technique is used for enhancement of images that are highly contaminated by impulse noise. The filtering technique is more effective in eliminating impulse noise and preserving the image features. The filter replaces a corrupted pixel by the median value or by its processed neighboring pixel value.

Keywords: sharpening, Unsharp Masking, Sharpening Filters, Sharpening Parameters

1. Introduction

Image sharpening is a powerful tool for emphasizing texture and drawing viewer focus. It's also required of any digital photo at some point -whether you're aware it's been applied or not. Digital camera sensors and lenses always blur an image to some degree, for example, and this requires correction. However, not all sharpening techniques are created equal. When performed too aggressively, unsightly sharpening artifacts may appear. On the other hand, when done correctly, sharpening can often improve apparent image quality even more so than upgrading to a high-end camera lens. Human perception is highly sensitive to edges and fine details of an image, and since they are

composed primarily by high frequency components, the visual quality of an image can be enormously degraded if the high frequencies are attenuated or completely removed. In contrast, enhancing the high-frequency components of an image leads to an improvement in the visual quality. Image sharpening refers to any enhancement technique that highlights edges and fine details in an image. Image sharpening is widely used in printing and photographic industries for increasing the local contrast and sharpening the images.

2. Types of Sharpening

A. Capture Sharpening

In an attempt to control the variables in image sharpening, many photographers adopted a three-step sharpening process where separate passes of sharpening are applied at different stages in the workflow. The first stage, often called **Capture sharpening**, adds a light amount of sharpening in the raw conversion process to compensate for the slight amount of image sharpness lost as the photo is digitized.

Note: The term capture sharpening is a bit of a misnomer as it is not a good idea to add sharpening in camera using your camera's menu. More often than not, sharpening added in-camera will cause problems later in your workflow.

B. Creative Sharpening

The first pass of sharpening should happen in your raw converter, not your camera. The second round of sharpening, called **Creative sharpening**, selectively sharpens key lines and focus areas within an image. For example, in a portrait, a photographer may add sharpening to the eyes, smile and jewelry to grab the Viewer's attention.

C. Output Sharpening

The final pass of sharpening, **Output Sharpening**, aims to optimize image sharpness based on the final image size, output medium (print or web; glossy or watercolor paper) and anticipated viewing distance. Of the three passes, this stage requires the greatest attention on the part of the photographer. It is very easy to over or under sharpen images and miss the mistake until the finished print rolls off the printer or appears in the magazine. To the uninitiated, this may feel like a bit of a high-wire act, but never fear, this article will help walk you through the process and provide plenty of guidance on what clues to look for to make sure you never oversharpen your images. It is far better to unsharpen images, than to oversharpen them.

An "unsharp mask" is actually used to sharpen an image, contrary to what its name might lead you to believe. Sharpening can help you emphasize texture and detail, and is critical when post-processing most digital images. Unsharp masks are probably the most common type of sharpening, and can be performed with nearly any image editing software (such as Photoshop). An unsharp mask cannot create additional detail, but it can greatly enhance the appearance of detail by increasing small-scale acutance.

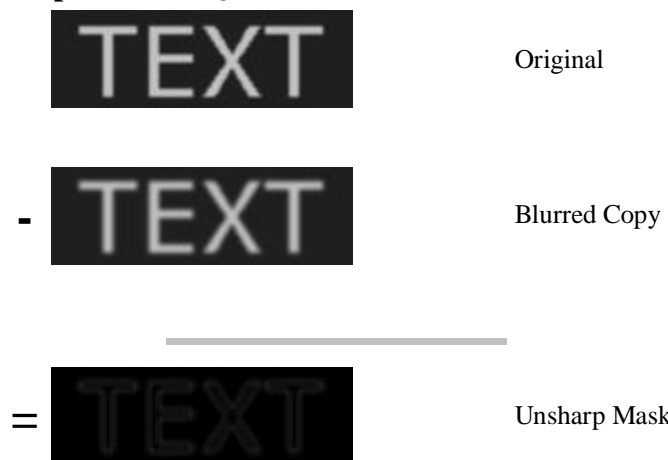
3. Sharpening: Unsharp Mask

An "unsharp mask" is actually used to sharpen an image, contrary to what its name might lead you to believe. Sharpening can help you emphasize texture and detail, and is critical when post-processing most digital images. Unsharp masks are probably the most common type of sharpening, and can be performed with nearly any image editing software (such as Photoshop). An unsharp mask cannot create additional detail, but it can greatly enhance the appearance of detail by increasing small-scale acutance.

3.1 How it works

The sharpening process works by utilizing a slightly blurred version of the original image. This is then subtracted away from the original to detect the presence of edges, creating the unsharp mask (effectively a high-pass filter). Contrast is then selectively increased along these edges using this mask — leaving behind a sharper final image.

Step 1: Detect Edges and Create Mask



Step 2: Increase Contrast at Edges

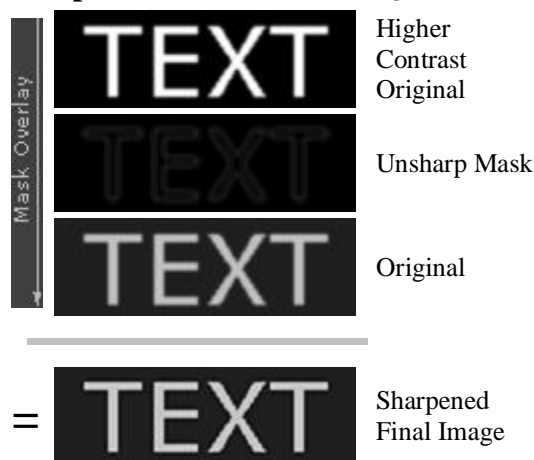


Figure 1: The sharpening process

Note: The "mask overlay" is when image information from the layer above the unsharp mask passes through and replaces the layer below in a way which is proportional to the brightness in that region of the mask. The upper image does not contribute to the final for regions where the mask is black, while it completely replaces the layer below in regions where the unsharp mask is white.

If the resolution in the above image is not increasing, then why is the final text so much sharper? We can better see how it works if we magnify and examine the edge of one of these letters as follows:

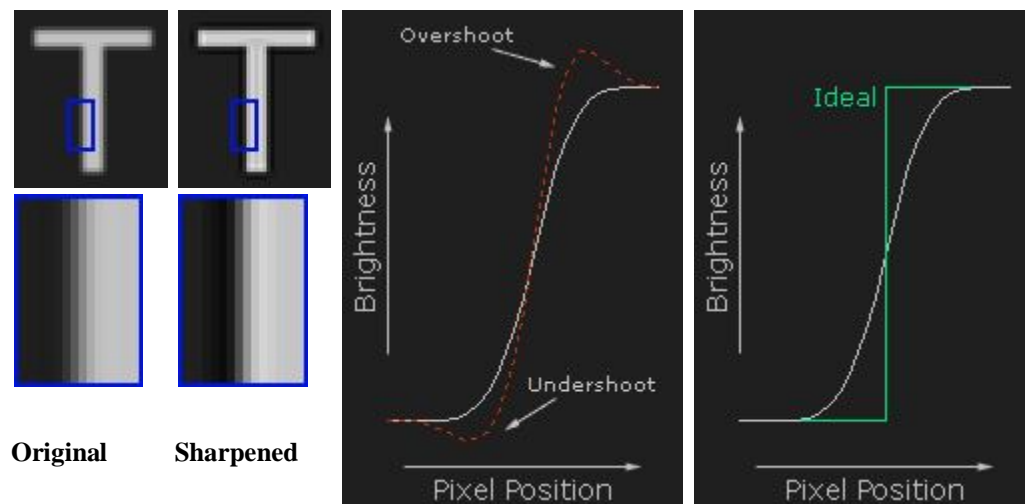


Figure 2: examine the edge of one of the letters

How it does not transform the edges of the letter into an ideal "step," but instead exaggerates the light and dark edges of the transition. An unsharp mask improves sharpness by increasing acutance, although resolution remains the same.

Unsharp masks are not new to photography. They were traditionally performed with film by utilizing a softer, slightly out of focus image (which would act as the unsharp mask).

The positive of the unsharp mask was then sandwiched with the negative of the original image and made into a print. This was used more to enhance local contrast than small-scale detail.

4. Sharpening: Unsharp Filter

The unsharp filter is a simple sharpening operator which derives its name from the fact that it enhances edges (and other high frequency components in an image) via a procedure which subtracts an unsharp, or smoothed, version of an image from the original image. The unsharp filtering technique is commonly used in the photographic and printing industries for crispening edges.

4.1 How It Works

Unsharp masking produces an edge image $g(x, y)$ from an input image $f(x, y)$ via

$$g(x, y) = f(x, y) - f_{smooth}(x, y)$$

Where $f_{smooth}(x, y)$ is a smoothed version of $f(x, y)$

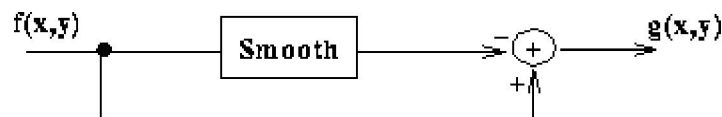


Figure 3: Spatial sharpening

We can better understand the operation of the unsharp sharpening filter by examining its frequency response characteristics. If we have a signal as shown in Figure 3(a), subtracting away the lowpass component of that signal (as in Figure 3(b)), yields the highpass, or 'edge', representation shown in Figure 3(c).

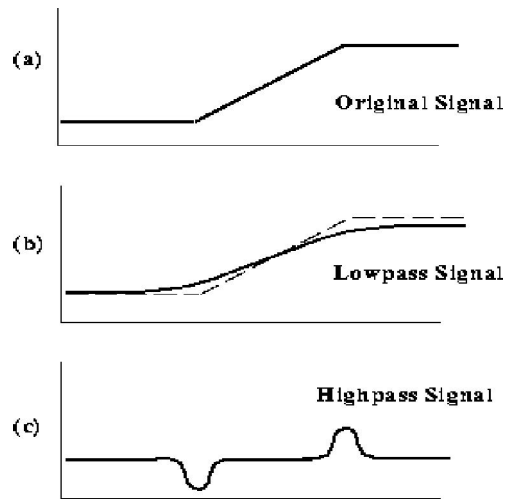


Figure 3: Calculating an edge image for unsharp filtering

This edge image can be used for sharpening if we add it back into the original signal, as shown in Figure 4.

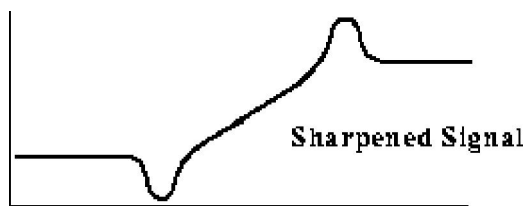


Figure 4: Sharpening the original signal using the edge image

Thus, the complete unsharp sharpening operator is shown in Figure 5.

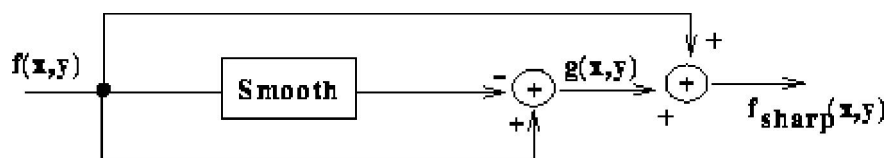


Figure 5: The complete unsharp filtering operator

We can now combine all of this into the equation:

$$f_{sharp}(x, y) = f(x, y) + k * g(x, y)$$

Where k is a scaling constant. Reasonable values for k vary between 0.2 and 0.7, with the larger values providing increasing amounts of sharpening.

5. Sharpening Workflow

Most photographers now agree that sharpening is most effective and flexible when it's applied more than once during image editing. Each stage of the sharpening process can be categorized as follows:

Capture sharpening aims to address any blurring caused by your image's source, while also taking image noise and detail into consideration. With digital cameras, such blurring is caused by the camera sensor's anti-aliasing filter and demosaicing process, in addition to your camera's lens. Capture sharpening is required for virtually all digital images, and may be applied automatically by the camera for photos which are saved as JPEG files. It also ensures the image will respond well to subsequent rounds of sharpening.

Creative sharpening is usually applied selectively, based on artistic intent and/or image content. For example, you might not want to apply additional sharpening to a smooth sky or a person's skin, but you may want to crank up the sharpness in foliage or a person's eye lashes, respectively. Overall though, its use may vary wildly from photo to photo, so creative sharpening is really a "catch all" category. It's also the least used stage since it can also be the most time-consuming.

Output sharpening uses settings customized for a particular output device, and is applied at the very end of the image editing workflow. This may include special considerations based the size, type and viewing distance of a print, but it can also be used to offset any softening caused by resizing an image for the web or e-mail. Overall, the above sharpening workflow has the convenience of being able to save edited images at a near-final stage. When printing or sharing one of these images, all that is needed is a quick top-off pass of sharpening for the output device. On the other hand, if all sharpening were applied in a single step, then all image editing would have to be re-done every time you wished share/print the photo using a different output device.

Capture Sharpening



Accounts for your image's source device, along with any detail & noise characteristics

Creative Sharpening



uniquely accounts for your Image's content & artistic intent

Output Sharpening



Final output medium

Figure 7: Sharpening Workflow

6. Sharpening Parameters

Most of the sharpening techniques uses only three parameters:

a. Radius

Controls the size of the edges you wish to enhance, where a smaller radius enhances smaller-scale detail. You'll

usually want a radius setting that is comparable to the size of the smallest detail within your image.

b. Amount

Controls the overall strength of the sharpening effect, and is usually listed as a percentage. A good starting point is often a value of 100%.

c. Threshold (Masking)

Controls the minimum brightness change that will be sharpened. This can be used to sharpen more pronounced Edges, while leaving more subtle edges untouched. It's especially useful to avoid sharpening noise.

7. Conclusion

In this paper we have discussed about what is sharpening, how the sharpening techniques was used in image processing, what types of sharpening methods are used in image processing and how the sharpening filters worked in image. The Sharpening technique is very useful for emphasizing texture and drawing viewer focus. There are a couple of areas which we would like to improve on. One area is in improving the de-noising along the edges as the method we used did not perform so well along the edges. Another area of improvement would be to develop a better optimality criterion as the MSE is not always the best optimality criterion.

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