

Image Sharpening Using Basic Enhancement Techniques

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Abstract: Digitized images usually faces problem of lack of quality, which includes specifically problem with contrast and occurrence of shading and artefacts which is caused due to the deficiencies in focusing, lighting and various other constraints. Hence the image quality has to be improved using the basic image enhancement techniques. Image enhancement is the processing of an image to bring out specific features explicitly. The available methods for image contrast enhancement concentrates on the features of the image to be processed and eliminating the user characteristics. Image sharpening is one of the prominent image enhancement techniques applied in every field where images are ought to be understood and analysed. In this paper different approaches of Image sharpening using Unsharp Masking(UM) are compared. These algorithms are analysed with different filtering techniques. The results show that majority of these algorithms are very sensitive to the enhancement factor and can be used for image sharpening.

Keywords: Image enhancement, Image sharpening, Unsharp Maskin, Discrete Wavelet Transform, Geographic data visualization.

1. Introduction

The targets of this method are mainly natural images obtained by scanning photographs or video equipments, etc. Sharpness is the most important factor on image quality. To improve image quality, the sharpness must be adjusted to an optimal value. For automatic image quality improvement, the following subjects need to be settled.

- A method to evaluate image sharpness, and to express it as physical value.
- Determining the optimal sharpness value that makes an image quality the best.
- An algorithm to alter an image into one which has optimal sharpness. To evaluate image sharpness, previous works usually used the modulation transfer function (MTF), or some other known blurring mechanism on the image [1]-[3]. However, when dealing with images obtained by scanning photographs, or from video equipment's, MTFs are usually unknown. Therefore, in these cases, the image sharpness could not be evaluated. In this paper, the image edge sharpness (ES) value is used to evaluate image sharpness. It is defined by average intensity of the high spatial frequency components in the edge area.

By using this, it is possible to calculate image sharpness

without MTF. In the following section, the ES value is described. Then experimental results, obtained from comparison between the ES value and subjective image sharpness, are presented, along with quality. Section 5 shows the algorithm to alter an image into another image which has different edge sharpness value. Using this method, image sharpness can be optimally and automatically adjusted. Image sharpening methods may be classified into two classes [1].

- Spatial domain methods
- Frequency domain methods.

The spatial domain techniques are implemented to the image lane itself and are based on direct operation of pixels in an image. Enhancement operations are based on the operations on the image pixels. Some of the spatial domain image enhancement operations include gray level transformation, histogram processing, basic spatial filters and unsharp masking. In the frequency domain methods, the image is first transferred in to frequency domain. It means that, the Fourier transform of the image is computed first. Image enhancement techniques can be applied to restore the contents of old documents. Very often the old documents used for storing valuable information suffers from severe background damage. Few examples of background damages are varying contrast, ancient document age and the documents have degraded over time due to storage conditions and the quality of the written parchment. Image processing offers a few techniques to make these documents readable. There are few enhancement methods which can be applied in such situations.

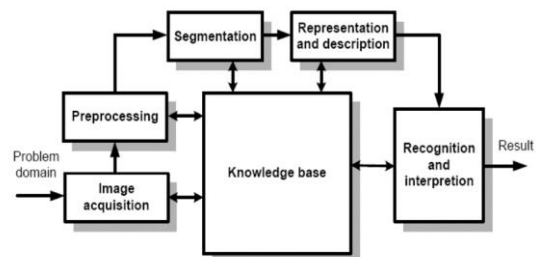


Fig. 1. Block diagram of image sharpening

2. Image sharpening principle

Image sharpening involves the addition of a signal that is proportional to a high- pass filtered version of the original

image to the original image [3]. The critical factor here is the option of the high pass filtering operation. In the conventional approach linear filters were used to implement the high pass filter. In case of the original image being corrupted with noise the linear approaches may provide us with unexpected and improper results.

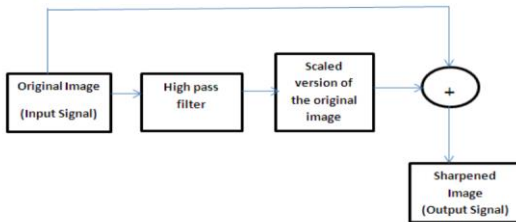


Fig. 2. Image sharpening principle

The Fig. 2, illustrates this procedure called an unsharp masking on a one-dimensional signal. As shown in the Fig(2),the original image is first filtered by a high-pass filter which removes the high-frequency components, and then a scaled version of the high-pass filter output is added to the original image and hence a sharpened image of the original will be produced.

3. Image enhancement techniques

The enhancement methods are:

- Image enhancement methods using binarization method or thresholding method,
- Image enhancement methods using binarization method or thresholding method and other methods,
- Image enhancement methods using other methods only [2].

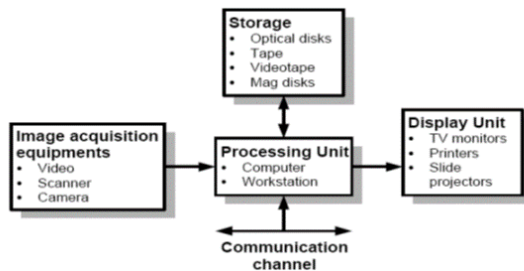


Fig. 3. Block diagram of image enhancement

4. Image sharpening masking

A. Sharpening images and unsharp mask

One of the most often used and abused post processing tools are the sharpen filters. When applied properly, sharpening can boost the image by making it look crisper and more defined. However, there is a tendency to go overboard with this and the image can come out looking unnatural and ‘oversharpened.’ There is the popular misconception that if you sharpen a blurry image, it will magically appear clearer. What does happen is that the blurry image will just look more terrible. Sharpening works by exaggerating the contrast of the object’s edges, giving

the viewer the impression of distinct delineation. There are many ways to do this. You can sharpen the entire image in one click with the Sharpen filter or you can use the Unsharp Mask for more control over how defined you want the sharpening to be. Some people prefer to use the High Pass Filter or the Smart Sharpen. Whichever method you use, just remember to be lighthanded when sharpening since too much can make the image look unnatural with distorted pixels. One tip would be to sharpen only certain areas in the shot instead of the whole image. For example, if your image is of a bird flying against the cloudy sky, sharpen only parts of the bird while leaving the sky untouched to keep it looking smooth. Image Sharpening using unsharp masking Image sharpening is done using unsharp masking for contrast enhancement. The basic concept of UM is to blur the original image first, then subtract the blurred image from the original image itself. As the final stage add the difference to the original image. The linear unsharp filtering approach is used to enhance the noisy image using the high pass filter. Unsharp masks are very applicable for sharpening images. But too much sharpening can also leads to artificiality in the image losing its natural look. This method has two major drawbacks such as the contrast in the darker area is enhanced much deeper than the lighter area. Next problem is the method also enhances the noise and digitization effects. Due to these issues the images loses its originality in most cases [6].Among all the image sharpening approaches used this UM approach is the easiest and simplest.

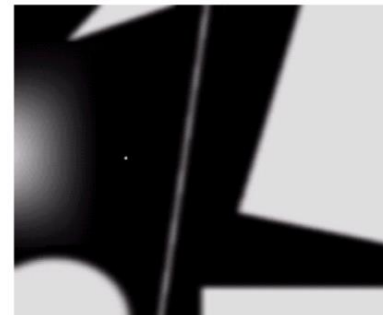


Fig. 4. One dimensional figure

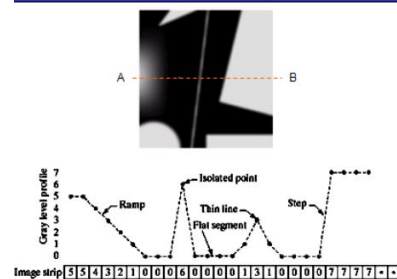


Fig. 5. Selection of for derivative

B. Image sharpening using adaptive unsharp masking(UM)

Many approaches were suggested for reducing the noise sensitivity of the conventional UM technique. They are usage of a quadratic filter as a local mean weighted adaptive high pass filter[6],and[8].The output noise obtained using these

approaches were less than that was there in the conventional unsharp masking approach. A polynomial operator function is used in [7][9] where the sharpening action is controlled by the output of an edge sensor which reduces the work of the high pass filter in situation where the processing mask is not located across an edge in the image. Hence, the system is less prone to a noisy input signal. Although the solution used in the above approaches reduce the noise sensitivity of Unsharp masking there are still some artifacts in smoother area because of amplification.

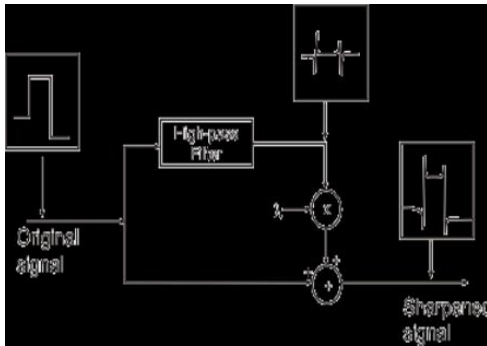


Fig. 6. Image sharpening block diagram representation

A variation of the basic UM scheme is proposed here that contains an adaptive filter in the correction path. This approach enhances images whose dynamic range matches with the available dynamic range of a CRT monitor. The reason for using the adaptive filter is to emphasize the medium contrast details in the input image more than large-contrast details such as abrupt edges so as to avoid overshoot effects in the output image. Smooth area will not be considered for sharpening using this filter, and hence the overall system is more robust to the presence of noise in the input images than traditional approaches. So this approach provides twin purposes of avoiding noise amplification as well as unnecessary overshoot in the detail regions for image enhancement [10].

C. Image sharpening using unsharp masking and wavelet transform

The basic idea of image sharpening is to add to the input signal a high pass filtered version of the original signal itself. Wavelet coefficients provide multi resolution high frequency details of an image. Using this concept, a wavelet based approach was used for image sharpening in [11]. Image sharpening is introduced to improve image contrast and brightness. In another method a combination of both Discrete Wavelet Transform (HAAR) and Unsharp Masking technique is used [12]. The wavelet coefficients provide high frequency coefficients of the image such as edge information. Unsharp masking technique is used to sharpen the image here. This approach is used to obtain edge information. This algorithm uses the correlation between different wavelet coefficients and hence high frequency coefficients are considered to be edge of an image. When 2D-DWT is applied to the image the

approximation coefficients and detail coefficients such as Vertical, Horizontal and Diagonal represented as CA, CV, CH and CD respectively. As the next stage, each of these coefficients are processed with UM. finally the new coefficient's CA', CV', CH' and CD' are obtained. Image sharpening was calculated using the amount of rise in the value parameter. It was observed that there was a 7.47% rise in the value parameter in the original image and it was observed that after using this approach there was 30.59% rise in the value parameter [12]. A simple image sharpening algorithm (WUM) which uses both Wavelet and UM approaches is mentioned in [11]. In this approach WUM was focused on grey scale images. Here the edge information of the original image was taken from a list of wavelet coefficients. The wavelet coefficients were obtained as a result of FDWT applied on the input image. The wavelet coefficients obtained ranges from different frequencies. Only the high frequency coefficients were selected, and the sub bands with low frequency information were ignored. The selection of the high frequency coefficients is critical because some of these frequencies might contain noise. The presence of noise in these coefficients hampers the output quality. The utilization of WUM using DWT principles is done for Geographic data visualization [13]. The data being visualized in a map could be enhanced using image sharpening techniques. Three geographical images were considered for sharpening. A three level DWT was applied to each of these three images and the sharpness was enhanced using Tenengrad measure. Unsharp masking for contrast enhancement of satellite images are discussed in [12]. Here nature of wavelet transform that separates the original image into low and high frequency sub-band images as low and high pass filter are considered. Specifically, a number of high frequency sub-band image.

D. Sharpening: unsharp mask

Types of 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. 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. 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 undersharpen 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 undersharpen 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.



Fig. 7. Basic image sharpening structure

Table 1
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Image Sharpening Algorithm	References	Filtering Technique used	Approach used	Results	Advantages
1. Image Sharpening using conventional Unsharp Masking	[5][6]	High pass filter used	Linear Unsharp masking approach	There is a very good background variance achieved at the expense of a smaller sharpening effect	Capability of taking into account the human visual system response Ability to sharpen images even in the presence of noise nonlinear approach
2. Image sharpening using adaptive Unsharp masking	[7][8][10]	Linear High pass filter used	Filter controls the contribution of the sharpening path in such a way that contrast enhancement occurs in high detail area and no /less sharpening occurs for smooth areas.	Linear UM and type IB operator provide good sharpening of the image in the low contrast details..	Medium contrast details enhanced. Due to Noise amplification constraint, cannot be used for online applications.
3. Image sharpening using UM and Wavelet Transform	[11][12]	High-pass filter	Edge information obtained using the wavelet coefficients.	7.47% rise in the value parameter in the original and 30.59% rise in the value parameter after sharpening.	Improve image contrast and brightness.
4. Image sharpening using unsharp masking the depth buffer	[10]	High pass filter	Like UM, the difference between the original depth buffer content and a low pass filtered copy is utilized to determine information about spatially important areas in a scene.	Operation relies solely on color and depth buffer operation.	Applied to images of any kind, ranging from complex landscape Data and technical artifacts, to volume rendering, photograph, and video with depth information.
5. Enhancement technique combining Sharpening and noise reduction .	[5][7]	Nonlinear Filters	Focuses on multiple output system that accepts fuzzy models in order to avoid the noise increase during sharpening.	Overall nonlinear behaviour is controlled by single fuzzy set parameter.	Better performance compared to other enhancement methods applied in images affected by Gaussian noise and no complicated tuning of fuzzy set parameters. Used in mobile applications
6. Rational Unsharp Masking Technique	[11]	Squared band pass filters	A control term represented as a rational function of the local input data is used.	Provides a good noise insensitive sharpening action without artificial overshoot artifacts.	Noise amplification is avoided and overshoot effects on sharp edges are limited.
7. Unsharp Masking Algorithm For Mammography Using Non-Linear Enhancement Function	[1][2]	Improved high pass filters	Algorithm combines the conventional UM with the non-linear enhancement function.	In addition with the enhancement of the edges of the image the algorithm also suppresses the background noise also.	Provides high frequency components of the image which are insensitive to noise.

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.

5. How it works

Most image sharpening software tools work by applying something called an "unsharp mask," which despite its name, actually acts to sharpen an image. Thus both positive-slope edges and negative-slope edges are equally highlighted. This procedure, where the top branch extracts the positive-slope edges and the middle branch extracts the negative-slope edges. In order to understand the effects of edge sharpening, a row of a test image is plotted in Figure 2 together with a row of the sharpened image when only the positive-slope edges are highlighted, only the negative-slope edges are highlighted, and both positive-slope and negative-slope edges are jointly highlighted.

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:

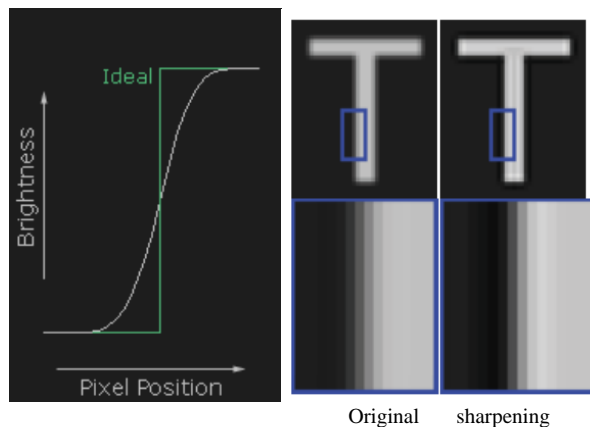


Fig. 8. Examine the edge of one of the letters

6. Sharpening parameters

Most of the sharpening techniques uses at least 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 the different methods for Image sharpening using the Unsharp Masking (UM) approaches are analyzed. It was observed that all algorithms are very sensitive to the enhancement factor used for sharpening. The adaptive approach supports the medium contrast details enhancement The Wavelet based UM provides good improvement in the value parameter percentage and also improves the contrast and brightness. The rational approach provides a good noise insensitive sharpening action without artificial overshoot artifacts.

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