A Review on the Image Sharpening Algorithms Using Unsharp Masking

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A Review on the Image Sharpening Algorithms Using Unsharp Masking

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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.

I. INTRODUCTION

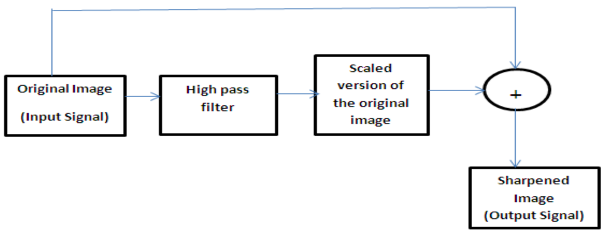
Image enhancement is considered as one of the most important techniques in image processing. The main aim of image enhancement emphasizes to enhance the quality and visual appearance of an image, or to provide a better transform representation for future automated image processing. Many images like medical images, satellite, aerial images and also real life photographs suffer from poor and bad contrast and noise [1].The aim of image enhancement is to raise the dynamic series of the chosen features so that they can be identified easily and hence it can improve the information in images for human observers. The characteristic information content of the data will not be increased, but it increases the dynamic range of the chosen features so that they can be identified very easily .For example medical image analysis and the analysis of images from satellites. Image sharpening refers to any enhancement technique which concentrates on the edges and the fine details of an image. Image sharpening is mostly used in printing and photographic sectors for increasing the limited contrast and sharpening the images. In general if method will be implemented, actual requirements will be obtained. Filtering of images will be done followed by sharpening to get enhanced visual effect for images. Image sharpening methods may be classified into two classes [1].

1. Spatial domain methods
2. Frequency domain methods.

The spatial domain techniques are implemented to the image plane 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. The enhancement methods are:(a) Image enhancement methods using binarization method or thresholding method, (b) Image enhancement methods using binarization method or thresholding method and other methods, (c) Image enhancement methods using other methods only[2].All these methods are used very often to restore documents. In[3] an approach named Histogram Equalization is mentioned. Histogram equalization uses the process of distributing the gray levels within an image so that every gray level is equally likely to occur. Hence histogram equalization increases the brightness and contrast of dark and low contrast images. This approach focusses prominently on contrast enhancement. In situation were contrast cannot be increased histogram equalization fails. Image sharpening is one among the image enhancement approach performed on images. In general the edges and fine details of images should be preserved since they are composed basically by high frequency modules. The chances for these modules to be degraded in case of these high frequency being removed or attenuated is more. Hence, the high frequency modules of an image needs to be enhanced in order to improve the visual quality of the image. 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 [4]. Image sharpening can be applied in Medical imaging also like in face recognition [5] where public security should be ensured. Usually in face recognition techniques which were available earlier there were chances for the images to be undefined and the identification rate also gets reduced. In this approach mentioned there are much improvement on image clarity and complexity as well.

II. 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(1) Image Sharpening principle

The Fig(1) illustrates this procedure called an unsharp masking on a one-dimensional signal. As shown in the Fig(1),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.

III. IMAGE SHARPENING ALGORITHMS USING UNSHARP MASKING:

3.1 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 looses its originality in most cases [6].Among all the image sharpening approaches used this UM approach is the easiest and simplest.

3.2. 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. 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].

3.3 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 multiresolution 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 [14]. 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 images consist of horizontal, vertical, and diagonal coefficients that contain detail of information. Taking inverse wavelet transform of each sub-band image separately except low frequency one, the calculation of high frequency information in horizontal, vertical, and diagonal image can be done. All of them are scaled by the scaling factor in each one separately. Adaptive algorithm is implemented to results the suitable scaling factor to obtain the enhanced image corresponding with the given criterion based on variance of each area smooth and detail area. Based on the experimental results obtained as a result of this approach it is observed that it achieves well to high enhance in detail area and low in smooth area.

3.4 Image Sharpening using Unsharp masking the depth buffer:

This approach is applied to enhance the perceptual features of images that contain depth information [15].Like UM, the difference between the original depth buffer content and a low-pass filtered copy is used to determine information about spatially important areas in a scene. Depending on these data the contrast, color and the other factors of the image are enhanced. The objective of this approach is to improve the perception of complex scenes by introducing additional depth cues. The basic principle used here is, a mask is created by subtracting a low-pass filtered copy from the original image which effectively produces a high-pass filter. This final high frequency signals are added to the original image to obtain a sharpening or a local contrast enhancement. For producing more effect, a larger filter kernel size can be used which results in an enlarged radius of influence. The approach can be applied for conventional image data without considering depth information, and as a result, enhances all local contrasts in an image. Still, by applying this technique to the depth buffer, which means we compute the difference between the original and the low-pass filtered depth buffer. Using this an additional fact is identified which is, the spatial relation between the objects in the scene.In case of an image that contains a blue object in front of a blue background, using the conventional unsharp mask the image cannot be altered due to the lack of color contrast. This approach enables to alter the colors in this scenario due to the additional depth information.

3.5 Image Enhancement technique combining Sharpening and noise reduction:

There are various reasons for using fuzzy logic in image processing which are as follows: firstly, there are various conditions by which an image has to travel through, which includes issues like projection of images in various dimensions, digitization of images. Secondly, the ambiguity associated to boundaries and non-homogeneous regions and few descriptions like edges, contrast enhancement are very common factors in fuzzy. Thirdly, image processing with deficiencies in data is also a problem and only using sufficient understanding of the situation the problem can be solved. The basic solution to these issues can be obtained using human language interpretation. But human natural language is imprecise and has a fuzzy nature. By considering all the factors above, we can conclude that fuzzy set theory is a useful mathematical tool for handling the ambiguity or uncertainty[16].]The approach explained in[17] concentrates on the contrast enhancement. It is based on a multiple output system that accepts fuzzy models in order to avoid the noise increase during the sharpening of the image details. It is considered to provide better performance considered to the other approaches implemented .There is no complicated tuning of fuzzy set parameters in this approach. Also the overall nonlinear behaviour of the enhancement system is very easily controlled by a single parameter only. Fuzzy networks can effectively model conflicting tasks such as noise removal and edge highlighting. Combining fuzzy networks in the same processing architecture is also very easy. In this approach the enhancement system includes three networks operating on different subsets of input data. However, no complicated tuning of fuzzy set parameters is necessary because the overall nonlinear behavior is very easily controlled by one parameter only. Results of computer simulations have shown that the proposed method outperforms state-of-the-art techniques in the enhancement of noisy image data.

3.6 Rational Unsharp Masking Technique:

Unsharp masking was introduced in image processing to make the image crisper[18].As shown in the fig(1) in unsharp masking approach a high pass filter is used to sharpen the image and also a scaling factor is used. But still it has few drawbacks such as noise sensitivity and excessive overshoot on sharp details. Linear Unsharp masking approach used for image enhancement is modified with few changes here. A control term is expressed as a rational function of the local input data in this approach which is the basic parameter used for image enhancement. The noise amplification or noise sensitivity as mentioned earlier as a drawback of unsharp masking which is caused during image sharpening can be eliminated as a result of this parameter. Also the overshoot effects on the sharp edges can be reduced at the end of image enhancement.

3.7 Nonlinear Unsharp Masking Algorithm For Mammography:

A new unsharp masking (UM) scheme, called nonlinear UM (NLUM), is used for mammogram enhancement. The NLUM provides few benefits for users which are 1) to embed different types of filters into the nonlinear filtering operator; 2)to choose different linear or nonlinear operations for the fusion processes that combines the enhanced filtered portion of the mammogram with the original mammogram; and 3) to allow the NLUM parameter selection to be performed manually or by using a quantitative enhancement measure to obtain the optimal enhancement parameters. Also a new enhancement measure method, called the second-derivative-like measure of enhancement is used here, which is shown to have better performance than other measures in evaluating the visual quality of image enhancement. The comparison and evaluation of enhancement performance demonstrate that the NLUM can improve the disease diagnosis by enhancing the fine details in mammograms with no a priori knowledge of the image contents [19].

In this approach [20] Unsharp Masking (UM) algorithm using a non-linear enhancement function is introduced. The algorithm tries to overcome the issues with the conventional approach. Here the combination of the conventional UM with the non-linear enhancement function is implemented. The conventional UM algorithm is extremely sensitive to noise because of the presence of the linear high pass filter. The improved high pass filter used in the proposed work provides high frequency components of the image which are insensitive to noise which reduces the noise sensitivity of the UM algorithm. The input image is simultaneously processed using the improved high pass filter and the non-linear enhancement function; both the images are then combined to get the final enhanced image. The Nonlinear enhancement function overcomes the problem found in the normal enhancement approaches used in medical images. When the fine detail of ROI in a medical image is enhanced, the noise present in the background also will be enhanced. Hence the Nonlinear enhancement function is used which not only enhances the edges of the masses, but at the same time suppresses the background noise also.

TABLE 1: Comparison of different Unsharp masking approaches for Image sharpening

Image Sharpening Algorithm	References	Filtering Technique used	Approach used	Results	Advantages
1.Image Sharpening using conventional Un sharp 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][13][14]	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	[15]	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 .	[16][17]	Nonlinear Filters	Focusses 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	[18]	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	[19][20]	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.

IV. 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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