Comprehensive Unsharp Masking Technique Elaborated in Detail

Miss. Snehal P. Powar[1] Prof. Atul V. Shah[2] Mr. Prashant P. Zirmite[3]
[1]PG Student [2,3]Assistant Professor
[1,2,3]DKTES TEI, Ichalkaranji, India

Abstract— One of the elementary image processing technique is image enhancement. Image Enhancement is most important and difficult techniques applied at beginning stage of algorithm or system in image research. It is used to improve the visibility of one aspect or component of an image. Image enhancement is a common approach to improve the quality of those images in terms of human visual perception. There exist lot of techniques that can enhance an image without spoiling it. Out of which Unsharp masking is used as for enhancement of sharpness of an image. There are several applications which requires enhancement in contrast as well as sharpness of an image. An image is mostly degraded by following reasons loss of sharpness or blur, and noise added to the image. Images also suffer from poor image quality, particularly lack of contrast and presence of shading and artifacts, due to the deficiencies in focusing, lighting, specimen staining and other factors. Unsharp masking has key applications in areas such as Health sciences to Enhance biomedical/medical image qualities, Robotic surgery, Low vision reading with electronic display, Machine vision, Forensics, Robot vision etc. This paper elaborates a generalized unsharp masking model by showing outputs at different levels of the algorithm.

Key words: Unsharp Masking; Adaptive Gain Control; Contrast Enhancement; Sharpening

I. Introduction

An Image with enhanced sharpness and contrast has many applications. In literature, many of techniques are discussed to sharpen blurred or poorly contrasted images. The unsharp masking technique is the most known method for contrast image enhancement. In this paper a method for enhancing the sharpness and contrast is discussed. As a Human being we make sense of the world around us through our vision. We not only look at things to recognize them, but we can scan for differences, and obtain an overall rough feeling for a scene with a quick look. Humans have very exact visual skills: we can recognize a face in an instant; we can differentiate colors; we can process a large amount of visual information very quickly.

II. Literature review

At present image enhancements by unsharp masking became very basic step or process for the research scholars. Many researchers had contributed in are of image enhancement. In [1] Guang Deng, used an investigative data model as a combined framework for developing generalized unsharp masking algorithms. Using that framework, he proposed a new algorithm to address three issues associated with classical unsharp masking algorithms: simultaneous enhancement of contrast and sharpness by means of individual treatment of the model component and the residual; reducing the halo-effect by means of an edge-preserving filter. Guang Deng et al. [2] shown new implementation of Lee's image enhancement algorithm based on the LIP model. The new approach has been shown to achieve effective improvement in both the overall contrast and the enhancement of details in the dark area of an image. Ankita Singh and K K Gupta [3] had given a alternative for the images taken in low light condition. In [4] Andrea Polesel et al. Presented a novel technique for unsharp masking for contrast enhancement of images. They used adaptive filters to control the contribution of the sharpening path. That change resulted contrast enhancement in high detail areas and little or no image sharpening occurs in smooth areas. The algorithm employed two directional filters whose coefficients are updated using a Gauss–Newton adaptation strategy. Giovanni Ramponi [5] presented the Cubic Unsharp Masking technique. Statistical study and some computer simulations both considered by him for study. With statistical analysis and its behavior, he had been able to demonstrate its reduced sensitivity to noise. The computer experiments performed had validated this analysis, and had practically shown the improvement of the visual quality achieved. In [6] Marco Fischer and José L. Paredes presented a new image sharpening structure based on Permutation Weighted Median (PWM) filters. According to them the PWM sharpener a robust sharpener that allowed to select the grade of noise attenuation in a tunable fashion. The statistical analysis presented by them verified the superior robustness properties of the proposed sharpening technique compared to the traditional linear sharpening method. They used computer simulations to demonstrate that the PWM sharpener enhances edges and details in an image without amplifying background noise as much as linear sharpening. Also, in post-filtering of compressed images, which were contaminated with artifacts introduced by compression algorithms, the PWM sharpener. In [7] J. Alex Stark proposed a scheme for adaptive image contrast enhancement based on a generalization of histogram equalization (HE). HE was a useful technique for improving image contrast, but its effect was too severe for many purposes. However, dramatically different results can be obtained with relatively minor modifications. A concise description of adaptive HE is set out, and this framework was used in a discussion of past suggestions for variations on HE. In [8] Kaiming He et al. proposed a very simple but powerful prior, called the dark channel prior, for single image haze removal. The dark channel prior is based on the statistics of outdoor haze-free images. Combining the prior with the haze imaging model, single image haze removal becomes simpler and more effective. Ahmed Zaafouri et al. in [9] had presented a developed unsharp masking approach for contrast images enhancement by using mean weighted high pass filter. There developed method gives satisfactory results compared with others known approaches. The contrast of all images is quite enhanced, in the dark area as bright region. The noise effects also well reduced.

III. IMPLEMENTATION STEPS

Unsharp masking is an image sharpening technique. The "unsharp" of the name derives from the fact that the technique uses a blurred, or "unsharp", negative image to create a mask of the original image. The unsharped mask is then combined with the positive (original) image, creating an image that is less blurry than the original. The resulting image, although clearer, may be a less accurate representation of the image's subject. The step implemented in system are defined as below, implementation is done through MATLAB Release 2013a.

1) Conversion of color image from the RGB color space to the HSI or the LAB color space.
2) Application of edge preserving filter for-
   a) Enhancement of the Detail Signal.
   b) To generate the Root Signal
3) Adaptive Gain Control-
   a) Linear mapping of detail signal.
   b) Proposed adaptive gain control function.
4) Contrast Enhancement.

A. RGB Color Space to the HSI or the LAB

In image processing or video processing color is a very important visual property of an object. As per different needs of various application areas, different methods are used to represent color, each method is based on different mathematical ideas, with different advantages as well as limitations. The CIE L*a*b* and CIE L*u*v* spaces are selected to represent a uniform color space. These two color spaces are derived from the CIE XYZ color space and attempt to produce a coordinate system in which perceptual distances correspond to Euclidean distances. In CIE L*a*b* color space, L* represents the lightness of color going from 0 (dark) to 100 (white), while a* and b* channels are the two chromatic components. The first of these two (a*) represents the colors position between red/magenta (+a) and green (-a). Similarly, b* indicates its position between yellow (+b) and blue (-b) [10].

To perform the transformation first a color transformation structure is created, that defines the color space conversion specified by a type given. Then apply created color transformation structure to the image (Fig. 1).

In general, we represent colors as RGB values, either directly (in an RGB image) or indirectly (in an indexed image). However, there are other models besides RGB for representing colors numerically. The various color spaces exist because they present color information in ways that make certain calculations more convenient or because they provide a way to identify colors that is more intuitive.

Fig. 1: Original Images and its Lab Transformations

B. Edge Preserving Filter

In image processing filters are mainly used to suppress either the high frequencies in the image, i.e. smoothing the image, or the low frequencies, i.e. enhancing or detecting edges in the image. An image can be filtered either in the frequency or in the spatial domain. The first involves transforming the image into the frequency domain, multiplying it with the frequency filter function and re-transforming the result into the spatial domain. The filter function is shaped so as to attenuate some frequencies and enhance others [11] [12].

1) The Median Filter

The median filter is normally used to reduce noise in an image, somewhat like the mean filter. Mean filtering is a simple, intuitive and easy to implement method of smoothing images, i.e. reducing the amount of intensity variation between one pixel and the next. It is often used to reduce noise in images. Iterative Median Filter improve the reduction in the corruption or noise added in input data, the number of iterations needed is dependent to the level of corruption and also the nature of the input image itself. Iterative method requires the same procedure to be repeated several times. In general, iterative median filter with *Ni* iterations, requires *Ni -1* temporary images. Iteration procedure enables median filtering process to use smaller filter size and reduce the computational time, while maintaining local features or edges of the image.

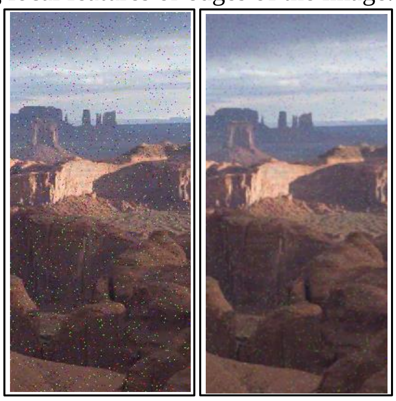

Fig. 2: Input RGB Image with Salt and Pepper Noise and the Filtered Image

2) Noise

Noise is introduced in the image at the time of image acquisition or transmission. Noise is a random variation of image Intensity and visible as grains in the image. Impulse noise (Salt and Pepper Noise) is one term used type of noise also known as spike noise, random noise or independent noise. In this type black and white dots appear in the image as a result of this noise and hence called salt and pepper noise as shown in Fig. 2.

Other type is Gaussian Noise. It is normal noise model is the substitute of Amplifier noise. This noise model is additive in nature and follow Gaussian distribution. Meaning that each pixel in the noisy image is the sum of the true pixel value and a random, Gaussian distributed noise value. The noise is independent of intensity of pixel value at each point (Fig. 3).

Fig. 3: Input RGB Image with Gaussian Noise and Filtered Image

3) The Root Signal

The root signal y_n is to be defined as follow

$$n = min\ (k) \tag{3.1}$$

subjected to $H(y_k, y_{k+1}) < \delta$

Where $H(y_k, y_{k+1})$ is a suitable measure of the difference between the two images and δ is a user defined threshold.

It can be easily seen that the definition of the root signal depends upon the threshold k. For example, it is possible to set a large value to such that is the root signal. The value of threshold is decided by setting various values for it and observing the resultant image as shown in figure. Looking at various result a threshold is decided, at that threshold the image information is not much altered by providing sharpening of image too.

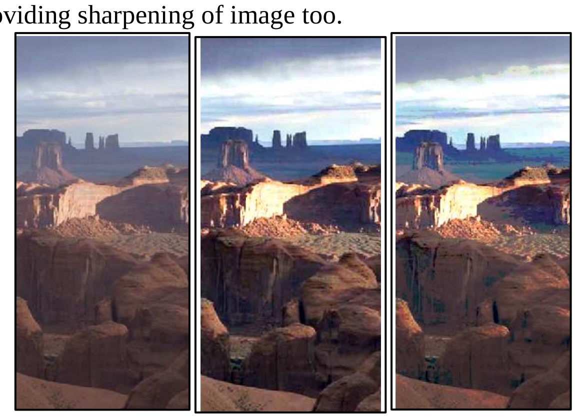

Fig. 4: Input RGB Image and Filtered Image with different Threshold for Non-Linear Filter

In Fig. 4 first is original RGB image then the filtered images having different threshold value and inn Fig. 5 first is original RGB converted into LAB space image then the filtered images having different threshold value.

Fig. 5: Converted Lab Image and Filtered Image with different threshold for non-linear filter

4) High-Pass Filter

A high-pass filter utilized to make an image appear sharper. These filters emphasize fine details in the image; exactly the opposite of the low-pass filter. High-pass filtering works in exactly the same way as low-pass filtering; it just uses a different convolution kernel. If there is no change in intensity, nothing happens. But if one pixel is brighter than its immediate neighbors, it gets boosted. That is shown in Fig 6.

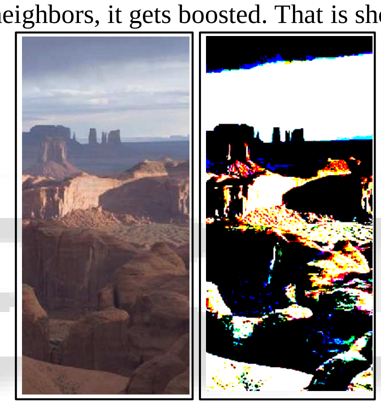

Fig. 6: High-Pass Component of Image

5) Thresholding

At this step the edges who are above the threshold are highlighted by setting the pixels bellow threshold to zero, result is found as shown in figure x, with threshold value decided in prior steps. It helps to sharpen the less visible edges of the image that can be seen in Fig. 7.

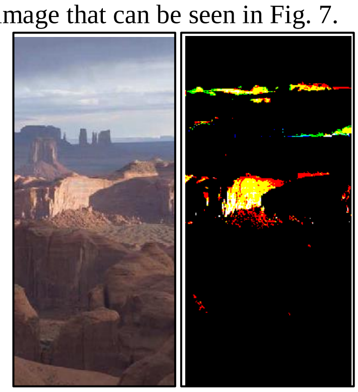

Fig. 7. Highlighted edges of images above threshold

6) Sharpening

Add the high-pass component with image to be sharpen. Addition of image can be done arithmetic operation. But here MATLAB function *imlincomb* was used to combine the high pass component and the input image. Which performs linear combination of images. more accurate results achieved by using imlincomb to combine the images, rather than nesting calls to the individual arithmetic functions.

Fig. 8: Original Input Image and Sharpen Image

The median filters are used to reduce noise in an image. Here at this stage Iterative Median Filter is used to reduce the noise. To observe the result of filter, different noise is added into image, such as Impulse noise (Salt-Pepper noise) and Amplifier Noise (Gaussian noise). The Fig.2 and Fig. 3 shows the effect of the IMF. Then using non-linear filters, the edge preservation of image is done, this is done by adding high pass component of image into the original image the result is sharpen image as seen in Fig. 8.

C. Contrast Enhancement

Contrast is the difference in visual properties that makes an object distinguishable from other objects and the background. It is created by the difference in luminance reflected from two adjacent surface. Contrast is an important factor in any subjective evaluation of image quality. In visual perception, contrast is determined by the difference in the color and brightness of the object with other objects. Human visual system is more sensitive to contrast than absolute luminance; therefore, human can perceive the world similarly regardless of the considerable changes in illumination conditions.

1) Implementation Steps

1) Step 1: Acquire input image, here the input was the output of system that is the edge preserving filter.
2) Step 2: Get all input values which was used in enhancement process like number of regions in row and Column direction separately, dynamic range (number of bins used in histogram transform function), *cliplimit*, distribution parameter type.
   B1=adapthisteq(image,'Distribution','rayleigh','Alpha', 0.5);
   Here distribution parameter selected here was Rayleigh as it provides bell shaped histogram. 'Alpha' is nonnegative real scalar a, which was used here as distribution parameter, that was set to 'rayleigh'; It's default value is 0.4.
3) Step 3: The inputs were then pre-processed to determine real clip limit from the normalized value and if necessary, the image was padded before splitting it into regions.
4) Step 4: Then each tile was processed to produce gray level mappings, from this a single image region was extracted. Afterwards a histogram for this region using the specified number of bins is made. Then this histogram was clipped by clip limit then a mapping (transformation function) for this region was created.
5) Step 5: At this step gray level mappings were interpolated in order to assemble final CLAHE image. This was done by extracting cluster of four neighboring mapping functions, then by processing the image region partly overlapping each of the mapping tiles, afterwards a single pixel, apply four mappings to that pixel was extracted, and interpolation was performed between the results to obtain the output pixel; same process was repeated over the entire image.

The adapthisteq is a MATLAB function to perform histogram equalization by provided different parameters. The output images after contrast enhancement are shown in Fig. 9 and Fig. 10.

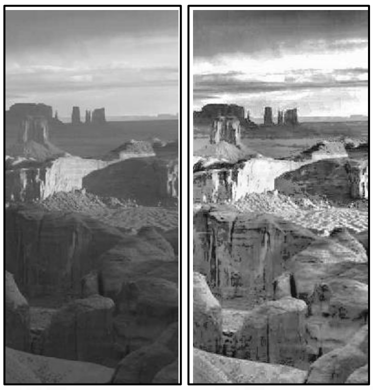

Fig. 9: Input gray image and contrast enhanced image

Fig. 10: Input image and Contrast Enhanced Image

D. Adaptive gain control

While doing the unsharp masking one needs to preserve image details in both lighted and dark areas. This can be achieved by gain control. From literature it can be seen that, for enhancement of the input signal the gain must be greater than one. But while using a universal gain for the whole image does not lead to good results. This happens because, a relatively large gain is required to enhance the small details. However, a large gain can lead to the saturation of the signal whose values are larger than a certain threshold. Saturation is undesirable because different amplitudes of the detail signal are mapped to the same amplitude of either 1 or 0. This leads to loss of information. Therefore, the gain must be adaptively controlled.

Fig. 11: Lab transformed Image and Image Gain Calculated

IV. RESULTS & CONCLUSION

Here in the results effects of the two contributing parts i.e. contrast enhancement and detail enhancement through adaptive gain control observed. Contrast enhancement is performed using adaptive histogram equalization, it removes the haze-like effect of the input image and contrast is greatly enhanced. This can be seen into clouds. But contrast enhancement does not cover the minute details on the rocks they are not sharpened (See Fig. 12). On the other hand, only using adaptive gain control image is sharpened but it does not improve the overall contrast. Therefore, combining these two operations both contrast and details are improved.

Fig. 12: First is Original Image then Results of Contrast Enhancement and Detail Enhancement Through adaptive Gain Control

The quantitative measure of performance for the implemented algorithm is a difficult task. So it is not attempted. The difficulty comes from the fact that image enhancement such as the results are a subject for human evaluation.

REFERENCES

[1] G. Deng, "A Generalized Unsharp Masking Algorithm", IEEE Transactions On Image Processing,, vol. 20, no. 11, pp. 1249-1261, 2011.

[2] L. W. C. a. G. R. T. G. Deng, "The Study of Logarithmic Image Processing Model and Its Application to Image Enhancement," IEEE Transactions On Image Processing, vol. 4, no. 4, pp. 506-512, April 1995.

[3] K. K. G. Ankita Sigh, "A Contrast Enhancement Technique for Low Light Images," in AIP Conference, Octomber 2015.

[4] G. R. a. V. J. M. Andrea Polesel, "Image Enhancement via Adaptive Unsharp Masking," IEEE Transactions On Image Processing, vol. 9, no. 3, pp. 505-510, March 2000.

[5] G. Ramponi, "A Cubic Unsharp Masking Technique For Contrast Enhancement," Elsevier, Signal Processing, vol. 67, pp. 211-222, 1989.

[6] J. L. P. a. G. R. A. Marco Fischer, "Weighted Median Image Sharpeners For The World Wide Web," IEEE Transactions On Image Processing,, vol. 11, no. 7, pp. 717-727, July 2002.

[7] J. A. Stark, "Adaptive Image Contrast Enhancement Using Generalizations of Histogram Equalization," IEEE Transactions On Image Processing, , vol. 9, no. 5, pp. 889-896, MAY 2000.

[8] J. S. a. X. T. Kaiming He, "Single Image Haze Removal Using Dark Channel Prior," IEEE Transactions On Pattern Analysis and Machine Intelligence, vol. 33, no. 12, pp. 2341-2353, December 2011.

[9] M. S. a. F. F. Ahmed Zaafouri, "A Developed Unsharp Masking Method For Images Contrast Enhancement," in 8th International Multi-Conference on Systems, Signals & Devices, 2011.

[10] "Wikipedia," [Online]. Available: https://en.wikipedia.org/wiki/Main_Page. [Accessed May 2017].

[11] "Image Processing Leraning Resource," [Online]. Available: http://homepages.inf.ed.ac.uk/rbf/HIPR2/median.htm.

[12] S. J. K. a. Y. H. Lee, "Center Weighted Median Filters And Their Applications To Image Enhancement," IEEE Trans. Circuits Systems, vol. 38, no. 9, pp. 984-993, 1991.