A Method of Color Image Denoised and Enhanced using Wavelet Transform

Swati D. Nikam, Sachin D. Ruikar

Abstract— ***The objective of the image enhancement is to remove the noise. Real color images are images with noise. In traditional image enhancement algorithms color images are firstly converted to gray images. These algorithms enhanced noise while they enhanced image. In this paper wavelet transform is used for color image enhancement. Wavelet transform is an efficient tool to represent a multi resolution analysis of an image. A novel method of color image enhancement based on Hue invariability in HIS color pattern is presented here.***

Index Terms— ***Image enhancement, HIS color space, Wavelet transform.***

I. INTRODUCTION

Color images have the widespread application in the multimedia, biomedical, internet, video etc. However, there are various factors such as dark color, low contrast, non-highlight details, and noise make impact on color images. This not only affects the visual effects, but also difficultly identify and distinguish some images. Therefore, it often needs to enhance images before dealing with them. The method used in this paper enhances an image to improve the interpretability of information present in an image. An enhancement algorithm can enhances an image by either suppressing noise or increasing the image contrast and brightness. Images are often corrupted owing to channel transmission errors in transmission, faulty image acquisition devices in acquisition, a.c. power interference. Because of the above reasons the objectives of corrupted images are hardly to distinguish. So these images need enhancement processing before objective recognition. Image enhancements are employed to emphasized, sharpen or smoothen image features for display and analysis. The greatest difficulty in image enhancement is quantifying the criteria for enhancement. One of two key problems of color image enhancement is that how to keep Hue Invariability and the other is which method is suitable for image enhancement when Hue Invariability is kept [1]. To solve the above problems a new algorithm is proposed: the algorithm based on HIS (Hue, Saturation and Intensity) color space. The HIS color space is divided into three channels, *H* channel, *S* channel, and *I* channel. In this method the *H* channel is kept invariable and in the *I* channel, the image is divided into the low frequency part and the high frequency part. Then histogram equalization processing is applied only to the low frequency part which has been equalized. In the S channel saturation enhancement is done by exponent stretching.

Manuscript Received on May 2014.

Swati D. Nikam, achieving masters degree in Electronics and Telecommunication Engineering in Pune, India.

Prof. Sachin D. Ruikar, working as a professor in Electronics and Telecommunication dept. He has achieved Ph D. in image processing., India.

The image is divided into the low frequency part and the high frequency part. Then histogram equalization processing is applied only to the low frequency part which has been equalized. In the S channel saturation enhancement is done by exponent stretching.

II. METHODOLOGY

1. HIS color space:

In all of the color spaces, the most popular one is HIS space because of the two advantages: First, *I* component is independent on other color channels. Secondly, *H* and *S* components was closely related to the way that our eyes obtaining color [2]. These characteristics make HIS color space is very suitable for color image processing algorithms with visual system to apperceive color [3].

HIS color space is based on human perception and *H* (hue) is one color length of main wave in chromatogram. *S* (saturation) is the pure degree and *I* (intensity) is the sensual equality quality. The performance of HIS color space is good in color improving. Among the three components of HSI color space, hue is the attribute of a color, which decides which color it is. For the purpose of enhancing a color image, it is to be seen that hue should not change for any pixel. If hue is changed then the color gets changed, thereby distorting the image. Compared with other perceptually uniform such as CIE LUV color space, it is easier to control the hue component of color and avoid color shifting in the HIS color space[4].

Because hue, saturation and intensity are separated efficiently in HIS color space, the HIS color space is beneficial to real color image enhancement. The characters of HIS color space make it easy to process color images. In this method first the RGB color space is transformed into HIS color space. The *H* components are not changed, because changes in the *H* components could change the color balance between HIS components. The wavelet transform is applied on the illumination component to decompose it into approximate and detail component for the selected blocks. Then the contrast as well as brightness enhancement method on the approximate component based on the human visual system to enhance the approximate component is applied. For the *I* components, a histogram equalization is applied for contrast enhancement. Then the wavelet transform is applied on the detail component and modified approximate components for selected blocks. The *H*, *S*, and *I* components are converted to RGB color space.

Converting colors from RGB to HSI:

$$H = \begin{cases} \theta, & \text{if } B \le G \\ 360 - \theta, & \text{if } B > G \end{cases}$$

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

$$\theta = \cos^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-B)^2+(R-B)(G-B)^{1/2}]}\right\}$$

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)]$$

$$I = \frac{1}{3}(R+G+B)$$

After performing the enhancement in HSI color space we need to convert back from HSI to RGB color space to exhibit the result of the enhancement. The inverse conversion algorithm can be given by,

Converting colors from HIS to RGB:

We begin by multiplying H by 360° which returns the hue to its original range of $[0^\circ, 360^\circ]$.

RG sector $(0^\circ \le H < 120^\circ)$: When H is in this sector the RGB components are given by the equations:

$$R = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

$$G = 1 - (R + G)$$

$$B = I(1 - S)$$

GB sector $(120^\circ \le H < 240^\circ)$: If the given value of *H* is in this sector we first subtract 120° from it. Then the RGB components are:

$$R = I(1 - S)$$

$$G = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

$$B = 1(R + G)$$

BR sector $(240^\circ \le H \le 360^\circ)$: Finally, if *H* is in this range, we subtract 240° from it.

Then the RGB components are,

$$H = H - 240^\circ$$

$$R = 1 - (G + B)$$

$$G = I(1 - S)$$

$$B = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

2. I Component Enhancement :

The enhancement methods generally divided into two kinds: space domain and frequency enhancement methods. The histogram equalization is one of the good space domain enhancement methods. Histogram modeling enhances an input image by modifying its histogram as a desired shape The histogram modeling in which the desired shape of histogram is uniform is called histogram equalization. The histogram equalization is the most widely used technique in histogram modeling.

The detail information and noise are almost both exist in high frequency domain and the noise would be easily lost when we adopt histogram equalization on the whole image[5].

Wavelet analysis has been applied to various research areas. In wavelet analysis the low frequency coefficients reflect the outline information and the high frequency coefficients reflect the detail information after a digital image was decomposed with wavelet transform. After wavelet decomposition histogram equalization is done just in low frequency domain. So the detail can avoid being blurred and the noise can't be magnified if we just process the low frequency.

a) Wavelet Decomposition:

By using discret wavelet trasform one-scale wavelet decomposition can be done on the component I. The DWT is used to divide the image into subbands. The edges are concentrated on HH, HL, LH, LL subbands. Hence even separating the HF components and apply some transformations on the LF will not cause any damage to the components.

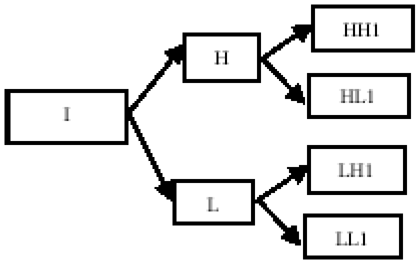

Figure 1. One scale wavelet decomposition of component I .

b) Histogram Equalization:

In this method, the histogram equalization in space domain is used to improve the image contrast by evenly re-distributing the gray level of the image.

Based on above analysis, histogram equalization is done on LL1 sub-image of figure 1. Assume the number of ri, the *i*th gray level of the image, is represented by ni in an image, and the appearance probability of pixel of this gray level pr(ri) is pr(ri) = ni/n, *n* is the total number of pixels. ri satisfies the normalization. The function of histogram equalization is as following:

$$S_i = T(r_i) = \sum_{i=0}^{k-1} P_r(r_i) = \sum_{i=0}^{k-1} n_i/n$$

where k is the total no of gray level, and the correspondin transformation is,

$$r_i = T^{-1}(S_i) r_i = T^{-1}(S_i)$$

Because the physics significance of histogram is the total number of pixels with the gray value of *r*, the total number of pixels of some gray range is equal to the total number of pixels gotten by mapping the pixels to new gray level with one by one by monotone increasing function. So it is: $P_s(S)\,ds = P_r(r)\,dr$

Then the differential coefficient based on s in the equation and the derivation of the equation in s:

$$P_s(s) = \frac{d}{ds}\left[\int_{-\infty}^{r} P_r(r)\,dr\right] = P_r\frac{dr}{ds} = P_r\frac{d}{ds}[T^{-1}(s)]$$

Histogram equalization requires *Ps* (S) be constant, so equalization requires *Ps* (S) be constant, so we can make *Ps* (S) =1.

From above two equations, ds = Pr(r)dr.

Then integrating this equation

$$s = T(r) = \int_0^r P_r(r)\,dr$$

c) Wavelet Reconstruction:

Then reconstruction of the component I is done using the LH1, HL1, HH1 and LL1' which is the low frequency domain after histogram equalization.

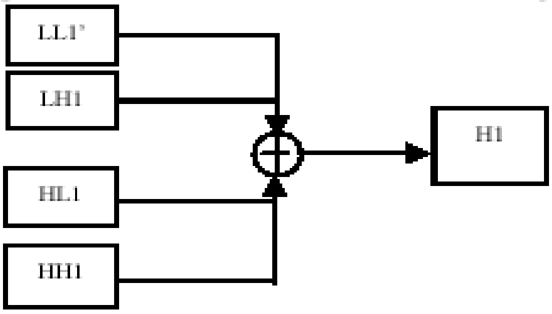

Figure 2. Wavelet Reconstruction

3. S component enhancement:

In order to make sure that the color more clearly, it can take nonlinear exponent adjustment to extend the color changing dynamic range and enhance its contrast. The exponent stretching formula is

$$S' = S^{\alpha}$$

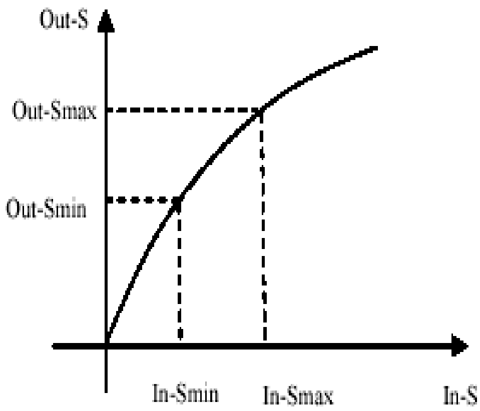

Figure 3. (a) Exponent stretching

III. RESULT

(a)

(b)

(c)

Figure 4. (a) Original noisy images, (b) The histogram equilization on I component, (c) The results with proposed method.

As shown , the figure (a) is the original noisy images of nature and a man. These are noisy with salt and paper noise with low brightness. The figure (b) is the result images after histogram equalization directly on I component in HIS color space and then turn into RGB space. The (c) is the result images with the proposed algorithm and it is observed that the in figure (c) the noise is removed by this proposed method and has improved image contrast and reserved the detail information.

Table1: The results evaluating enhancement methods for nature image:

Evaluate parameters	Original Image	Histogram equalization method	Proposed method
Image mean	105.575	115.6106	95.5602
Image variance	2570.1	13511	4373.3
C		4.2573	0.7016
L		0.0951	-0.0949

Table 2: The results evaluating enhancement methods for man image:

Evaluate parameters	Original image	Histogram equalization method	Proposed method
Image mean	18.6278	87.2772	48.54
Image variance	355.0653	7918.7	1402.2

Contrast		21.3022	2.9497
Luminance		3.68	1.60

IV. CONCLUSION

Using wavlet decomposition, histogram equalization and wavelet reconstruction it is possible to improve contrast of the image. The proposed method can effectively enhance the color images. The algorithm can effectively enhance the color images especially the fuzzy ones with low brightness and effectively remove the noise. This method is easy and cost less time.

REFERENCES

1. Wang Ping, Cheng Hao, Lou Yingxin. "Color Image Enhancement Based on Hue Invariability". Journal. Journal of Image and Graphics.2007 IEEE.
2. SHI Meihong, LI Yonggang, ZHANG Junying. "Novel method of color image enhancement" Journal. Computer Application, 2004 IEEE.
3. Zhang Yujun, Image Engineering. Tsinghua University Press Beijing.1999 IEEE.
4. Kartik Sau, Amitabha Chanda, Milan Pal, "Color Image Enhancement based on Wavelet Transform and Human Visual System". IEEE 2011.
5. Zhang Yanhong, Hou Dewen. "An Image Enhancement Algorithm Based on Wavelet Frequency Division and Bi-histogram Equalization", Journal. Computer Application and Software 2007 IEEE.
6. S. Daly, "The visible differences predictor: an algorithm for the assessment of image fidelity," in Digital Images and Human Vision, A. B.Watson, Ed., chapter 14, pp. 179–206, MIT Press, Cambridge, Mass, USA, 1993.
7. L .Meylan, Tone mapping for high dynamic range images, Ph.D. thesis, EPFL, Lausanne, Switzerland, July 2006.
8. Meylan and S. S¨usstrunki, "Bio-inspired color image enhancement," in Human Vision and Electronic Imaging Conference, vol. 5292 of Proceedings of SPIE, pp. 46–56, San Jose, Calif, USA, 2004.
9. Ruan Qiuqi. Digital Image Processing, Publishing House of Electronics Industry, Beijing 2001.
10. Jinyong Cheng, Caixia Liu, - "Novel Method of Color Image Enhancement Based on Wavelet Analysis", 2008 IEEE.
11. Shaohua Chen and Azeddine Beghdadi, - "Natural Enhancement of Color Image", 2010 IEEE.
12. R. C. Gonzalez, R. E. Woods, and S. L. Eddins, Digital Image Processing, Prentice Hall, Upper Saddle River, NJ, USA, 2004 IEEE.
13. Han Xiaowei. "The research on Color image processing key technology". North Eastern University, 2005. 1.1.
14. Zhang Yanhong, Hou Dewen. "An Image Enhancement Algorithm Based on Wavelet Frequency Division a Bi-histogram Equalization", Journal. Computer Application and Software. 2007.11, 24(11), pp.159-161
15. Jobson D J, Rahman Z U, Woodell G A. The statistics of visual representation [C] // Processing of SPIE Visual Information processing XI. Washington: SPIE Press, 2002:25-35 438
16. V. Buzuloiu, M. Ciuc, M. R. Rangayyn & C. Vartan. Adaptive neighborhood histogram equalization of color images. International journal of electron Image. 10(2), 2001, 445-459.
17. P. E. Trahanias, & A. N. Venetsanopoulos, Color image enhancement through 3-D histogram equalization Proc. 11th IAPR conference on pattern recognition, The Hague, Netherlands, 1992, 545-548.
18. B. A. Thomas. R. N. Strickland, & J. J. Rodriguez, Color image enhancement using spatially adaptive saturation feedback. Proc. 4th IEEE conf. on image processing, Santa Barbara, CA, USA, 1997, 30-33
19. A. Gupta, & B. Chanda, A hue preserving enhancement scheme for a class of color images, Pattern recognition Letters, 17(2), 1996, 109-114
20. Kartik Sau, Amitabha Chanda, - "Color Image Enhancement Based on Wavelet Transform and Human Visual System", IEEE2011.
21. S. Chen and A. Beghdadi, "Natural rendering of color image based on retinex" in Proceedings of the IEEE International Conference on Image Processing (ICIP '09), Cairo Egypt, November 2009.