Color image enhancement based on Daubechies wavelet and HIS analysis

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ABSTRACT
Low contrast and poor quality are main problems in the production of images. By using the wavelet transform and HIS color analysis, a new idea is proposed. Color images are usually converted to gray image first in traditional image enhancement algorithms. The detail information was easily lost and at the same time these algorithms enhance noise while they enhance image, which lead to the descent of information entropy. With the combination of the characteristics of multi-scale and multi-resolution of Daubechies wavelet transform and the pre-dominance of histogram equalization, a novel method of color image enhancement based on hue invariability with characteristics of human visual color consciousness in HIS color pattern is presented here. The experimental results showed that this new algorithm can enhance color images effectively and cost less time.

General Terms
Image enhancement, colour image, Daubechies transform. Histogram equalization

Keywords
colour image enhancement, Daubechies wavelet transform, HIS analysis, Histogram equalization.

1. INTRODUCTION
Images are often corrupted owing to channel transmission errors in transmission, faulty image acquisition devices in acquisition, engine sparks, a.c. power interference and atmospheric electrical emissions. Because of above reasons, the objectives of corrupted images are hardly to distinguish. So these images need enhancement processing before objective recognition. The purpose of enhancement is to stand out the useful information and enlarge the difference of characters in different objects in order to improve the vision effect and stand out the characters. The traditional enhancement algorithms are usually based on the computation of the whole image and the low frequency, high frequency and the noise were transformed synchronously while calculating transformation of the whole image. These algorithms enhance noise signal in images while they enhance, which leads to the descent of information entropy. At the same time, image enhancement in gray-level images is a well-established area; image enhancement in color images has not received the same attention. With respect to gray-scale images, color images generally include rich measurement information that can be successfully exploited in order to improve the performance of image-base instrumentation and/or extend its application range.

The wavelet transform is a time-frequency analysis tool developed in 1980s, which has been successfully applied in the image processing domain after Mallat [1] presented the fast decomposition algorithm. There are many image enhancement methods based on wavelet transform, such as Lu et al. [2], Yang and Hansell [3], Fang and Qi [4], Zhou et al. [5], Wu and Shi [6], etc. In these papers, methods of image enhancement based on wavelet transform were proposed. It's important to use color in image processing for two reasons [7]: firstly, color is a powerful describing tools in image analysis and it can predigest the processing of recognizing and extracting objectives. Secondly, the gray layers that human eyes can distinguish are about twenties kind of. However, human can recognize thousands upon thousands colors. One of the two key problems [8] 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.

The HIS color space is divided into three channels H channel, S channel and I channel. We first make the H channel keep invariable and in the I channel, the image is divided into the low frequency part and the high frequency parts, then histogram equalization processing is only applied to the low frequency part. After that, the wavelet is reconstituted by the low frequency part which has been equalized. In the S channel, we adopt saturation enhancement by exponent stretching.

2. METHODOLOGY
2.1 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 are closely related to the way our eyes obtain color [9]. These characteristics make HIS color space more suitable for color image processing algorithms with visual system to apperceive color [4]. 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. I quality is separated from chroma and is independent of color information. H and S qualities is closely related to the way people perceive color. The characters of HIS color space make it easy to process color image [5].

$$H = \begin{cases} \theta, & if\ B<G \\ 360-\theta, & if\ B>G \end{cases} \qquad (1)$$

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

$$s = 1 - \frac{3}{(R+G+B)}[\min(R*G*B)] \qquad (3)$$

$$I = \frac{1}{3}(R+G+B) \qquad (4)$$

2.2 I Component

The enhancement methods are generally divided into two kinds: space domain and frequency domain enhancement methods. The space domain enhancement methods include gray-level transformation enhancement algorithms (such as points operation (square root transform and inversion changing), histogram equalization and histogram specification and so on) and space filter enhancement methods which include smoothing filter and sharpening filter. The smoothing filters include linear smoothing filter (such as neighborhood medium filter, wiener filter and gauss filter) and nonlinear smooth filter (such as max value filter, least value filter). The templates of sharpening filters include Laplacian operator template, Prewitt operator template and so forth. Frequency domain enhancement methods include low-pass filter, high-pass filter, homeostasis filter, Fourier filter and wavelet transform enhancement and so on. Space domain enhancement methods can make the whole image uniform and is useful to the next processing. The histogram equalization is one of good space domain enhancement methods. However, the detail information and noise are almost both exist in high frequency domain and the noise would be magnified and the detail information would be easily lost when we adopt histogram equalization on the whole image [10].

Wavelet analysis is a local analysis method with fixed window and changing window shape, time window and frequency window. Comparing with Fourier transform and Gabor transform, the wavelet transform has good local character both in time domain and frequency domain. The low frequency coefficients reflect the outline information and the high frequency coefficients reflect the detail information and noise after a digital image was decomposed with wavelet transform. At the same time, the visual feeling of the general image is dependent on the low-frequency information. On this point, we can do histogram equalization 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.

2.2.1 Wavelet Decomposition

An image can be seen as a 2D signal, so an image's wavelet transform can be obtained by the Mallat algorithm. In the wavelet frequency field, an image's edge feature information and detail information are distributed in high-frequency sub-images. The 2-D wavelet decomposition of an image is performed by applying 1-D DWT along the rows of the image first, and, then, the results are decomposed along the columns. This operation results in four decomposed subband images referred to as low–low (LL), low–high (LH), high–low (HL), and high–high (HH). The frequency components of those subband images cover the frequency components of the original image as shown in Figure 1.

LL	HL
LH	HH

Figure.1.The result of 2-D DWT decomposition

2.2.2 Histogram Equalization

Assume that the gray level range is from 0 to 255 of the whole image. If the difference of the gray level is less than 10 of two adjacent objects, then we can't distinguish the two objects. In this case, the histogram equalization in space domain is used to improve the image contrast by evenly redistributing the gray level of the image. Based on above analysis, we make histogram equalization on LL sub-image of Figure 1.

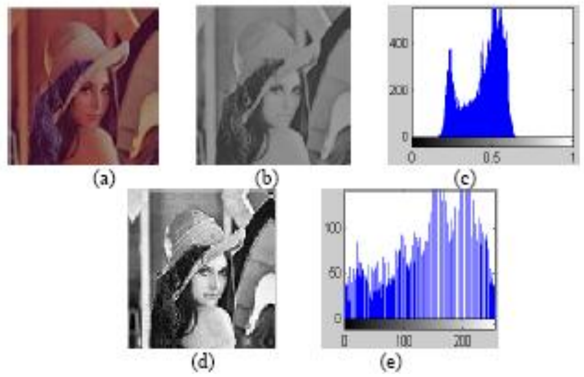


Figure 2. (a) Original image, (b) LL Component of (a) after wavelet decomposition, (c) the histogram of (b), (d) the image after histogram equalization in figure (b), (e) the histogram of (d).

From figure2 (d) we can see that the I component is enhanced and the noise is reduced after histogram equalization in figure (b).

2.2.3 Wavelet Reconstruction

Then we reconstruct the component I use the LH, HL, HH and LL which is the low frequency domain after histogram equalization. The result is shown in Figure 3.

Figure 3 Reconstructed Image.

2.3 S Component

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

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

and α is the stretch factor, determining saturated degree of saturation component.

(a) (b)

Figure 4 (a) Original S Component image, (b) Stretch image.

Normalize H, S, I component and convert HIS color space to RGB space.

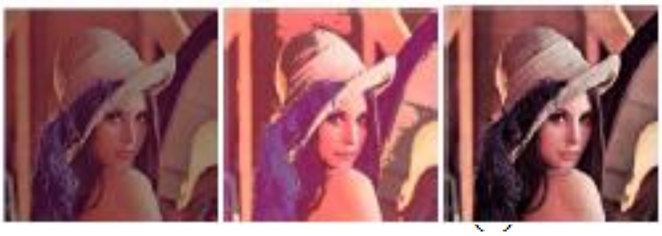
3. RESULT ANALYSIS

As shown in Figure 5, the (a) is the original image. It is fuzzy with low brightness. The (b) is the result image after histogram equalization directly on I component in HIS color space and then turn into RGB space. The (c) is the result image with our algorithm and we can see that the (c) has improved the image contrast and reserved the detail information. The situation is the same as in (d), (e), (f). In order to validate the validity of our method, we calculated the image mean, variance, the change rates of luminance and contrast according to the measurement methods of luminance and contrast proposed in literature [7] on figure 6(a)

$$C = \frac{\overline{var}\left(I_{out}(x,y)\right) - \overline{var}\left(I_{in}(x,y)\right)}{\overline{var}\left(I_{in}(x,y)\right)}$$

$$L = \frac{mean\left(I_{out}(x,y)\right) - mean\left(I_{in}(x,y)\right)}{mean\left(I_{in}(x,y)\right)}$$

$I_{in}(x,y)$ is the original image before processed, $I_{out}(x,y)$ is the result image. $\overline{var}$ and $mean$ stand for calculating the mean of local variance and the mean of the whole image. C is the contrast change rate and L is the luminance change rate.



(a) (b) (c)

Figure 5. (a) Original Image, (b) Histogram Equalization Image, (c) Output image

4. CONCLUSION

A new image enhancement algorithm was proposed based on color images. In the first, The HIS color space was divided into three channels H channel, S channel and I channel. The H channel kept invariable and in I channel, we used wavelet decomposition and histogram equalization in order to reduce noise and improve contrast. After that, the wavelet was reconstructed by the low frequency part which had been equalized. In the S channel, we adopt saturation enhancement by exponent stretching. The algorithm can effectively enhance the color images especially the fuzzy ones with low brightness. At the same time, this method is easy and cost less time.

5. REFERENCES

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